53

CULTURA, CIENCIA Y DEPORTE

ESPAÑA • SEPTIEMBRE 2022 • VOL. 17 • NUM. 53 • PÁGS. 1 A 214

REVISTA DE LA FACULTAD DE DEPORTE
UNIVERSIDAD CATÓLICA DE MURCIA

CCD

9 40181 700982
ISBN DIGITAL 1529-7413
DOI 10.12800'ccd

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CULTURA, CIENCIA Y DEPORTE 53

SUMARIO • SUMMARY

Los resúmenes de los trabajos publicados en la Revista Cultura, Ciencia y Deporte, se incluyen en las bases de datos: ISI Web of Science, SCOPUS, EBSCO, IN-RECS, DICE, LATINDEX, REDALYC, DIALNET, RESH, COMPLUDOC, RECOLECTA, CEDUS, REDINET, SPORTDISCUS, MIAR, PSICODOC, CIRC, DOAJ, ISOC, DULCINEA, SCIRUS, WORLDCAT, LILACS, GTBib, RESEARCH GATE, SAFETYLIT, REBIUN, Universal Impact Factor, Genamics, Index Copernicus, e-Revistas, Cabell's Directory. Scientific Journal Impact Factor, ERIH PLUS, DLP, JOURNALS FOR FREE, BVS, PRESCOPUS RUSSIA, JournalTOCs, Viref, Fuente Académica Plus, ERA. Sello de calidad en la cuarta convocatoria de evaluación de la calidad editorial y científica de las revistas científicas Españolas, FECYT 2013. Los artículos de la revista CCD son valorados positivamente por la ANECA para la evaluación del profesorado (ANEP/FECYT [A]).

The abstracts published in Cultura, Ciencia y Deporte are included in the following databases: ISI Web of Science, SCOPUS, EBSCO, IN-RECS, DICE, LATINDEX, REDALYC, DIALNET, RESH, COMPLUDOC, RECOLECTA, CEDUS, REDINET, SPORTDISCUS, MIAR, PSICODOC, CIRC, DOAJ, ISOC, DULCINEA, SCIRUS, WORLDCAT, LILACS, GTBib, RESEARCH GATE, SAFETYLIT, REBIUN, Universal Impact Factor, Genamics, Index Copernicus, e-Revistas, Cabell's Directory. Scientific Journal Impact Factor, ERIH PLUS, DLP, JOURNALS FOR FREE, BVS, PRESCOPUS RUSSIA, JournalTOCs, Viref, Fuente Académica Plus, ERA. Seal of quality in the fourth call for evaluation of scientific and editorial quality of Spanish scientific journals, FECYT 2013. Articles from this journal are positively evaluated by the ANECA in the evaluation of Spanish professors (ANEP/FECYT [A]).

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Publicación periódica trimestral de la Facultad de Deporte de la Universidad Católica de San Antonio de Murcia

Periodical published three times per year by the Faculty of Sport at the Catholic University San Antonio of Murcia

ENTIDAD EDITORA • PUBLISHING ORGANIZATION
Universidad Católica San Antonio
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Campus de los Jerónimos s/n. 30107 Guadalupe (Murcia). España
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DEPÓSITO LEGAL • LEGAL DEPOSIT
MU-2145-2004
ISSN
1696-5043
ISSN DIGITAL • DIGITAL ISSN
1989-7413
DOI
10.12800/ccd
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Gender equality in sports science research

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Gender equality in sports science research

"Gender equality is not only a fundamental human right, it is one of the essential foundations for building a peaceful, prosperous and sustainable world. So begins the declaration of Sustainable Development Goal 5 of the United Nations (UN).

Fortunately, the presence of women in all areas of society is becoming more and more noticeable. However, the latest UNESCO report highlights gender inequalities in universities and research organisations, finding gender to be a variable that influences entry, tenure and success within a scientific community. Only 33% of research staff worldwide are women, receiving less research funding and being less likely to be promoted, according to UN-Women. In this sense, the Spanish Foundation for Science and Technology (FECYT) in its gender equality plan (2021-2025) promotes the promotion of the gender perspective in science and innovation.

Since the founding of the journal Cultura, Ciencia y Deporte (CCD), the search for equity and equality has been present, with the Catholic University San Antonio of Murcia (UCAM) being a benchmark among Spanish universities in terms of positions of maximum responsibility held by women, starting with its Rector Magnificent Josefina García Lozano, and its vice-rectors for Research, María Estrella Núñez Delicado, and for Virtual Teaching, María Belén López Ayuso, as well as several deans, vice-deans and directors of different university bodies. In this sense, and in line with the values of the institution, editorial decisions have been taken in the interests of equality and in the search for excellence, and this is the basis for the changes that have taken place.

This is the first issue of a new era in the journal Cultura, Ciencia y Deporte, where we are pleased to announce that FECYT has recently awarded the journal Cultura Ciencia y Deporte the Mention of good editorial practices in gender equality. In addition, the editorial team of the journal has been renewed, with both the editor-in-chief and the editors of the journal now being women who have received numerous awards and have scientific experience. Not in vain, on the occasion of the celebration of the International Day of Women and Girls in Science created by the United Nations General Assembly in 2015, whose objective is to achieve greater participation and inclusion of women and girls in the world of science and technology, the Association of Women Scientists of the Region of Murcia (Lyceum of Science) annually awards the Young Women Scientists of the Region of Murcia Awards, with the aim of raising awareness and promoting the scientific vocation of girls, and to recognise deservedly deserved women scientists. Dr. Noelia González Gálvez (awarded by the Sports Area in 2021) and Dr. María de la Trinidad Morales Belando (awarded for the Area of Social Sciences in 2022), two of the professors who are part of the Faculty of Sport of the UCAM and whose research was awarded in two consecutive years for being valued by the highest level committee in their area, representing for them a personal and professional recognition; and a pride for the institution, will be from now on the editors of this journal.

The change within the journal Cultura, Ciencia y Deporte is received with excitement and enthusiasm. On the verge of coming of age and after its long and successful trajectory, we hope that this issue will be the first of many in the new structuring of the editorial team. We cannot end without expressing our utmost admiration, recognition and homage to the founders of the journal: Prof. Dr. Antonio Sánchez Pato and Prof. Juan de Dios Bada Jaime, for the hard and constant work carried out up to now, which has brought this journal to the level of excellence at which it is now. As well as the editorial team that has worked and continues to do so in order to contribute to quality scientific dissemination.

Finally, we would like to coin one of Margarita Salas' most famous phrases in the form of a wish: "Women will occupy the position in the scientific world that corresponds to their capacity, and we will not need quotas or anything like that".

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La igualdad de género en la investigación en ciencias del deporte

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La igualdad de género en la investigación en ciencias del deporte

"La igualdad de género no solo es un derecho humano fundamental, sino que es uno de los fundamentos esenciales para construir un mundo pacífico, próspero y sostenible". Así da comienzo la declaración del objetivo 5 de desarrollo sostenible de la Organización de las Naciones Unidas (ONU).

Afortunadamente, la presencia de la mujer en todos los ámbitos sociales es cada vez más notable. Sin embargo, el último informe de la UNESCO pone de manifiesto las desigualdades de género en las universidades y organizaciones de investigación, encontrando el género como una variable que influye en el ingreso, permanencia y éxito dentro de una comunidad científica. Sólo el 33% del personal de investigación en todo el mundo está compuesto por mujeres, recibiendo menos fondos para investigación y presentando menos probabilidades de lograr un ascenso según ONU-Mujeres. En este sentido, la Fundación Española para la Ciencia y Tecnología (FECYT) en su plan de igualdad de género (2021-2025) promueve impulsar la perspectiva de género en ciencia e innovación.

Desde la fundación de la revista Cultura, Ciencia y Deporte (CCD) se ha tenido presente la búsqueda de la equidad e igualdad, siendo la Universidad Católica San Antonio de Murcia (UCAM) un referente de las universidades españolas en cuanto a cargos de máxima responsabilidad ocupados por mujeres, empezando por su Rectora Magnífica Josefina García Lozano, y sus vicerrectoras de Investigación, María Estrella Núñez Delicado, y de Enseñanza Virtual, María Belén López Ayuso, amén de varias decenas, vicedecanas y directoras de distintos órganos de la universidad. En este sentido y siguiendo los valores de la institución, las decisiones editoriales han respondido en aras de la igualdad y en búsqueda de la excelencia, y en ello se conciben los cambios plasmados.

Se presenta aquí el primer número de una nueva era en la Revista Cultura, Ciencia y Deporte, donde tenemos el placer de comunicar la que FECYT ha concedido recientemente a la revista Cultura Ciencia y Deporte la Mención de buenas prácticas editoriales en igualdad de género. Además, se ha producido en el equipo editorial de la Revista una renovación del mismo, siendo en la actualidad tanto la editora jefa como las editoras de la misma mujeres ampliamente galardonadas y con experiencia científica. No en vano, con motivo de la celebración del Día Internacional de la Mujer y la Niña en la Ciencia creado por la Asamblea General de las Naciones Unidas en 2015, cuyo objetivo es lograr una mayor participación e inclusión de las mujeres y las niñas en el mundo de la ciencia y la tecnología, la Asociación de Mujeres Científicas de la Región de Murcia (Lyceum de Ciencia) concede anualmente los Premios a Jóvenes Científicas de la Región de Murcia, con el objetivo de concienciar y promover la vocación científica de las niñas, y para reconocer a las mujeres científicas merecidamente. La Dra. Noelia González Gálvez (premiada por el Área de Deportes en año 2021) y la Dra. María de la Trinidad Morales Belando (premiada por el Área de Ciencias Sociales en el año 2022), dos de las profesoras que forman parte del claustro de la Facultad del Deporte de la UCAM y cuyas investigaciones fueron premiadas en dos años consecutivos por ser valoradas por el comité de mayor nivel en su área, suponiendo para ellas un reconocimiento personal y profesional; y un orgullo para la institución, serán a partir de ahora las editoras de esta revista.

Se recibe con emoción e ilusión el cambio dentro de la revista Cultura, Ciencia y Deporte. A punto de cumplir su mayoría de edad y tras su larga exitosa trayectoria, esperamos que el presente número sea el primero de muchos de la nueva estructuración del equipo editorial. No podemos finalizar sin mostrar la máxima admiración, reconocimiento y homenaje a los fundadores de la revista: Prof. Dr. Antonio Sánchez Pato y Prof. Juan de Dios Bada Jaime, por el arduo y constante trabajo realizado hasta el momento que ha llevado a esta revista al nivel de excelencia en el que se encuentra. Así como al equipo editorial que ha trabajado y lo sigue haciendo para contribuir con una difusión científica de calidad.

Para finalizar, acuñamos una de las frases más célebres de Margarita Salas en forma de deseo "La mujer ocupará en el mundo científico el puesto que le corresponda de acuerdo con su capacidad, y no necesitaremos cuotas ni nada de eso".

Return-to-play process after injuries in the hamstring region in soccer players: A systematic review

Proceso de vuelta a la competición en lesiones de la región isquiosural en el futbolista: Una revisión sistemática

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Short title:
Return-to-play process after hamstring injury in soccer

How to cite this article:
Pajuelo, A., Bazan, E., & Caparrós, T. (2022). Return-to-play process after injuries in the hamstring region in soccer players: A systematic review. *Cultura, Ciencia y Deporte, 17*(53), 5-19. https://doi.org/10.12800/ccd.v17i53.1813

Received: 30 september 2021 / Accepted: 16 may 2022

Abstract

Injuries to the ischiosural musculature account for 12% of all injuries to soccer players. The aim of this systematic review is to present the current methodology used during the rehabilitation process in soccer players with respect to injuries to the ischiosural region. For this purpose, a search was carried out using Google Scholar, Pubmed and Sportdiscus platforms including a time frame from 2011 to May 2021. Inclusion criteria included soccer players, in addition to including only studies with intervention. An analysis of 7 studies was carried out, in which it has been possible to observe how a multifactorial approach, acting on coadjuvant components and with the aim of improving the return to play process, offers greater efficacy in the return to competition. During the rehabilitation process it is necessary to identify synergies in sport-specific movement patterns in order to offer the player an optimal recovery.

Keywords: Return to play, multifactorial, coadjuvant, synergies.

Resumen

Las lesiones de la musculatura isquiosural engloban el 12% de las lesiones totales del futbolista, El objetivo de la presente revisión sistemática es exponer la metodología actual durante el proceso de rehabilitación en futbolistas respecto a la lesión de la región isquiosural. Para ello, se ha realizado una búsqueda mediante las plataformas Google Scholar, Pubmed y Sportdiscus incluyendo una franja temporal desde el 2011 hasta mayo de 2021. Los criterios de inclusión incluían jugadores de fútbol, además de incluir solo estudios con intervención. Se realizó un análisis de 7 estudios, en los que se ha podido observar cómo un enfoque multifactorial, actuando sobre componentes coadyuvantes y con el fin de mejorar el proceso de return to play ofrece mayor eficacia en la vuelta a la competición. Durante el proceso de rehabilitación es necesario identificar las sinergias en los patrones de movimiento específicos del deporte, con el fin de ofrecer al jugador una óptima recuperación.

Palabras clave: vuelta a la competición, multifactorial, coadyuvante, sinergias.

Introduction

In high-performance men's soccer, approximately 9 injuries occur in every 1000 hours of exposure, taking training and competition into account (Cos et al., 2010). Of these injuries, 90% affect the hamstring area, adductors, quadriceps, and gastrocnemius (Ekstrand et al., 2012); although within this subtype we must bear in mind that injury to the hamstring area, comprising the biceps femoris, semi-membranosus, and semitendinosus (Mason et al., 2012), is the most common, accounting for 12% of all injuries (Ekstrand et al., 2016a). The rate of injuries in male professional soccer players, in turn, has increased substantially since 2001, averaging an annual increase of 2.3% and a total of 4.1% over the following 13 years (Ekstrand et al., 2016b).

The mechanism of injury is defined mainly by two specific actions. The first arises during high-speed running and may include the long head of the biceps femoris, and the second can occur in movements involving an extensive lengthening of the region (kicking a ball), a situation that could involve the proximal tendon of the semimembranosus (Brukner, 2015). As risk factors, the literature reports that elements such as instability of the joint, lack of muscle strength, asymmetry of force or amplitude of movement between the two legs, an excess of tension in the reported area, psychological issues such as anxiety, unsuitable mechanical postures, the athlete's level of training, field conditions, level of competition, position on the field, and finally having had a previous injury in the same area, as well as inadequate rehabilitation of the affected area may be potential predisposing factors for suffering an injury (Dvorak & Junge, 2000).

In 44% of cases relapse of muscle injuries involves the same mechanism of injury and location as the previous injury, showing that a third of moderate or severe injuries occur less than two months after a lesser injury (Dvorak & Junge, 2000). With regard to the hamstring area, relapse rates are between 12% and 41% and as the above-mentioned authors show, the relapse is usually more severe than the initial injury (Visser et al., 2012), normally involving biceps femoris injuries (Brukner, 2015). These data could indicate that traditional rehabilitation treatments, based on unidirectional methodologies and analytical contents of rehabilitation, are not sufficiently effective, in contrast to current multifactorial and complex proposals (Mendiguchía et al., 2012).

In this context, the objective of this systematic review is to define the current methodology for the rehabilitation process in soccer players with regard to injury in the hamstring region.

Methodology and procedure

Sources of information

We carried out a bibliographical search in the period from 2011 to 2021, ending in May 2021. The databases used in the review were PubMed, Google Scholar, and SPORTDiscus.

Search strategy

We searched title, abstract, and keyword fields in each of the databases used, with the following search terms: in PubMed, we used Rehabilitation AND Hamstring injury AND male soccer. In the Google Scholar search, we used Rehabilitation AND male football player reconditioning NOT prevention, as well as using "Hamstring injuries" as words implicit in the title. Finally, regarding the search in SPORTDiscus, we used Rehabilitation OR treatment AND hamstring injury AND soccer.

Eligibility criteria

The eligibility criteria for the review were to use studies that included an intervention, with subjects in an age range between adolescence and adulthood, related only to male soccer. Finally, the languages included in the criteria were Spanish, Catalan and English. We excluded interventions based on prevention of injuries, uncontrolled trials, studies that used auxiliary elements, letters to the editor, conference summaries, books, and reviews. The methodological quality was rated according to the SIGN criteria (Müller-Riemenschneider et al., 2008).

No study was excluded on grounds of methodological quality.

Data extraction and study selection process

The records were exported to an electronic database with bibliographic reference management software (Mendeley Desktop, 1.19.4, Mendeley Ltd., 2008–2019) in which duplicate references were eliminated. A total of 3 researchers carried out the review process, which was done in 3 stages. In a first stage, the authors examined the titles, abstracts, and keywords of the relevant studies. In the second step, full-text articles were examined, the exclusion criteria were applied to exclude studies not related to the research, and then a full review of texts was conducted to definitively exclude studies that did not conform to the selected criteria or were not related to the objective of the study. In the third phase, we looked for additional articles in the reference lists of the articles included and of review articles on the rehabilitation process in soccer players with respect to injury in the hamstring region. Two articles were included. Any disagreement was discussed until a consensus was reached.

A protocol was developed for extracting data from the articles. Information related to (1) authors, (2) sample, (3) intervention, and (4) results was extracted.

Synthesis of the results

The texts were reviewed in search of the main study variables, such as: type of protocol used during rehabilitation, type of training used during the protocol, days of periodization, and recovery time.

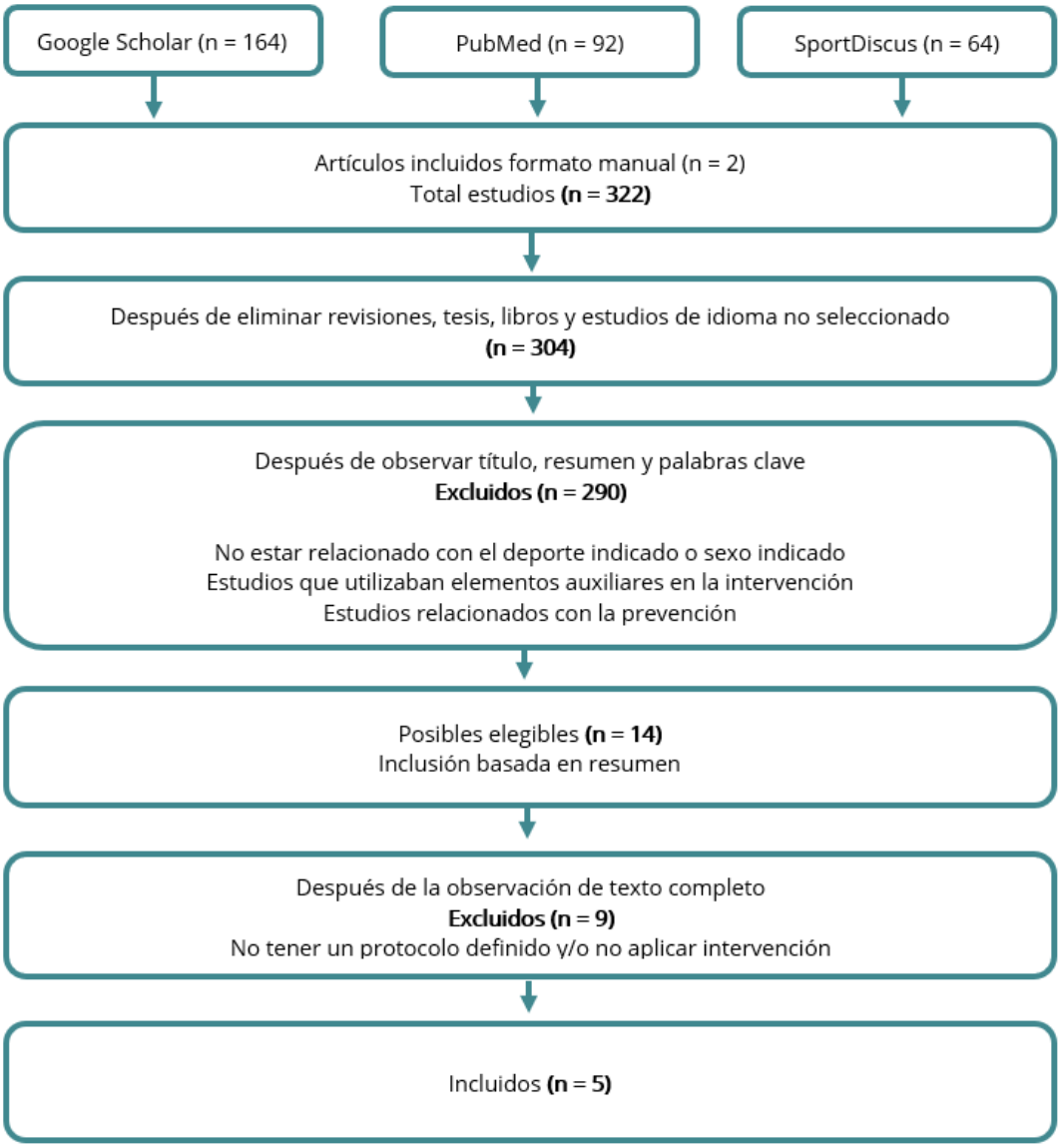
The measures and parameters derived from the variables presented were considered their main result.

Results

Study selection

The search we carried out reported a total of 322 results, and 2 articles identified in the bibliography were included manually; after elimination of duplicates, previous reviews, theses and books, the search was reduced to 304 results. Subsequently, review of the titles, abstracts and keywords used eliminated a total of 290 studies, and we obtained a total of 14 studies as possibly eligible. During screening of the full texts, 9 articles were excluded, leaving a total of 5 studies in the final selection (Figure 1).

Figure 1. Flow diagram in relation to the search



Participants

The search was conducted in studies related to the male sex, although in one of the studies the female sex was included (Askling et al., 2013). As regards sports, five selected studies used soccer players in their intervention. The athletes in the studies analyzed were aged between 13 years and adulthood.

Characteristics of the studies

The types of interventions performed were randomized in four cases; one study was not randomized. According to SIGN criteria, most of the studies were of low quality (N = 3); only 2 were of moderate quality. The low-quality rating was due in most cases to small sample size, inadequate duration of the study or possible selection and information bias.

Reported results

In relation to the type of training, the results of three of the studies used working methodologies based on a multifactorial approach, including different manifestations of movement (Jiménez-Rubio et al., 2020b; Tol et al., 2014; Mendiguchía et al., 2017), although in other studies an analytic approach was found, directly solely at the area of the injury (Askling et al., 2013; Silder et al., 2013). However, regardless of the type of approach, all show positive results in relation to return to play (RTP) and the reduction of asymmetries (Table 1).

Table 1. Variables analyzed in the selected studies

Authors	Sample	Intervention	Results	QUALITY
Silder et al. (2013)	24 subjects 24 ± 9	1. Progressive agility and trunk stabilization work 2. Progressive running work and exercises with eccentric emphasis 5 sessions/week in 3 phases	No significant differences between the two protocols used ($P > .05$)	LOW
Askling et al. (2013)	75 subjects L: 25 ± 5 C: 25 ± 6	**Protocol L:** Emphasis on eccentric actions **Protocol C:** Traditional exercises without emphasis on the eccentric component **PROTOCOL** 1. Increase in flexibility 2. Strength + trunk stabilization 3. Specific strength exercise 5 sessions/week and 1 phase	Positive correlations were found in relation to days of recovery and protocol L ($P > .001$)	LOW
Tol et al. (2014)	52 subjects 24.9 (range: 18-38)	Program consisting of exercises for range of motion amplitude, central stabilization, progressive strengthening and agility + Specific program made up of specific actions simulating muscle fatigue 6 phases	Reduction of asymmetry in relation to peak force in an isokinetic machine in different manifestations of force until reaching <10%	MODERATE
Mendiguchía et al. (2017)	48 subjects RP: 22.9 ± 6.0 RA: 24 ± 4.4	**RP:** Protocol of emphasis on eccentric actions + general rehabilitation program + progressive running program **RA:** Modified Mendiguchía and Bruguelli (2011) protocol including manual therapy, flexibility, hamstring strength, gluteal strength, plyometrics, ankle stabilization, lumbopelvic control and running technique. **RP:** 4 sessions/week **RA:** minimum of 3 sessions/week 3 phases	Significant differences in maximum power, maximum speed, V0 and time at 10 m (s) (90% *CI*)	MODERATE
Jiménez-Rubio et al. (2020b)	19 subjects 24.3 ± 5.36	**I:** Controlled knee and hip mobilizations →Controlled movements in the frontal and sagittal planes increasing speed→Unipedal strength work and motor actions involving posterior chain activation **O (from AE to ANAE):** Re-education of ACC+DECC patterns→Motor control of lower limbs and CORE → Repeated sprint work → Tactical rehabilitation Average range (16 to 26 days) 2 phases	Significant differences ($P > .001$) with moderate improvements were identified in variables such as maximum sprint speed and distance; on the other hand, small improvements were found in variables such as mean speed, distance at very high intensity and distance at high intensity.	LOW

RP: Rehabilitation protocol, RA: Rehabilitation algorithm, I: Indoor, O: Outdoor, AE: Aerobic, ANAE: Anaerobic

Discussion

The most important finding of this systematic review is that methodologies of a multifactorial nature, acting on contributory components with the aim of improving the return-to-play process, offer greater effectiveness for this purpose that those of an analytic nature. Current methodologies for rehabilitation of injuries in the hamstring area show two types of approach (unidirectional and multidirectional), and they are defined in turn according to their proposal for treatment when confronted with this injury. While the unidirectional approach is based on rehabilitation of the muscles in question, the multidirectional approach is based on rehabilitation of the movement as a whole, taking into account the synergy of those muscles with the adjacent muscles and their relationship during movement in sport.

We can see how both an analytic approach (Askling et al., 2013; Silder et al., 2013), and a multifactorial approach (Jiménez-Rubio et al., 2020b; Tol et al., 2014; Mendiguchía et al., 2017) produce improvements in recovery treatment, although when the two types of treatment are compared, significant improvements are observed in relation to possible relapses, as well improving performance in sprinting and mechanical properties (Mendiguchía et al., 2017). These benefits provided by the multidirectional model, involving a synergistic interaction of all parts, can be exemplified by situations such as those that occur when reduced activation of the gluteus produces more tension in the hamstring area, or the way in which lumbopelvic control affects the ability to extend/flex the knee and hip, or even discovering the relationship between excessive neural tension and how this can affect horizontal force production (Mendiguchia et al., 2012). This multidisciplinary approach could help physiotherapists and fitness coaches during the

processes and times of injury prevention and rehabilitation of those muscles (Lahti et al., 2020).

Phases of recovery and criteria of progress

With regard to phases of recovery, there is a relationship between the number of phases and the type of approach to the rehabilitation of that injury, since in unidirectional approaches the number of phases is lower (1 phase) (Askling et al., 2013), whereas in multifactorial approaches a higher number of phases is established (Mendiguchía et al., 2017; Tol et al., 2014). The 3-phase method (acute, regeneration and functional phases) of Mendiguchía et al. (2017) shows features in common with the proposal presented by Caparrós et al. (2017), which follows progressive patterns in relation to the type of kinetic chain (from closed to open), type of contraction (isometric-concentric-eccentric), extent of work (internal-medial, external-total, and total) and orientation of content (general, directed, and specific).

In connection with this, while the unidirectional protocols showed their emphasis on the target muscles (Askling et al., 2013; Silder et al., 2013) through flexibility and strength exercises, the multifactorial protocols focused not only on these target muscles, but on the use of manual therapy, improving the flexibility of hip extensors and flexors, strength of the hamstring group, exercises for the gluteal area, plyometric work, lumbopelvic control, ankle stabilization, and running technique in the frontal and sagittal planes (Mendiguchía et al., 2017), as well as adding actions specific to the sport itself (Tol et. al., 2014) and the reeducation of biomechanical postural patterns (Jiménez-Rubio et. al., 2018).

The objectives for each phase will be different (Mendiguchia & Brughelli, 2011), showing how in phase 1 they will be aimed at preventing excessive inflammation, increasing tissue elasticity, reducing interstitial fluid accumulation, and identifying and treating lumbopelvic dysfunctions. With respect to phase 2, the approach will be directed more at reducing pain during muscle actions by improving muscle strength and symmetry, as well as improving the flexibility of the chain flexors and extensors, providing better neuromuscular control. In phase 3, we should supplement the previous objectives with improvement of horizontal force production while running and improving torsional capacities. Finally, in a higher phase (Tol et al., 2014), the objectives would be to guide players toward their return to play through technical and tactical actions conditionally similar to the sport in question, evolving from an aerobic toward an anaerobic context (Jiménez-Rubio et al., 2020b). There are discrepancies between authors on the criteria of progress to be followed.

Mendiguchía et al. (2017) focus on reducing leg asymmetries through strength and/or flexibility exercises (between 20% and 5%), while Tol et al. (2014) aim their proposal at improving the range of motion of the affected leg and managing the sensations of pain when performing the proposed exercises. This last point has been analyzed by Hickey et al. (2015), who adopts a controversial stance on doing exercises without pain, indicating that tolerating up to 4 or less out of 10, on a numerical pain rating scale (NPRS), does not provide a reduction in RTP time, but does show greater recovery of isometric strength and better maintenance of the length of the fascicles in the area.

Type of muscle stimuli to be applied during treatment

The main objective of the initial phase of treatment is to prevent excessive inflammation, and early mobilization of the area by the physiotherapy staff is important (Mendiguchía et al., 2017), with the objective of promoting proper alignment and regeneration of the myofibrils (Mendiguchía & Brughelli, 2011) as well as sacroiliac mobilization and the use of auxiliary elements that may help to prevent excessive inflammation, such as cryotherapy and/or non-steroidal anti-inflammatory drugs (NSAIDs), although the use of the latter is controversial in the literature because of their possible harmful effects on muscle repair (Mendiguchía & Brughelli, 2011), inhibition of angiogenesis and revascularization, delaying of neutrophil and macrophage infiltration, and increase in immature myofibrils, issues that could lead to impairment of tissue repair and excessive synthesis of collagen (Dubois & Esculier, 2020).

Subsequently, in a phase oriented toward regeneration, as well as initiating stimulation of flexibility for chain extensors and flexors, work is also done on the antagonist muscles (Tol et al., 2014) with the aim of not losing functionality. Furthermore, in this phase we can begin the task of isometric stimulation of the target muscles (Mendiguchía & Brughelli, 2011), evolving toward concentric stimulation and then toward eccentric contractions, although it is of interest to prioritize the eccentric emphasis over the concentric during the recovery process (Arnason et al., 2013), given that the former reported a lower percentage of recurrence than the concentric group. This phase must be supplemented by nerve release exercises, since traction or compression forces may compress the nerve tissue, thereby making this one of the risk factors in hamstring injury (Mendiguchía & Brughelli, 2011). It could be interesting to introduce stimulation of horizontal force production in this phase, by activating the gluteus, with the aim of reducing demand on the hamstrings during hip extension in the sprint mechanism (Mendiguchía & Brughelli, 2011). At the same time, exercises oriented toward biomechanical re-education of sports actions can be added, by introducing running technique exercises (Mendiguchía et al., 2017), in which hip extension will be the predominant movement (Jiménez-Rubio et al., 2020b), as well as initiating actions in a sagittal plane in a controlled manner (Jiménez-Rubio et al., 2018), with the object of offering players a return to their sports discipline through the safest and most effective possible rehabilitation process (Mendiguchía et al., 2017).

When we enter the functional phase (Mendiguchía et al., 2017), we need to distinguish dominant hip or knee exercises with the object of stimulating different muscle bellies, depending on the location of the injury and the mechanism of injury (Mendiguchía et al., 2017). Coupled with this factor, introducing rotational exercises seems indicated, given that good stabilization levels will be required in specific actions such as changes of direction, kicking or high-speed running (Mendiguchía & Brughelli, 2011), to help perform these actions correctly; Jiménez-Rubio et al. (2018) propose using asymmetric exercises. During this phase, deficits in horizontal force production could involve a risk of relapse during the running support phase. A type of training to be included in this phase would be plyometrics (Mendiguchía et al., 2017), with the object of resolving neuromuscular deficiencies and being able to prepare the musculoskeletal system for the demands imposed during sports practice (Chmielewski et al., 2006). A means of doing so would be to gradually increase speed in lateral movements as well as using exercises involving pushing sledges (Jiménez-Rubio et al., 2018).

Finally, having completed the three stages mentioned above, a specific phase of readjustment to soccer needs to be introduced (Tol et al., 2014) through a progressive program in terms of volume and intensity, in which a retraining of the specific qualities of the sport in question is introduced, also increasing complexity during the process. This can be structured in 13 items (Jiménez-Rubio et

al., 2018), progressively introducing frontal and lateral movement, as well as actions such as receiving and specific motor skills, progressing toward the re-education of specific agility and coordination patterns. Finally, an evolution from an aerobic to an anaerobic context, involving RSA (repeated sprint ability) training, would be aimed at completing the RTP process by performing simulations of specific situations, with an emphasis on decision-making (Jiménez-Rubio et al., 2020a). As a cross-cutting element, aerobic conditioning by running is valuable, as long as the player does not report discomfort or pain during the movement (Mendiguchía et al., 2017), although in previous stages this element could be emphasized through activities that do not produce discomfort or pain (Tol et al., 2014).

Limitations of the study

The main limitation of the study was the small number of studies that applied an intervention process and used a control group, since in the documents we found, the predominant type of study was descriptive, without intervention, a factor that impeded analysis of the benefit of these protocols for the injury studied. In addition, the selection of these sources of information possibly restricted access to important unidentified information.

Conclusions

The multifactorial approach in relation to the treatment of hamstring injuries and the return-to-play process shows more benefits than a protocol with a unidirectional component. During this process, it is important to recognize synergies in the specific patterns of movement of the sport in question, seeking to offer the player a safe and effective recovery, with the object of combating the possible future risk factors and preventing relapses. Elements such as including lumbopelvic control training, running technique, training of the gluteal area or plyometrics show benefits in the RTP process in hamstring injuries. Furthermore, knowledge of the affected area and its mechanism of injury is essential when it comes to applying correct treatment, given the differences in muscle activation that are present depending on their dominance.

Practical applications

To carry out this process, coordination of all the staff who will take part in it is indispensable, in order to provide and reinforce the multidisciplinary approach during this process and seek the overall recovery of the player. To achieve this, protocolization in the record and more longitudinal studies would enable us to confirm effectiveness with regard to the type of approach in the multidisciplinary rehabilitation process (Mendiguchía et al., 2017).

Funding

The authors have no conflicts of interest to declare and have not received any subsidy from any public or private body.

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Proceso de vuelta a la competición en lesiones de la región isquiosural en el futbolista: Una revisión sistemática

Return-to-play process after injuries in the hamstring region in soccer players: A systematic review

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Título abreviado::
Proceso de vuelta a competición en lesiones de isquiosural en futbol

Cómo citar el artículo::
Pajuelo, A., Bazan, E., & Caparrós, T. (2022). Proceso de vuelta a la competición en lesiones de la región isquiosural en el futbolista: Una revisión sistemática. *Cultura, Ciencia y Deporte, 17*(53), 5-19. https://doi.org/10.12800/ccd.v17i53.1813

Recibido: 30 septiembre 2021 / Aceptado: 16 mayo 2022

Resumen

Las lesiones de la musculatura isquiosural engloban el 12% de las lesiones totales del futbolista, El objetivo de la presente revisión sistemática es exponer la metodología actual durante el proceso de rehabilitación en futbolistas respecto a la lesión de la región isquiosural. Para ello, se ha realizado una búsqueda mediante las plataformas Google Scholar, Pubmed y Sportdiscus incluyendo una franja temporal desde el 2011 hasta mayo de 2021. Los criterios de inclusión incluían jugadores de fútbol, además de incluir solo estudios con intervención. Se realizó un análisis de 7 estudios, en los que se ha podido observar cómo un enfoque multifactorial, actuando sobre componentes coadyuvantes y con el fin de mejorar el proceso de return to play ofrece mayor eficacia en la vuelta a la competición. Durante el proceso de rehabilitación es necesario identificar las sinergias en los patrones de movimiento específicos del deporte, con el fin de ofrecer al jugador una óptima recuperación.

Palabras clave: vuelta a la competición, multifactorial, coadyuvante, sinergias.

Abstract

InInjuries to the ischiosural musculature account for 12% of all injuries to soccer players. The aim of this systematic review is to present the current methodology used during the rehabilitation process in soccer players with respect to injuries to the ischiosural region. For this purpose, a search was carried out using Google Scholar, Pubmed and Sportdiscus platforms including a time frame from 2011 to May 2021. Inclusion criteria included soccer players, in addition to including only studies with intervention. An analysis of 7 studies was carried out, in which it has been possible to observe how a multifactorial approach, acting on coadjuvant components and with the aim of improving the return to play process, offers greater efficacy in the return to competition. During the rehabilitation process it is necessary to identify synergies in sport-specific movement patterns in order to offer the player an optimal recovery.

Keywords: Return to play, multifactorial, coadjuvant, synergies.

Introducción

En el futbol de alto rendimiento masculino, ocurren aproximadamente 9 lesiones cada 1000 horas de exposición, teniendo en cuenta entrenamientos y competición (Cos et al., 2010). De estas, un 90% de las lesiones afectan a la zona isquiosural, aductores, cuádriceps y gastrocnemios (Ekstrand et al., 2012); aunque dentro de este subtipo, debemos tener en cuenta que la lesión de la zona isquiosural, la cual engloba las lesiones sufridas en bíceps femoral, semimembranoso y semitendinoso (Mason et al., 2012) es la más común, representando el 12% de las lesiones totales (Ekstrand et al., 2016a). A su vez, la tasa de lesiones en jugadores profesionales de fútbol masculino ha aumentado substancialmente desde 2001, promediando un aumento anual de 2,3% y un total de 4,1% durante los siguientes 13 años (Ekstrand et al., 2016b).

El mecanismo lesional viene definido principalmente por dos gestos específicos. El primero es durante la carrera a alta velocidad, la cual puede incluir la cabeza larga del bíceps y la segunda se puede producir en movimientos que impliquen un alargamiento extenso de la región (golpear un balón), aspecto que podría implicar el tendón proximal del semimembranoso (Brukner, 2015). Como los factores de riesgo, la literatura reporta que aspectos como la inestabilidad de la articulación, la falta de fuerza muscular, asimetría de fuerza o amplitud de movimiento entre las dos piernas, un exceso de tensión en la zona reportada, aspectos psicológicos como la ansiedad, posturas mecánicas no adecuadas, el nivel de formación del deportista, las condiciones del campo, el nivel de competición, la posición en el campo y por último haber tenido una lesión anterior en la misma zona además de una inadecuada rehabilitación de la zona afectada, pueden ser factores potenciales que predispongan a sufrir una lesión (Dvorak & Junge, 2000).

Un 44% de recaídas respecto a lesiones musculares presentan el mismo mecanismo de lesión y localización que la lesión anterior, mostrando que un tercio de las lesiones moderadas o severas se producen antes de los dos meses después de una lesión menor (Dvorak & Junge, 2000). Respecto a la zona isquiosural, los ratios de recaída se mueven entre un 12 y un 41% y tal como muestran los autores anteriores la recaída suele ser más severa que la primera lesión (Visser et al., 2012) normalmente envolviendo a las lesiones de bíceps femoral (Brukner, 2015). Estos datos podrían ser indicativos de que los tratamientos tradicionales de rehabilitación, basados en metodologías unidireccional y contenidos analíticos de rehabilitación, no son suficientemente efectivos, en contraposición a propuestas multifactoriales y complejas actuales (Mendiguchia et al., 2012).

En este contexto, el objetivo de esta revisión sistemática es definir la metodología actual para el proceso de rehabilitación en futbolistas respecto a la lesión de la región isquiosural.

Metodología y procedimiento

Fuentes de información

Se realizó una búsqueda bibliográfica en el período comprendido entre 2011-2021 que finalizó en mayo de 2021, las bases de datos utilizadas en la revisión han sido PubMed, Google Scholar y SportDiscus.

Estrategia de búsqueda

Se buscaron campos de título, resumen y palabras clave en cada una de las bases de datos utilizadas, utilizando los siguientes términos: En PubMed, se utilizaron Rehabilitation AND Hamstring injury AND male soccer. En la búsqueda realizada en Google Scholar, se utilizó Rehabilitation AND male football player reconditioning NOT prevention además de utilizar como palabras implícitas en el título "Hamstring injuries". Por último, en relación con la búsqueda en SportDiscus, se utilizaron Rehabilitation OR treatment AND hamstring injury AND soccer.

Criterios de eligibilidad

Los criterios de elegibilidad de la revisión fueron utilizar estudios que incluyan una intervención, que utilizasen sujetos entre un rango de edad comprendida entre la adolescencia y edad adulta, solo relacionados con el futbol masculino. Por último, el lenguaje incluido en los criterios fue castellano, catalán e inglés. Se excluyeron las intervenciones basadas en la prevención de lesiones, los ensayos no controlados, estudios que usaron elementos auxiliares, las cartas al editor, los resúmenes de congresos, los libros y las revisiones. La calidad metodológica se calificó según los criterios de SIGN (Müller-Riemenschneider et al., 2008). No se excluyó ningún estudio por su calidad metodológica.

Proceso de extracción de datos y selección de estudios

Los registros se exportaron a una base de datos electrónica con un software de referencias bibliográficas (Mendeley Desktop, 1.19.4, Mendeley Ltd., 2008-2019) en el cual se eliminaron las referencias duplicadas. Un total de 3 investigadores llevaron a cabo el proceso de revisión, que se realizó en 3 etapas. En una primera etapa, los autores examinaron los títulos, los resúmenes y las palabras clave de los estudios pertinentes. En el segundo paso, se examinaron los artículos de texto completo, se aplicaron los criterios de exclusión para excluir los estudios no relacionados con la investigación y seguidamente se realizó una revisión de textos completa para seguidamente excluir definitivamente los estudios que no seguían con los criterios seleccionados o no tenían relación con el objetivo del estudio. En el tercer paso, se buscaron artículos adicionales en las listas de referencias de los artículos incluidos y de los artículos de revisión sobre el proceso de rehabilitación en futbolistas respecto a la lesión de la región isquiosural. Se incluyeron dos artículos. Cualquier desacuerdo se discutió hasta que se alcanzó el consenso.

Se elaboró un protocolo para la extracción de datos de los artículos. Se extrajo información relacionada con (1) autorías, (2) muestra, (3) intervención, (4) resultados.

Síntesis de los resultados

La revisión de los textos fue en busca de las variables principales del estudio como son: Tipo de protocolo utilizado durante la readaptación, tipo de entrenamiento utilizado durante el protocolo, días de periodización y tiempo de recuperación. Las medidas y parámetros derivados de las variables expuestas fueron consideradas el resultado principal de estos.

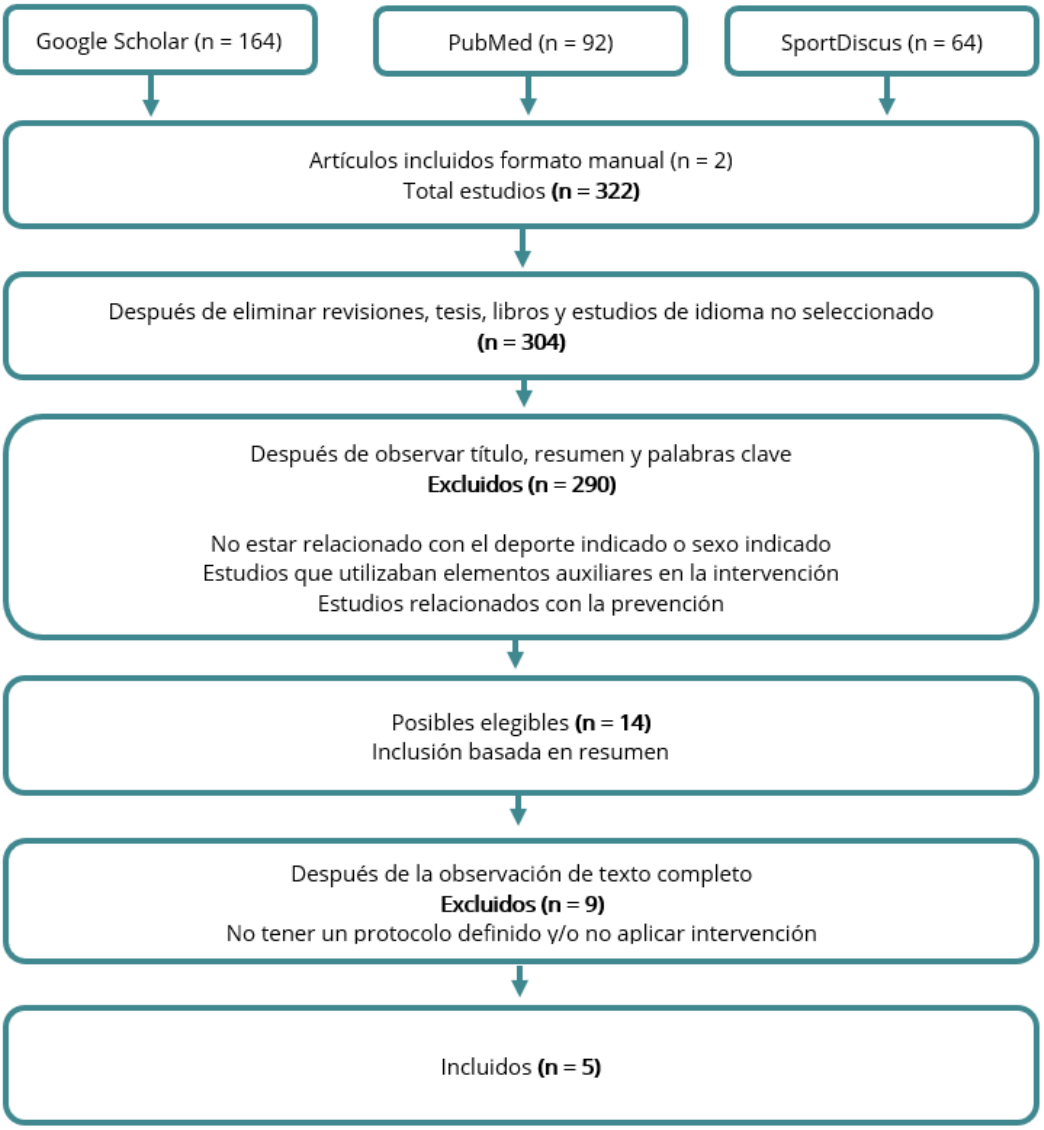
Resultados

Selección de estudios

La búsqueda realizada reportó un total de 322 resultados, se incluyeron 2 artículos de forma manual identificados en la bibliografía, a partir de la eliminación de duplicados,

anteriores revisiones, tesis y libros; la búsqueda se redujo a 304 resultados. Seguidamente, la revisión del título, resumen y palabras clave utilizadas, se eliminaron un total de 290 estudios, obteniendo un total de 14 estudios como posibles elegibles. Durante la observación del texto completo, se excluyeron 9 artículos, obteniéndose un total de 5 estudios en la selección final (Figura 1).

Figura 1. Diagrama de flujos en relación con la búsqueda



Participantes

La búsqueda fue realizada en estudios relacionados al sexo masculino, aunque en uno de los estudios, se ha producido la inclusión del sexo femenino (Askling et al., 2013). En relación a los deportes, seis estudios seleccionados han utilizado futbolistas en su intervención. Los deportistas de los estudios analizados, se comprendían edades desde los 13 años hasta la edad adulta.

Características de los estudios

El tipo de intervenciones realizadas fueron randomizadas en cuatro casos y un estudio no fue randomizado. Según los criterios de SIGN, la mayoría de los estudios son de baja calidad (N = 3), y solo 2 son de calidad moderada. La calificación de baja calidad se debe en la mayoría de los casos al pequeño tamaño de la muestra, a la duración inadecuada del estudio o al posible sesgo de selec-ción e información

Resultados reportados

En relación con el tipo de entrenamiento, los resultados de tres de los estudios utilizaron metodologías de trabajo fundamentadas en un enfoque multifactorial, incluyendo diferentes manifestaciones del movimiento (Jiménez-Rubio et al., 2020b; Mendiguchia et al., 2017; Tol et al., 2014) aunque en otros estudios se encontró un enfoque analítico dirigido únicamente a la zona de la lesión (Askling et al., 2013; Silder et al., 2013). Ahora bien, independientemente del tipo de enfoque, todos muestran resultados positivos en relación al return to play (del inglés vuelta a la competición, RTP) y en la reducción de asimetrías (Tabla 1).

Tabla 1. Variables analizadas en los estudios seleccionados

Autoría	Muestra	Intervención	Resultados	CALIDAD
Silder et al. (2013)	24 sujetos 24+/-9	1.Trabajo progresivo de agilidad y estabilización del tronco 2.Trabajo progresivo de carrera y ejercicios con énfasis excéntrico 5 sesiones/semana en 3 fases	No hay diferencias significativas entre los dos protocolos utilizados (p > .05)	BAJA
Askling et al. (2013)	75 sujetos L:25+/-5 C:25+/-6	**Protocolo L:** Énfasis en acciones excéntricas **Protocolo C:** Ejercicios tradicionales sin énfasis en componente excéntrico **PROTOCOLO** 1.Aumento flexibilidad 2.Fuerza + estabilización del tronco 3.Ejercicio específico de fuerza 5 sesiones / semana y 1 fase	Se encontraron correlaciones positivas en relación a los días de recuperación y el protocolo L (p > .001)	BAJA
Tol et al. (2014)	52 sujetos 24.9 (rango de 18 a 38)	Programa constituido por ejercicios de amplitud del rango de movimiento, estabilización central, fortalecimiento progresivo y agilidad + Programa específico formado por acciones específicas simulando fatiga muscular 6 fases	Reducción de la asimetría respecto al pico de fuerza en máquina isocinética en diferentes manifestaciones de la fuerza hasta llegar a <10%	MODERADA
Mendiguchía et al. (2017)	48 sujetos RP:22.9+/-6.0 RA:24+/-4.4	**RP:** Protocolo de énfasis en acciones excéntricas + programa general de rehabilitación + programa de carrera progresiva **RA:** Protocolo modificado de Mendiguchía y Bruguelli (2011) incluye terapia manual, flexibilidad, fuerza de isquiosurales, fuerza de glúteos, pliometría, estabilización de tobillo, control lumbopélvico y técnica de carrera. **RP:** 4 sesiones/semana **RA:** mínimo de 3 sesiones/semana 3 fases	Diferencias significativas en Potencia máxima, en máxima velocidad, en V0 y en tiempo a los 10 m (s) (90% *CI*)	MODERADA
Jiménez-Rubio et al. (2020b)	19 sujetos 24.3+/-5.36	**I:** Movilizaciones controladas de rodilla y cadera→Desplazamientos controlados en plano frontal y sagital incrementando velocidad→Trabajos de fuerza unipodales y acciones motrices que involucren activación de cadena posterior **O:(de AE a ANAE):** Reeducación de patrones de ACC+DECC→Control motor de miembros inferiores y CORE → Trabajo de Sprints repetidos → Readaptación táctica Rango promedio (16 a 26 días) 2 fases	Diferencias significativas (p > .001) con mejoras moderadas han sido identificadas en variables como máxima velocidad y distancia a sprint, por otro lado con mejoras pequeñas se encuentran variables como la velocidad media, distancia a muy alta intensidad y distancia a alta intensidad	BAJA

RP: Protocolo de rehabilitación, RA: Algoritmo de rehabilitación,
I: Indoor, O: Outdoor, AE: Aeróbico, ANAE: Anaeróbico

Discusión

El hallazgo más relevante de esta revisión sistemática es que las metodologías de carácter multifactorial, actuando sobre componentes coadyuvantes y con el fin de mejorar el proceso de return to play ofrecen mayor eficacia en la vuelta a la competición que las de carácter analítico. Las metodologías actuales para la rehabilitación de lesiones de la zona isquiosural muestra 2 tipos de enfoque (unidireccional y multidireccional), y a su vez se definen según su propuesta de tratamiento delante de esta lesión. Mientras el enfoque unidireccional, se basa en la readaptación de la musculatura en cuestión, el multidireccional se basa en la readaptación integral del movimiento, teniendo en cuenta la sinergia de dicha musculatura con la musculatura adyacente y su relación durante el movimiento deportivo.

Se puede observar cómo tanto un enfoque analítico (Askling et al., 2013; Silder et al., 2013), cómo un enfoque multifactorial (Jiménez-Rubio et al., 2020b; Mendiguchía et al., 2017; Tol et al., 2014) producen mejoras en el tratamiento de recuperación, aunque en el momento que se comparan los dos tipos de tratamiento se observan mejoras significativas en relación a posibles recaídas, además de mejorar el rendimiento en el sprint y propiedades mecánicas (Mendiguchía et al., 2017). Estos beneficios que aportaría el modelo multidireccional, el cual supone una interacción sinérgica de todas las partes, puede ser ejemplificado con situaciones como las que suceden cuando el tener una disminución de activación del glúteo supone más tensión a la zona isquiosural. O como la afectación del control lumbopélvico a la capacidad de extensión/flexión de la rodilla y cadera, o incluso conocer la relación entre una excesiva tensión neural y cómo

esta puede afectar a la producción de fuerza horizontal (Mendiguchia et al., 2012).

Este enfoque multidisciplinar, podría ayudar a cooperar a fisioterapeutas y preparadores físicos durante los procesos y momentos de prevención y readaptación de dicha musculatura (Lahti et al., 2020).

Fases de recuperación y criterios de progresión

En relación a las fases de recuperación, hay una relación entre el número de fases y el tipo de enfoque en la readaptación de dicha lesión, dado que en enfoques unidireccionales el número de fases es menor (1 fase) (Askling et al., 2013), mientras que en enfoques multifactoriales se establecen un mayor número de fases (Mendiguchía et al., 2017; Tol et al., 2014). El planteamiento de las 3 fases (fase aguda, de regeneración y funcional) de Mendiguchía et al (2017) muestra una relación con la propuesta presentada por Caparros et al. (2017), la cual sigue pautas progresivas en relación al tipo de cadena cinética (de cerrada a abierta), al tipo de contracción (Isométrica-concéntrica-excéntrica), amplitud de trabajo (interna-media, externa-total y total) y a la orientación de contenidos (generales, dirigidos y específicos).

En este sentido, mientras los protocolos unidireccionales mostraban su énfasis en la musculatura diana (Askling et al., 2013; Silder et al., 2013) mediante ejercicios de flexibilidad y fuerza, los protocolos multifactoriales incidían no solo en esta musculatura diana, sino en la utilización de la terapia manual, mejora de la flexibilidad de extensores y flexores de cadera, fuerza del grupo isquiosural, ejercicios para la zona glútea, trabajo pliométrico, control lumbopélvico, estabilización de tobillos y técnica de carrera en planos frontal y sagital (Mendiguchía et al., 2017) además de añadir acciones específicas del propio deporte (Tol et al., 2014) y la reeducación de patrones biomecánicos posturales (Jiménez-Rubio et al., 2018).

Los objetivos para cada fase serán distintos (Mendiguchia & Brughelli, 2011) mostrando como en fase 1, estos irán destinados a la prevención de la inflamación excesiva, aumentar la elasticidad del tejido, reducir el cúmulo de líquido intersticial e identificar y tratar disfunciones lumbo-pélvicas. Respecto a la fase 2, el enfoque irá más destinado a reducir el dolor durante las acciones musculares mejorando la fuerza y simetría muscular, además de mejorar la flexibilidad de los flexores y extensores de cadena, proporcionando una mejora del control neuromuscular. En la fase 3 deberíamos sumar a los objetivos anteriores la mejora de la producción de fuerza horizontal durante la carrera y mejorar las capacidades torsionales. Por último, en una fase superior (Tol et al., 2014) los objetivos serían orientar al jugador hacia su retorno a la competición mediante acciones técnico-tácticas similares condicionalmente al deporte en cuestión, evolucionando de un contexto aeróbico hacia un contexto anaeróbico (Jiménez-Rubio et al., 2020b).

Los criterios de progresión a seguir muestran discrepancias según autores. Mendiguchía et al (2017) focalizan en la disminución de las asimetrías por pierna mediante ejercicios de fuerza y/o flexibilidad (entre un 20% y un 5%), mientras que Tol et al (2014) dirigen su propuesta hacia la mejora del rango de movimiento de la pierna afectada y la gestión de las sensaciones de dolor al realizar los ejercicios planteados. Este último aspecto ha sido analizado por Hickey et al (2015), mostrando controversia en relación a la realización de ejercicios sin dolor, indicando que la tolerancia hasta un 4 o menor sobre 10, en una escala numérica de dolor (NRS); no proporciona una reducción del tiempo en el RTP, pero si muestra una mayor recuperación de la fuerza isométrica y un mejor mantenimiento en la longitud de los fascículos de la zona.

Tipo de estímulos a aplicar durante el proceso

La fase inicial del tratamiento tiene como objetivo principal prevenir la inflamación excesiva, siendo importante por parte del personal fisioterapéutico la movilización temprana de la zona (Mendiguchía et al., 2017), con el objetivo de favorecer a la alineación y regeneración adecuada de las miofibrillas (Mendiguchía & Brughelli, 2011) además de la movilización sacroilíaca y de la utilización de elementos auxiliares que puedan ayudar a prevenir la inflamación excesiva, como pueden ser la crioterapia y/o antiinflamatorios no esteroideos, aunque la utilización de estos últimos se encuentra en controversia en la literatura a causa de sus posibles efectos perjudiciales sobre la reparación muscular (Mendiguchía & Brughelli, 2011), alteración de la angiogénesis y la revascularización, retraso de la infiltración de neutrófilos y macrófagos y aumento las miofibrillas inmaduras, aspectos que podrían llevar a una reparación tisular deteriorada y una síntesis excesiva de colágeno (Dubois & Esculier, 2020).

Posteriormente, en una fase orientada hacia la regeneración, además de iniciar la estimulación de la flexibilidad para extensores y flexores de cadena, también se trabaja la musculatura antagonista (Tol et al., 2014) con el fin de no perder funcionalidad. Además, en esta fase podemos iniciar el trabajo de estimulación isométrica de la musculatura diana (Mendiguchía & Brughelli, 2011) evolucionando hacia una estimulación concéntrica y seguidamente hacia contracciones excéntricas, aunque es interesante recalcar el énfasis excéntrico por encima del concéntrico durante el proceso de recuperación (Arnason et al., 2013), dado que el primero reportó un porcentaje de recaída menor al del grupo concéntrico. A esta fase se deben añadir ejercicios de liberación neural, dado que las fuerzas de tracción o compresión pueden comprimir el tejido neural, provocando así que sea uno de los factores de riesgo en la lesión de isquiosurales (Mendiguchía & Brughelli, 2011). La estimulación de la producción de fuerza horizontal, mediante la activación del glúteo, podría ser interesante de introducir en esta fase con el objetivo de reducir la demanda de los isquiosurales durante la extensión de cadera en el mecanismo del sprint (Mendiguchía & Brughelli, 2011). Simultáneamente, se pueden añadir ejercicios con una orientación hacia la reeducación biomecánica de acciones deportivas, introduciendo ejercicios de técnica de carrera (Mendiguchía et al., 2017) en los cuales la extensión de cadera será el movimiento predominante (Jiménez-Rubio et al., 2020b), además de iniciar acciones en un plano sagital de forma controlada (Jiménez-Rubio et al., 2018) con el objetivo de ofrecer al jugador un retorno a su modalidad deportiva mediante un proceso de rehabilitación lo más seguro y eficaz posible (Mendiguchía et al., 2017).

Al entrar en la fase funcional (Mendiguchía et al., 2017) la diferenciación de ejercicios dominantes de cadera o rodilla es necesaria, con el objetivo de estimular diferentes vientres musculares, dependiendo de la localización de la lesión y el mecanismo lesional (Mendiguchía et al., 2017). Sumado a este factor, la introducción de ejercicios rotacionales parece indicado, dado que se requerirá de buenos niveles de estabilización en acciones específicas como cambios de dirección, golpeos o carreras a alta velocidad (Mendiguchía & Brughelli, 2011), para ayudar a un correcto desarrollo de las acciones mencionadas; Jiménez-Rubio et al. (2018) propone la utilización de ejercicios asimétricos. Durante esta fase, los déficits en la producción de fuerza horizontal podría suponer un riesgo de recaída durante la fase de apoyo de la carrera. Un tipo de entrenamiento a incluir en esta fase sería la pliometría

(Mendiguchía et al., 2017), con el objetivo de resolver las deficiencias neuromusculares y poder preparar al sistema musculoesquelético para las exigencias impuestas durante la participación deportiva (Chmielewski et al., 2006). Un medio para ello sería el incremento progresivo de la velocidad en movimientos laterales además de la utilización de ejercicios mediante empuje de trineos (Jiménez-Rubio et al., 2018).

Por último, al finalizar las tres etapas mencionadas anteriormente, es necesario la introducción de una etapa específica de readaptación al futbol (Tol et al., 2014) mediante un programa progresivo en relación al volumen y la intensidad, en el cual se produzca un reentrenamiento de las cualidades específicas del deporte en cuestión, aumentando también complejidad durante el proceso. Esta puede programarse según 13 ítems (Jiménez-Rubio et al., 2018), introduciendo de forma progresiva desplazamientos frontales y laterales, además de la introducción de acciones como las recepciones y de habilidades motrices específicas, progresando hacia la reeducación de patrones de agilidad y coordinación específicos. Finalmente, una evolución desde un contexto aeróbico hacia un contexto anaeróbico pasando por la realización de RSA (entrenamiento de capacidad de repetir sprints) tendría como objetivo finalizar el proceso de RTP realizando simulacros de situaciones específicas enfatizando sobre la toma de decisión (Jiménez-Rubio et al., 2020a). Cómo elemento transversal, se valora el acondicionamiento aeróbico mediante carrera, en el momento que el jugador no reporte molestias o dolor durante el movimiento (Mendiguchía et al., 2017); aunque en etapas anteriores, se podría enfatizar en este aspecto mediante actividades que no produzcan molestias o dolor (Tol et al., 2014).

Limitaciones del estudio

La limitación principal del estudio ha sido la escasa bibliografía que ha aplicado un proceso de intervención en sus estudios y que ha utilizado un grupo control, dado que, en los documentos encontrados, el tipo de estudio predominante ha sido el descriptivo sin intervención, aspecto que interfería en el análisis del beneficio de dichos protocolos sobre la lesión estudiada. Por otro lado, la selección de estas fuentes de información posiblemente ha coartado el acceso a información relevante no identificada.

Conclusiones

El enfoque multifactorial en relación con el tratamiento y el proceso de "return to play" de la lesión de isquiosurales, muestra más beneficios que un protocolo con componente unidireccional. Durante este proceso, es importante reconocer las sinergias en los patrones de movimiento específicos del deporte en cuestión, con el fin de ofrecer al jugador una recuperación segura y eficaz, con el objetivo de combatir contra los posibles factores de riesgo futuros y prevenir recaídas. Aspectos como la inclusión del entrenamiento del control lumbo-pélvico, técnica de carrera, el entrenamiento de la zona glútea o la pliometria muestran beneficios en el proceso de RTP en la lesión de isquiosural. Por otro lado, el conocimiento de la zona afectada y el mecanismo lesional de esta resulta imprescindible a la hora de aplicar un correcto tratamiento, dada las diferencias en activación muscular presentes según la dominancia de estos.

Aplicaciones prácticas

Para llevar este proceso a cabo, es imprescindible una coordinación entre todo el personal que participará durante el proceso, con el fin de aportar y reforzar el enfoque multidisciplinar durante este proceso y buscar la mejora conjunta del deportista. Para ello, la protocolización en el registro y un mayor número de estudios longitudinales, permitiría confirmar la eficacia respecto al tipo de enfoque en el proceso de rehabilitación multidisciplinar (Mendiguchía et al., 2017).

Financiación

Los autores declaran no tener ningún conflicto de interés ni subvención por parte de ninguna entidad pública o privada.

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Effects of different strength training intensities on health-related parameters towards engaging in physical activity in elderly

Efectos de diferentes intensidades del entrenamiento de la fuerza sobre los parámetros relacionados con la salud en la atracción hacia la actividad física de las personas mayores

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Short title:
Towards engaging in physical activity in elderly

How to cite this article:
Carcelén, R., Navarro, J., Juesas, A., Baños, R. M., Colado, J. C., & Lisón, J. F. (2022). Effects of different strength training intensities on health-related parameters towards engaging in physical activity in elderly. *Cultura, Ciencia y Deporte*, *17*(53), 21-30. https://doi.org/10.12800/ccd.v17i53.1833

Received: 25 november 2021 / Accepted: 19 may 2022

Abstract

To assess the effects of a progressive resistance training program at different intensities on health-related quality of life, anxiety, and motivation towards engaging in physical activity among older people. Prospective, municipal multi-centers, non-randomized controlled trial. 76 older adults were assigned to: vigorous intensity (n = 19), vigorous-moderate intensity (n = 21), moderate intensity (n = 19), or control group (n = 17). The exercise groups performed six exercises with elastic bands per session, twice a week, for 8 months. Vigorous intensity, vigorous-moderate intensity and moderate intensity group performed 6, 10 and 15 repetitions, respectively. Health-related quality of life was assessed using the 36-Item Short Form Health Survey, trait and state anxiety using the State-Trait Anxiety Inventory, and motivation towards engaging in physical activity using the Behavioural Regulation in Exercise Questionnaire. The moderate intensity group showed a significant increase in the summary of the physical components of health-related quality of life ($p = 0.001$; $\eta p^2 = 0.158$) and a significant decrease in external regulation ($p = 0.002$; $\eta p^2 = 0.145$) and amotivation ($p = 0.013$; $\eta p^2 = 0.97$). In contrast, the vigorous intensity group showed a significant increase in state anxiety ($p = 0.004$; $\eta p^2 = 0.076$) and a significant decrease in introjected regulation ($p = 0.018$; $\eta p^2 = 0.097$). Moderate intensity strength training programs are best suited for older adults because they improve health-related quality of life and decrease less self-determined forms of regulation, all without increasing anxiety states.

Keywords: motivation, quality of life, well-being.

Resumen

Evaluar los efectos de un programa de entrenamiento progresivo de la fuerza a diferentes intensidades sobre la calidad de vida relacionada con la salud, la ansiedad y la motivación para atraer hacia la realización de actividad física entre las personas mayores. Ensayo controlado prospectivo, multicéntrico municipal, no aleatorizado. 76 adultos mayores fueron asignados a: grupo de intensidad vigorosa (n = 19), vigorosa-moderada (n = 21), moderada (n = 19), o grupo de control (n = 17). Los grupos de ejercicio realizaron seis ejercicios con bandas elásticas por sesión, dos veces por semana, durante 8 meses. Los grupos de intensidad vigorosa, vigorosa-moderada y moderada realizaron 6, 10 y 15 repeticiones, respectivamente. La calidad de vida relacionada con la salud se evaluó mediante la Encuesta de Salud de formulario corto de 36 elementos, el rasgo y el estado de ansiedad mediante el Inventario de Ansiedad Estado-Rasgo, y la motivación para realizar actividad física mediante el Cuestionario de Regulación del Comportamiento en el Ejercicio. El grupo de intensidad moderada mostró un aumento significativo en el resumen de los componentes físicos de la calidad de vida relacionada con la salud ($p = 0.001$; $\eta p^2 = 0.158$) y una disminución significativa en la regulación externa ($p = 0.002$; $\eta p^2 = 0.145$) y desmotivación ($p = 0.013$; $\eta p^2 = 0.97$). En contraste, el grupo de intensidad vigorosa mostró un aumento significativo en el estado de ansiedad ($p = 0.004$; $\eta p^2 = 0.076$) y una disminución significativa en la regulación introyectada ($p = 0.018$; $\eta p^2 = 0.097$). Los programas de entrenamiento de la fuerza de intensidad moderada son más adecuados para los adultos mayores porque mejoran la calidad de vida relacionada con la salud y disminuyen las formas de regulación menos autodeterminadas, todo sin aumentar los estados de ansiedad.

Palabras clave: motivación, calidad de vida, bienestar.

Introduction

Older people constitute a substantial proportion of the total population, and their numbers are projected to increase. In 2019, more than one billion people were aged over 60 years and this number will increase to 1.4 billion by 2030 and 2.1 billion by 2050. This increase is occurring at an unprecedented rate and will accelerate in the coming decades, especially in developing countries (WHO, 2020). In the European Union, 20.3% of the population was aged over 65 years in 2019, some 2.9 percentage points more than in the previous decade (Eurostat, 2020). Specifically in Spain, according to data from National Institute of Statistics, 19.58% of the total population was aged over 65 years old in 2019 (INE, 2020).

'Healthy ageing' is defined as the process of promoting and maintaining the functional capacity that permits wellbeing in old age, with functional capacity being understood as the attributes related to health that allow people to be and do what is important to them (Beard et al., 2016; Who, 2015). Although healthy ageing has traditionally focused on indicators such as physical impairments, cognitive disabilities, and social restrictions (Rowe & Kahn, 1997), psychological indicators have also more recently been highlighted (Fox et al., 2007).

Among the modifiable factors, data published in the academic literature suggests that engaging in physical activity (PA) could improve the well-being and quality of life of elderly individuals and consequently, contribute to increasing the probability of healthy aging among this population (Daskalopoulou et al., 2017; Makino et al., 2015; WHO, 2015). Thus, it is very important to understand the best type of physical activity to encourage and at what intensity in order to maximize its possible benefits.

Numerous studies have shown the relationship between PA and quality of life (Bize et al., 2007; Calatayud et al., 2015; Gómez-Morales et al., 2019; Pucci et al., 2012) and have demonstrated improvements both in physical dimensions (e.g., pain, physical function, and physical role; Espejo et al., 2016; Wanderley et al., 2011) as well as in mental health dimensions (Olsson et al., 2015; Prieto et al., 2015). However, there is disparity in the results in this population, especially in terms of the type and intensity of physical activity that these older adults should engage in order to obtain the greatest improvements (Van Malderen et al., 2013).

Similarly, engaging in PA has been associated with an increase in general psychological well-being and decreased stress and anxiety levels (Conn, 2010; Kadariya et al., 2019). Most studies that have found a reduction in anxiety have done so after the completion of aerobic exercise (Ekkekakis et al., 2008; Hale et al., 2002; Pan et al., 2018) practiced at moderate to low intensities (Guszkowska, 2004). While, on the contrary, other studies have found that high-intensity PA is associated with increased anxiety (Arent, 2004; Katula et al., 1999). However, a recent review (Mochcovitch et al., 2016) concluded that more work would be needed to identify the ideal PA modality, frequency, duration, and intensity to optimize the positive effects of exercise on anxiety in this population.

Moreover, motivation plays a key role in the initiation and continued engagement in PA. In this regard, the self-determination theory (SDT; Ryan & Deci, 2002) provides an excellent framework for examining PA motivation in older adults (Frederick-Recascino, 2002). SDT suggests that PA regulation is supported by different levels of motivation, from intrinsic motivation to extrinsic motivation (which, in order from lowest to highest extrinsic motivation, includes the following dimensions: identified regulation, introjected regulation, and external regulation) and amotivation. Forms of more self-determined regulation towards PA (intrinsic motivation) are related to greater adherence to PA (Duncan et al., 2010; Teixeira et al., 2012; Vanroy et al., 2019).

In general, most of the interventions and programs for adults include aerobic exercise activities, while interventions aimed at increasing strength are less frequent (Pan et al., 2018; Weisser et al., 2009). However, physical strength training programs aimed at older people are now becoming increasingly common because they are easy to apply, and are low cost, durable, accessible, and effective (Colado & García-Massó, 2009; Martins et al., 2013).

To the best of our knowledge, no studies have yet evaluated the impact of PA on quality of life, emotional well-being, or motivation in this population by implementing the same strength training program at different intensities. Thus, the main objective of this study was to compare the effect of strength training programs that differed only in intensity (vigorous, vigorous–moderate, or moderate) on quality of life, anxiety, and motivation towards engagement in PA among older individuals.

Methods

Study design

This prospective, multi-center, non-randomized controlled trial (trial registration: ClinicalTrials.gov NCT03952104) was approved by the Universidad Cardenal Herrera-CEU Human Ethics Committee and followed the ethical guidelines set out in the Declaration of Helsinki. All participants signed a written informed-consent statement and were allocated, according to their center, to the different strength training intensity study groups (vigorous, vigorous–moderate, moderate, or control).

Eligibility Criteria

To be eligible for inclusion, participants had to be aged 65 or older, able to ambulate independently, able to communicate, and willing to stay in the same municipal activity center for the elderly for the subsequent eight months. The exclusion criteria were the presence of unstable cardiovascular disease or a neurological disorder that could prevent or compromise engagement in PA or the previous completion of a strength training program in the six months prior to the start of the study.

Procedure

Upon enrollment in the study and after completing the primary and secondary outcome measures (baseline), the four municipal activities centers (and therefore, their respective participants) were randomly assigned either to the eight-month vigorous strength training intensity group (n = 19), the vigorous–moderate group (n = 21), the moderate group (n = 19), or the control group (n = 17). All the outcome measurements (baseline and postintervention) were recorded by the same two trained psychologists who were blinded to the group allocation.

All the intervention groups underwent two familiarization sessions in the first week before starting the definitive training program. The participants had an instructor and an assistant to learn the assimilation of the technique (ergonomics, amplitude, breathing, etc.), the adequate control of the intensity in each of the exercises and their possible progression throughout the eight-months. Participants were asked to maintain their eating

habits and regular physical activity from the beginning until the end of the study, and were told not to participate in any alternative exercise programs for the duration of the study. Likewise, during the training sessions the participants were instructed to wear comfortable and suitable clothing and footwear, not to drink stimulating drinks, and to bring a bottle of water to avoid dehydration. Adherence was controlled by keeping session attendance records, and we recommended that the participants attend at least 80% of the total planned sessions. All the sessions were carried out in groups in each of the centers and were always directed by the same instructor. Before completing the training program, the instructors demonstrated the exercises and their proposed implementation techniques to ensure that all the exercises were completely executable by the target population, and to ensure that the total duration of each session did not exceed 60 minutes.

Before and after the intervention, each participant completed three questionnaires. The first to assess the level of physical activity before starting the interventions, the second to determine quality of life, and the third to diagnose anxiety and distinguish it from depressive syndromes. Interviewers were psychologists, each of whom received extensive training and supervision in conducting this interview.

Intervention

The physical intervention program consisted of two weekly strength training sessions for eight consecutive months. In each session, the three intervention groups performed identical exercises in terms of movement execution and pace (Figure 1), order, number of exercises (six exercises), and number of sets per exercise (four sets), but with different intensities (i.e., resistances), using elastic bands (TheraBand®, Akron, OH, USA). These elastic bands have different levels of stiffness against elongation that allowed to modified the employed resistance across the training program. To achieve an adequate use of the training resistance, and also an equivalent progression in the training of each one the three groups over the eight-month period, the handgrip length of the elastic bands was modified according to an equivalent prescribed rating of perceived exertion (RPE). This RPE was obtained of the OMNI-Resistance Exercise Scale of perceived exertion with elastic bands (Colado et al., 2012). All groups trained with a RPE of six or seven, at the end of each set of each exercise, during the first fourth weeks, and of eight or nine until the end of the study. The vigorous intensity group performed six submaximal repetitions (equivalent to 85% of the one-repetition maximum [1RM]) of each exercise; the intermediate intensity group (vigorous–moderate) performed 10 submaximal repetitions (equivalent to 75% of 1RM) of each exercise; finally, the moderate intensity group performed 15 submaximal repetitions (equivalent to 70% of 1RM) of each exercise.

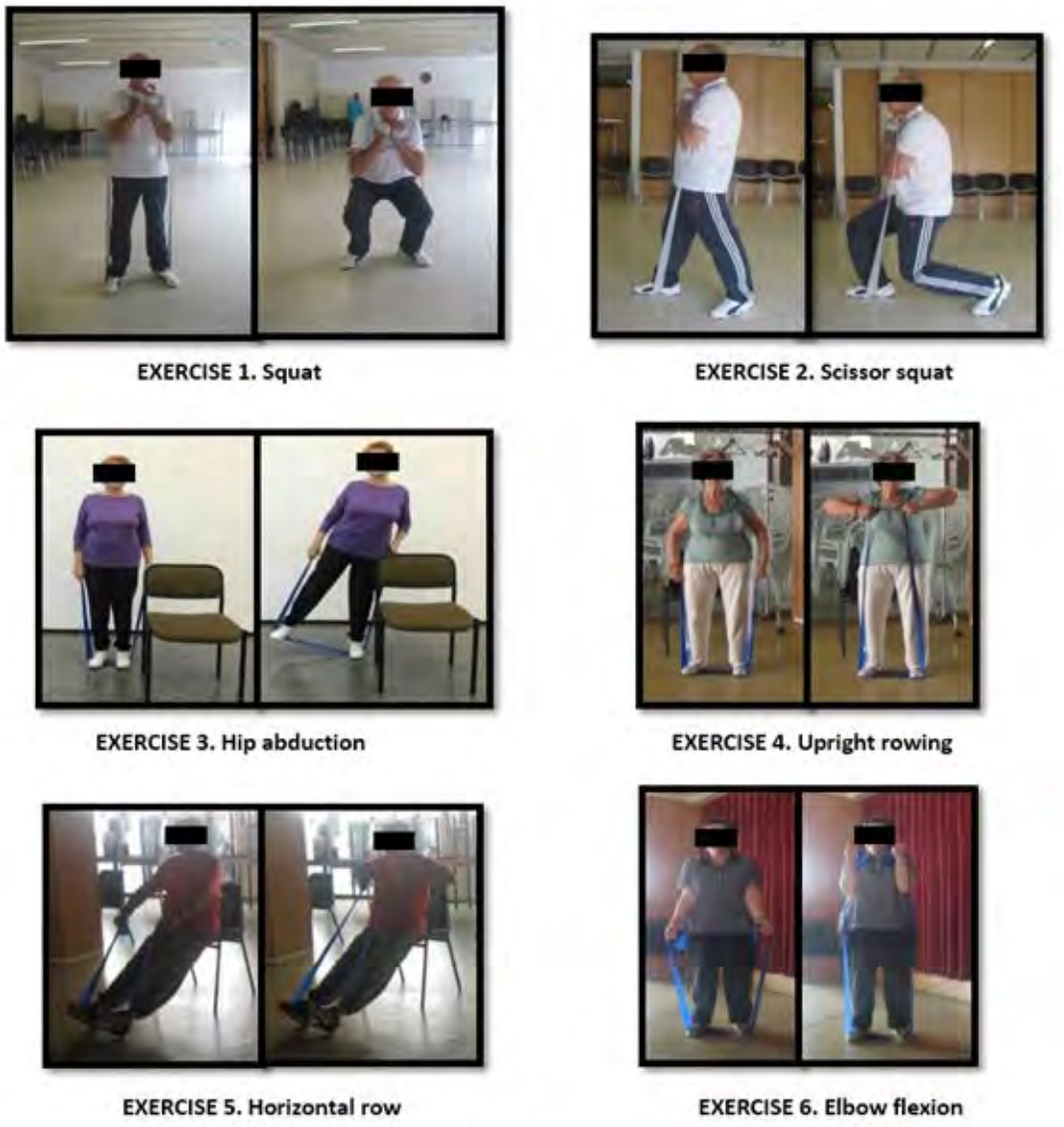

Figure 1. Initial and final position of the 6 strength training exercises performed with TheraBand elastic bands

Outcome measures

a) Sociodemographic data

An ad-hoc questionnaire was designed to collect information regarding age, sex, and level of education. We used the short form of the International Physical Activity Questionnaire (IPAQ-SF; Booth, 2000) to assess the participants' level of physical activity before starting the interventions (baseline). This self-report questionnaire uses seven items to collect data on PA performed in the past seven days (Craig et al., 2003; Lee et al., 2011). This questionnaire has been validated in 12 countries (Craig et al., 2003) and shows adequate psychometric properties. Moreover, the short version (IPAQ-SF) has shown acceptable validity in the adult Spanish population (Román et al., 2013).

The total number of days and minutes of PA were calculated by adding the scores from all the PA categories from the seven days prior. The data from the IPAQ-SF were then converted to Metabolic Equivalent minutes per week (MET-min/week), using the formula published by Ainsworth et al., (2011). We used this measure as an indicator of PA. Specifically, the IPAQ-SF questionnaire records activity at four intensity levels: (1) vigorous activity such as aerobics; (2) moderate activity such as leisure cycling; (3) walking; and (4) sitting. This makes it possible to classify participants according to their PA level: high (> 1.500 METs), moderate (600–1.500 METs) and low (< 600 METs).

b) Primary outcome

The 36-Item Short Form Health Survey (SF-36), is a generic health-related quality of life questionnaire comprises 36 questions that correspond to two domains, the physical component summary (PCS) and mental component summary (MCS; Ware & Sherbourne, 1992), and eight dimensions, the PCS comprises four dimensions (physical functioning, role physical, bodily pain and general health), and the MCS includes vitality, social functioning, emotional role, and mental health. The score for both the PCS and the MCS domains ranged from 0 to 100, with 100 representing the best state of health and 0 representing the worst. PCS and MCS were used as primary outcomes to indicate physical domain and mental domain scores, respectively,

in order to generalize the overall effect of physical and mental health status. Studies published on the metric characteristics of the Spanish version of the SF-36 have provided sufficient evidence for its reliability, validity, and sensitivity in similar contexts (Alonso et al., 1995).

c) Secondary outcomes

The State-Trait Anxiety Inventory (STAI) is a commonly used measure of trait and state anxiety (Spielberger et al., 1982; Spielberger, 1983) that can be used in clinical settings to diagnose anxiety and distinguish it from depressive syndromes. The STAI is used to assess trait anxiety and state anxiety, and we used the state anxiety scale to assess anxiety in this study. State anxiety refers to a transitory period characterized by a feeling of tension, apprehension, and an increase in the activity of the autonomic nervous system, which can vary both in time and in intensity. This scale comprises 20 items scored on a Likert-type response scale from 0 ('Not at all') to three ('A lot'). The total score is obtained by adding the values of the items (after inverting the scores of the negative items), and ranges from 0 to 60 with higher scores corresponding to higher levels of detected anxiety (Kvaal et al., 2005). The published reliability coefficient for the state anxiety scale is 0.94. In addition, the STAI generally maintains adequate metric properties and is sensitive to increases in environmental stimuli that produce stress (Guillén-Riquelme & Buela-Casal, 2011).

Motivation towards engaging in PA was assessed through the Behavioural Regulation in Exercise Questionnaire (BREQ-2; Markland & Tobin, 2004) which consists of 19 items measuring stages on the continuum of self-determination. It measures external regulation (four items), introjected regulation (three items), identified regulation (four items), intrinsic regulation (four items), and amotivation (four items) on a scale from one ('Not at all true for me') to five ('Absolutely true for me'). Each of the subscales has a maximum score, with a maximum of 20 for external regulation, identified regulation, intrinsic regulation, and amotivation, and 15 for introjected regulation. The BREQ-2 showed an acceptable internal consistency (α ranging from 0.81 to 0.89) in previous work (Moreno Murcia et al., 2007).

Data analysis

The desired sample size was calculated after undertaking a pilot study of 20 participants, which indicated an effect size of 0.22 for the primary outcome; considering this, as well as an α value of 0.05 and a desired power of 80%, we used G*Power (v.3.1.9.2) software (Faul et al., 2009) to estimate that a sample size of 64 participants would be required. Accounting for potential losses of 20%, we established the final total sample size at 76 participants. No participants suffered adverse effects due to the intervention, and withdrawals from the study were due to family issues.

We analyzed our data using an intention-to-treat approach. First, we determined the baseline differences between the groups by using one-way analysis of variance (ANOVA) for continuous variables (age and adherence) or the χ. test for categorical variables (sex and physical activity level). Two-way mixed ANOVA tests were used to compare the effects of the interventions on the outcome measures between the groups, with time (baseline versus the eight-month follow-up) serving as the within-group factor and the intervention type as the between-group factor (vigorous, vigorous–moderate, moderate, and control). The effect sizes were estimated using the ηp. and were interpreted following Cohen's guidelines for small, moderate, and large effect sizes (ηp. = 0.01, 0.06, or 0.14, respectively; Cohen, 1988). We performed the statistical analyses using version 19.0 of the SPSS statistical package (IBM Corp., Armonk, NY, USA). Probabilities exceeding 95% (alpha .-values less than 0.05) were used as the threshold cut-off for statistical significance.

Results

We screened 139 participants in this non-randomized controlled trial and a total of 76 were recruited to this study; 63 were not allocated to the different groups because they declined to participate (n = 52) or did not meet the inclusion criteria: unable to ambulate independently (4 participants), presence of unstable cardiovascular disease or a neurological disorder that could compromise the exercise (4 participants), or completion of a previous strength training program in the six months prior to the start of the study (3 participants). Finally, 76 Spanish older adults (76.30 % females; 70.10± 5.71 years) were allocated to the different groups (vigorous, vigorous–moderate, moderate, or control). Figure 2 shows the progression of the participants through the trial.

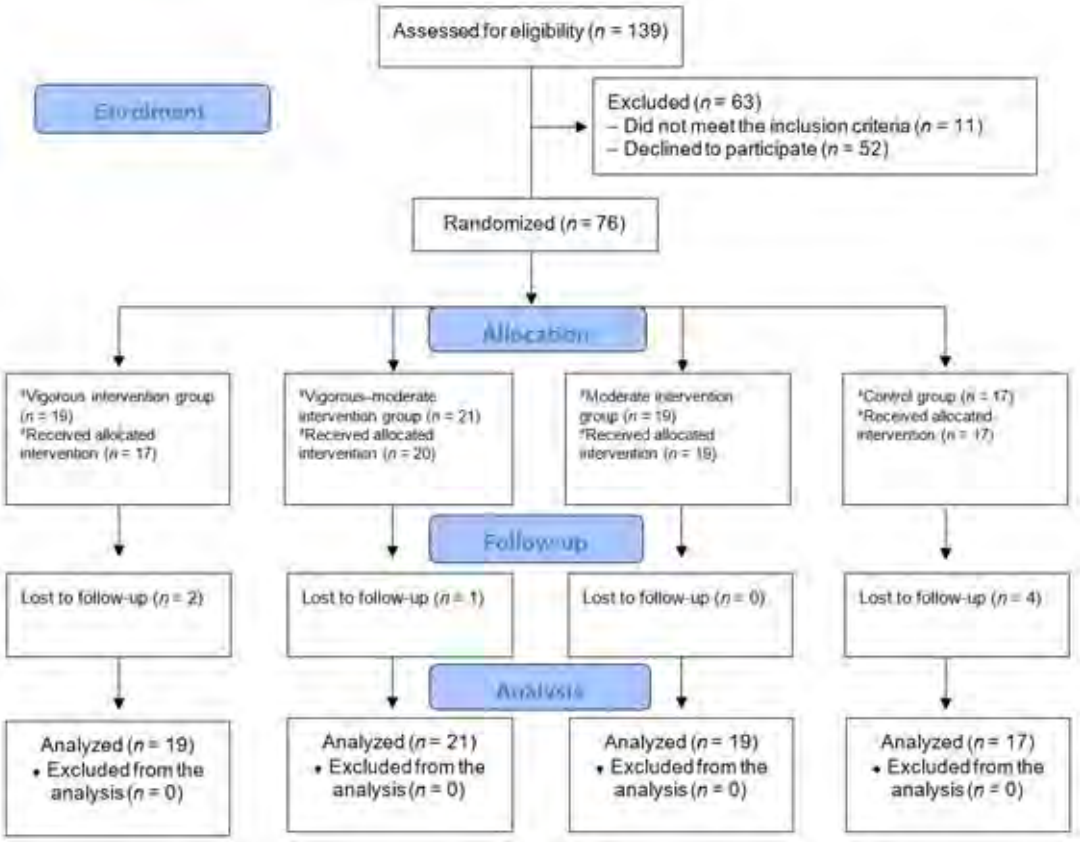

Figure 2. Progression of the participants through the trial

The χ^2 tests showed no baseline differences between groups in the gender distribution (p = .145) or in terms of the physical activity level (p = .122). Similarly, the one-way ANOVA did not show any significant differences between groups in the percentage of adherence to the strength training sessions (vigorous [79 %]; vigorous–moderate [88 %]; and moderate [84 %], p = .181). Regarding age, the pair comparison only showed significant differences at baseline between vigorous and moderate groups (vigorous [73.31 ± 6.12 years]; vigorous–moderate [70.11 ± 5.02 years]; moderate [67.02 ± 4.21 years]; control [70.06 ± 6.13 years]).

The results of the 2-way mixed ANOVA showed a significant increase in the physical component summary (p = .001; large effect size), and a significant decrease in external regulation (p = .002; large effect size) and amotivation (p = .013; moderate effect size) after eight months in the moderate intervention group (table 1). In contrast, we observed a significant increase in the STAI score (p = .004; moderate effect size) and a significant decrease in introjected regulation (p = .018; moderate effect size) in the vigorous intervention group.

Table 1. Intragroup comparisons: baseline vs. postintervention (at 8 months)

VARIABLES	GROUP	Baseline	Post-intervention	Diff. (95 % *CI*)	*Partial eta²*	*P*
Physical Component Summary (PCS)	CONTROL	75 ± 18	70 ± 24	5 (-3 to 12)	.027	.188
	VIGOROUS	73 ± 11	76 ± 16	-3 (-9 to 2)	.027	.192
	MODERATE-VIGOROUS	82 ± 12	83 ± 14	-2 (-6 to 3)	.006	.541
	MODERATE	65 ± 19	74 ± 15	-9 (-14 to -4)	.158	.001**
Mental Component Summary (MCS)	CONTROL	84 ± 9	77 ± 15	8 (-2 to 18)	.036	.127
	VIGOROUS	74 ± 15	80 ± 12	-6 (-13 to 1)	.051	.069
	MODERATE-VIGOROUS	75 ± 19	85 ± 13	-10 (-17 to -4)	.128	.003**
	MODERATE	67 ± 20	73 ± 16	-6 (-13 to 1)	.047	.080
State-Trait Anxiety Inventory (STAI)	CONTROL	12.5 ± 6.1	13.3 ± 7.0	-0.8 (-4.7 to 3.1)	.003	.688
	VIGOROUS	13.1 ± 6.5	16.7 ± 7.2	-3.6 (-7.1 to -0.2)	.076	.004**
	MODERATE-VIGOROUS	10.8 ± 5.5	18.2 ± 7.9	-7.5 (-11.5 to -3.4)	.201	.001**
	MODERATE	18.0 ± 9.2	18.2 ± 9.9	-0.2 (-4.2 to 3.9)	.000	.940
Intrinsic regulation (BREQ-2)	CONTROL	4.5 ± 0.8	4.5 ± 0.8	0 (-0.2 to 0.2)	.001	.814
	VIGOROUS	4.7 ± 0.4	4.7 ± 0.3	0 (-0.3 to 0.2)	.001	.791
	MODERATE-VIGOROUS	4.5 ± 0.4	4.4 ± 0.5	0.1 (-0.2 to 0.3)	.002	.738
	MODERATE	4.6 ± 0.4	4.7 ± 0.6	-0,1 (-0.4 to 0.2)	.004	.622
Identified regulation (BREQ-2)	CONTROL	3.8 ± 0.4	3.9 ± 0.5	-0.1 (-0.5 to 0.3)	.003	.681
	VIGOROUS	4.4 ± 0.5	4.2 ± 0.5	0.2 (-0.1 to 0.5)	.023	.258
	MODERATE-VIGOROUS	4.1 ± 0.6	4.0 ± 0.5	0.1 (-0.2 to 0.5)	.012	.405
	MODERATE	4.5 ± 0.5	4.2 ± 0.4	0.3 (0 to 0.7)	.058	.068
Introjected regulation (BREQ-2)	CONTROL	2.3 ± 0.9	3.0 ± 1.1	-0.7 (-1.5 to 0)	.064	.055
	VIGOROUS	3.7 ± 1.1	2.9 ± 1.4	0.8 (0.1 to 1.4)	.097	.018*
	MODERATE-VIGOROUS	3.2 ± 1.2	2.9 ± 1.6	0.3 (-0.3 to 1.1)	.021	.276
	MODERATE	3.4 ± 0.7	3.5 ± 1.3	-0.1 (-0.9 to 0.7)	.001	.800
External regulation (BREQ-2)	CONTROL	1.6 ± 0.9	1.2 ± 0.6	0.4 (-0.1 to 0.8)	.045	.102
	VIGOROUS	1.4 ± 0.7	1.1 ± 0.2	0.3 (0 to 0.7)	.048	.090
	MODERATE-VIGOROUS	1.2 ± 0.3	1.2 ± 0.6	0 (-0.4 to 0.3)	.002	.704
	MODERATE	1.8 ± 0.9	1.1 ± 0.6	0.7 (0.2 to 1.1)	.145	.002**
Amotivation (BREQ-2)	CONTROL	1.3 ± 0.4	1.4 ± 0.6	-0.1 (-0.3 to 0.1)	.008	.487
	VIGOROUS	1.1 ± 0.3	1.0 ± 0.2	0.1 (-0.1 to 0.3)	.010	.446
	MODERATE-VIGOROUS	1.0 ± 0.1	1.0 ± 0.1	0 (-0.2 to 0.3)	.001	.793
	MODERATE	1.4 ± 0.5	1.1 ± 0.3	0.3 (0.1 to 0.6)	.097	.013*

BREQ-2 = Behavioural Regulation in Exercise Questionnaire *p<.01 **p<.05

Discussion

As far as we are aware, this is the first study that has compared the effect of strength training programs that only differ in intensity (vigorous, vigorous–moderate, or moderate) on quality of life, anxiety, and motivation towards engaging in PA among older people. Our main finding was that, in general terms, engaging in a moderate intensity PA program generated greater benefits in the variables we studied compared to the vigorous or vigorous–moderate intensity programs.

Specifically, our results showed that the group of older people who performed the resistance training program at moderate intensity for 32 weeks significantly improved their quality of life, especially that related to physical health, with a large effect size. Therefore, it seems that the participants in this group obtained greater benefits in the physical dimensions (physical functioning, physical role, bodily pain, and general health) and thus, this intervention positively contributed to healthy aging. These results are congruent with other studies that showed the positive benefits of engaging in physical exercise by performing strength training programs to improve the quality of life among elderly populations (Cakar et al., 2010; Krist et al., 2013; Lobo et al., 2010; Park et al., 2015; Paterson & Warburton, 2010) as well as with those that observed functional improvements by practicing this type of PA at a moderate intensity (Capodaglio et al., 2007; Cavani et al., 2002; Lobo et al., 2010; Skelton & McLaughlin, 1996; Taaffe et al., 1999; Vincent et al., 2002).

Regarding motivation, the results of the intragroup analysis showed that, unlike the other two groups, the moderate intensity group scored significantly less in external regulation and demotivation at the end of the training program, with large and moderate effect sizes respectively. We interpreted this result as a positive finding because it implies that extrinsic motivation decreased after exercising at this intensity. In this sense, reasons for engaging in PA that focus on pressure from other people, or to obtain external rewards, can have a negative impact on maintaining this behavior. In this line, some studies have shown that demotivation is negatively related to the continuity of practicing sports (García-Calvo et al., 2011; Thogersen-Ntoumani et al., 2007). In summary, the results of this study suggest that participation in moderate PA programs could modify, in the desired direction, the degree of internalization of the goals and values that participants associate with exercise; that is, it can reduce their extrinsic motivation.

With regard to anxiety levels, our results showed that, unlike the moderate intensity group, individuals who performed PA at a higher intensity (vigorous or moderate–vigorous) suffered a significant increase in state anxiety scores. Interestingly, previous studies have found similar results (Arent, 2004; Katula et al., 1999; Raglin et al., 1993) although without differentiating between PA intensities. In fact, some authors have argued that exercise can cause various types of stress, specifically distress, which could induce negative effects (Li & He, 2009), such as tension or anxiety. If we consider anxiety as the level of activation or arousal experienced by an individual, participants in the vigorous or moderate–vigorous PA groups may have experienced greater muscle tension and greater activation of the nervous system as a consequence of performing these PAs at a higher intensity and thus, would have scored higher in questionnaire items referring to states of tension. Furthermore, subjectively perceiving greater tension and/or activation may not be experienced as a positive experience by older adults. In this sense, this would be an undesired consequence of engaging in PA which, together with the decrease in introjected regulation (vigorous PA group), could mean these individuals would be less motivated to continue PA practice once the program finishes.

Although it is desirable that older adults should be intrinsically motivated to engage in PA, introjected regulation includes reasons such as avoiding feelings of guilt or achieving feelings of pride. However, although this latter form of regulation supposes minimal internalization of the value of PA by participants, there is no benefit to achieving decreased levels of this regulation unless it is to increase other more self-determined forms of regulation. Considering this fact, and the results related to anxiety, it seems that vigorous PA would not be the most recommended option to achieve sustained engagement in PA over time in older adults. We were unable to find any academic literature that compared the variables we studied in this type of PA program at different intensities, thus making it very difficult to contrast our results with previous publications.

Finally, we would like to note the limitations of this study. The main limitation was its lack of participant randomization, presumably introducing bias. Although participants were recruited and alternately randomized by center (due to limited resources), a randomized allocation would be required to control the influence of other extraneous variables. Nonetheless, no baseline differences between groups were found in terms of gender distribution, PA level, or percentage of adherence to the strength training sessions, and baseline comparisons only showed statistical differences in age between the vigorous and moderate exercise groups. Furthermore, the participants we enrolled had demonstrated an initial level of motivation to engage in a strength training program. Therefore, our findings may only be generalizable to individuals who are similarly interested in such interventions. In addition, our participants were recruited from municipal activity centers for the elderly, which may have further influenced our results because of the sociodemographic status of these individuals. Finally, the time limitations of our study did not allow us to determine whether any increase in PA would be maintained in the long term. Nevertheless, our results related to motivation towards PA and state anxiety suggest that the greater the intensity of the resistance training, the harder it was to maintain engagement in the PA over time.

Despite these limitations, this study is the first to compare how different intensities of strength training programs (vigorous, vigorous-moderate, moderate) effect health-related quality of life (physical and mental components), state anxiety, and motivation towards PA in an elderly population. In addition, the design of the strength training programs used (total number of sessions and identical exercises in terms of execution of the movements, order, number, and number of series per exercise), allowed us to isolate and specifically determine the effect of intensity on the variables studied. In summary, our findings support the implementation of moderate intensity programs because these improve health-related quality of life (physical component summary) and decrease external regulation and amotivation, without increasing state anxiety.

Acknowledgments/ Funding

The authors would like to express their sincere thanks to all of the participants, as well as to the directors of the Municipal Centers of Physical Activity for Older People (Valencia, Spain), for taking part in this study. Jesús and Mari Paz deserve special mention for their work in the development of the department for the ageing within the Council of Valencia, Spain, and Pedro Gargallo helped us to coordinate the sample used of this study. CIBER Fisiopatología de la Obesidad y Nutrición (CIBERobn) is an initiative of the ISCIII.

This work was supported by grants from the Generalitat Valenciana (grants for consolidable research groups-AICO/2019/331), from the University CEU Cardenal Herrera (INDI 19/27), and by grants from the Mapfre Foundation awarded to Ignacio Larramendi as a 2014 research fellow (Code: OTR2015-140931NVES). Jessica Navarro was supported by a predoctoral scholarship (FPU14/04053) awarded by the Spanish Ministry of Education, Culture, and Sport.

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Decision-making, contextual intelligence, maximum oxygen consumption and explosive strength in futsal players during COVID-19

Toma de decisiones, inteligencia contextual, consumo máximo de oxígeno y fuerza explosiva en deportistas de futsal durante el covid-19

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Short title:
Psychological and physiological variables in futsal

How to cite this article:
Peña-Tovar, D.S., Rodríguez-Duque, A.F., & Villaquiran-Hurtado, A.F. (2022). Decision-making, contextual intelligence, maximum oxygen consumption and explosive strength in futsal players during COVID-19. *Cultura, Ciencia y Deporte, 17*(53), 31-54. https://doi.org/10.12800/ccd.v17i53.1855

Received: 10 march 2022 / Accepted: 20 may 2022

Abstract

The present research sought to determine the relationship between maximum oxygen consumption, explosive strength, decision making and contextual intelligence in futsal players during confinement by COVID-19. This is a descriptive study, carried out with 30 futsal players from the city of Popayan during confinement by COVID-19. Training characteristics, body mass index, aerobic capacity, lower limb explosive strength, contextual intelligence and decision making were evaluated. The average value of players' VO2max was 43.60 ml/kg/min, the average jumping height was 38.22 cm, the average reaction time for the Stroop test was 1,41 s. Furthermore, a statistical relationship among VO2max, intuition to detect the opponent's actions (p= 0,016), quick reaction to changes in the competition (p= 0,012) and the taking of initiative (p= 0,017) was found. During confinement, players showed overweight levels, slow reaction times for decision making and low values in Vo2max and explosive strength. VO2max. is related to better cognitive response and decision making.

Keywords: COVID-19, Sports, Oxygen consumption, Muscle strength, Sport teams, (MeSH).

Resumen

La presente investigación buscó determinar la relación entre el consumo máximo de oxígeno, la fuerza explosiva, la toma de decisiones y la inteligencia contextual en deportistas de fútbol sala durante el aislamiento por Covid-19. Estudio descriptivo, realizado con 30 deportistas de futbol sala de la ciudad de Popayán durante el confinamiento por Covid-19, en donde se evaluó las características de entrenamiento, el índice de masa corporal, la capacidad aeróbica, la fuerza explosiva de miembros inferiores, la inteligencia contextual y la toma de decisiones. El promedio de VO2máx de los deportistas fue de 43,60 ml/kg/min, la media en la altura de salto fue de 38,22 cm; el tiempo de reacción promedio para la prueba de Stroop fue de 1,41 s. Además, se encontró relación estadística entre el VO2máx, la intuición para detectar las acciones de mi oponente (p= 0,016), la reacción rápida a los cambios en la competición (p= 0,012) y tomar la iniciativa (p= 0,017). Durante el aislamiento, los deportistas presentaron niveles de sobrepeso, tiempos de reacción lentos para la toma de decisiones, y valores bajos en Vo2 máx. y fuerza explosiva. El VO2 máx. está relacionado con una mejor respuesta cognitiva y toma de decisiones.

Palabras clave: Covid-19, Deportes, Consumo de oxígeno, Fuerza muscular, Equipos de deporte, (DeCS).

Introduction

Futsal is characterized by the high physical, physiological, biomechanical, neuromuscular, cognitive and biochemical demand generated by the intermittent moderate and vigorous intensity that require effective responses from the player from a physical, technical, tactical and psychological point of view during the two 20-minute halves of a game (Spyrou et al., 2020). The rules of this sport were designed to maintain a high intensity in the game, playing between 75 to 85% of the total scheduled time. During this time the player is constantly fulfilling defensive and offensive tasks framed in different patterns of play, performing high and maximum intensity efforts every 43 to 56 seconds, respectively (Naser et al., 2017; Sanmiguel et al., 2021).

Futsal players must have an optimal aerobic condition to be able to tolerate the high intensity physiological demands present both in training and in competition. The level of maximum oxygen consumption (VO2max) has been related to a greater number of sprints performed, greater distance traveled, greater contact and participation with the ball, with less fatigue and less cardiovascular stress during the game (Álvarez-Kurogi, 2020; Matzenbacher et al., 2014). For its part, jumping ability is a basic and determining gesture in sports practice (Portilla et al., 2019). Likewise, Sekulic et al., (2021) state that measuring jumping performance is essential for the assessment of lower limb power, which is related to specific high-intensity game actions such as sprinting, jumping and changing direction.

By the end of 2019 and early 2020, the world was affected by the COVID-19 pandemic, which generated the adoption of isolation and social distancing measures by national and local governments in order to reduce the contagion. This negatively affected the participation of athletes in different organized competitions, generating that futsal players were forced to long-term isolation (Spyrou et al., 2022). In sport, confinement produced negative effects on physiological, emotional and training variables, on sleep patterns and on players' lifestyle (Mon-Lopez et al., 2020). The decrease in athletic performance induced by prolonged detraining periods during the isolation process could cause changes in aerobic performance (Bisciotti, 2020), jumping ability and body composition (Grazioli et al., 2020). Besides, the stoppage of specific training for futsal and/or the adaptation of this in reduced and limited spaces at home, the lack of motivation to continue with the preparation process by the athlete, difficulties in the management and control of intensities and workloads, could also influence the total or partial detriment of physiological and cognitive adaptations (Sarto et al., 2020).

Regarding the cognitive variables, contextual intelligence allows the athlete to know when to take the initiative, to recognize his strengths and weaknesses, giving him the possibility to adapt and propose a timely response to demanding situations in the physiological and psychological component (Pérez et al., 2014). Additionally, the set of cognitive operations that are essential for decision-making in complex environments such as a futsal match must be taken into account in the assessment processes. This on the understanding that cognitive function has been related to aerobic fitness, and that adequate training generates physiological and performance adaptations that favor cognition and executive function (Hansen et al., 2004). Furthermore, memory, attention, information gathering, anticipation and decision-making skills may be modulated by individual characteristics and sport context (Huertas et al., 2019).

For their part, interaction with the environment through sufficient and necessary stimuli to improve decision making, and attention are essential for the development of contextual intelligence. This allows the player to collect information from his environment, process, select and execute motor responses according to the game, fundamental for sporting success (Guerrero, 2020). This reasoning confirms the relevance of decision making and contextual intelligence as essential elements to determine the athletes' response to the game conditions (Salazar & Montoya, 2015). This is a situation that should be considered by coaches for evaluation and monitoring, especially during the process of confinement that brought noticeable and substantial changes in the way of training. As a result, the present research sought to determine the relationship among maximum oxygen consumption, explosive strength, decision making and contextual intelligence in futsal players from the city of Popayan during confinement by COVID-19.

Method

Study design

Descriptive cross-sectional study.

The present research was conducted under the parameters and recommendations established for research in humans given by the Declaration of Helsinki (World Medical Association - *WMA*, 2013) and resolution 8430 (Ministry of Health, 1993), this research was classified as minimal risk and had the approval of the Ethics Committee of the Vice-Chancellery of Research of the Universidad del Cauca and registration in the research system with identification code No. 5666.

Participants

Thirty futsal players from the city of Popayan participated in this study. The sample was selected intentionally from a population of 40 players registered in the club and who met the selection criteria: to belong as a futsal player attached to a professional club with current recognition by the Cauca Soccer League, to have participated as a player in national competitions in 2019, to be performing the mandatory confinement in the city of Popayan, to manifest, by signing the informed consent, the voluntary participation in the study. For the purposes of this research, players who did not completely finish the tests, presented some musculoskeletal injury at the time of the evaluation and those who requested voluntary withdrawal were excluded. It is important to mention that 10 athletes were not taken into account because they were performing their mandatory confinement outside the city and/or had not participated in official competitions during 2019, although they were part of the tele-directed trainings during the confinement.

Procedure

For the execution of the research, the club's directors, coaching staff and players were initially informed of the objectives and scope of the project. Once they had given their approval, the process of data collection and respective evaluations with the players at each of their homes was initiated. These evaluations were carried out in September, with the evaluators adopting and complying with the restriction and biosecurity measures issued by the national and municipal governments during that month.

As a first step for data collection, a survey was conducted to collect sociodemographic data (age, sex, socioeconomic stratum and schooling), sports data (years of practice,

practice time per daily session, weekly frequency of practice, among others), and training data during COVID 19 confinement (type of training, training place, training space (open, closed), musculoskeletal injuries, signs and symptoms of COVID 19), adjusted by pilot test. Subsequently, the questionnaire of contextual intelligence perceived in sport was administered. This has a three-dimensional structure (anticipatory intelligence, tactical intelligence and competitive intelligence), composed of 23 items, where each item presented a Likert-type scale from 1 to 10, validated by Ruiz et. al (2014).

Once the two previous questionnaires were answered, the evaluators went to the athlete's home to take anthropometric measurements (Stewart et al., 2011) and to continue with the Stroops test. This is a test of mental speed (Afsaneh et al., 2012), considered as a reliable psychometric measure to determine performance in terms of selective attention by introducing an interference, where the words inserted in the identification of colors act as a distractor for the individual (Araya and Saenz, 2019), based on the premise that individuals can read words much faster than they can identify and name colors, generating the Stroops effect (Golden, 1999). This test has been validated, presenting high reliability for various population groups, being successfully applied as a psychometric measure (Ahmed et al., 2015). The result of each test showed the total score, the total number of successful attempts and missed attempts, and the average time per response (Suresh et al., 2018).

Adapting to the confinement regulations and using the resources available at each player's confinement site for the assessment of maximum oxygen consumption, the Chester Step Test (Heydenreich et al., 2019) was used. This allowed the assessment of the athlete's aerobic capacity. The test consists of 5 stages, 1st stage: 15 *steps/min*, 2nd stage: 20 *steps/min*, 3rd stage: 25 *steps/min*, 4th stage: 30 *steps/min* and 5th Stage: 35 steps/min; where the assessed person had to go up and down a 30 cm high step. To mark the rhythm of execution of the test an audio was used. This determined the steps per minute executed by the assessed person while going up and down. The test marks a speed established by the beat of the metronome of the aforesaid previously recorded audio where the initial speed is 15 steps per minute and every 2 minutes the time increased by 5 steps per minute. At the end of each stage, the heart rate (*HR*) and the range of perceived exertion (*RPE*) were taken on a Borg scale of 6-20. The following formula was used to find the VO2max:

VO2max = Step height (m) × number of cycles × weight (kg) × 0.16357.21

Subsequently, lower limb explosive strength was evaluated by means of the Counter Movement Jump (*CMJ*) vertical jump through the mobile application My Jump 2 (Haynes et al., 2019). The application is a mobile tool that takes advantage of the cell phone camera, capable of recording at 120 Hz, which allows accurate measurement of jump performance, with high validity and reliability in the data, with excellent correlation between the application and contact platforms, making it an easy-to-use tool and with a much lower economic cost than jumping platforms (Balsalobre et al., 2014).

Statistical analysis

For the statistical analysis, descriptive analysis was performed with frequency and percentage distributions, and measures of central tendency and dispersion for quantitative variables. Subsequently, inferential analysis was performed with nonparametric Mann Whitney U tests for two independent samples, the Wilcoxon test for two related samples and the Kruskal-Wallis test for several independent samples, assuming the value of $p < 0,05$ as statistically significant. Bivariate correlations between quantitative and ordinal variables were also used. Microsoft Excel was used for data collection and the analysis was performed using SPSS software version 24.

Results

Regarding sociodemographic and anthropometric variables, the mean age of the athletes was 25 years, while body weight was 70,22 ±8.78 kg. As for height, the mean height was 170,7 ±6.21 cm, with a mean *BMI* of 24,07 ±2.51 kg/m2. However, it was shown that 36,6 % of the athletes were overweight.

Table 1. Training characteristics during confinement by COVID-19

	N	%
Place of confinement		
House	28	93,3
Apartment	1	3,3
Room	1	3,3
Has undergone training during confinement		
Yes	29	96,7
No	1	3,3
Training days during confinement		
1 – 3	5	16,7
3 - 5	21	70
More than 5	4	13,3
Type of space for training during confinement		
None	1	3,3
Open	4	13,3
Closed	9	30
Open and Closed	16	53,3
Type of training performed during confinement		
None	1	3,3
Endurance and/or strength or speed	12	40
Endurance, strength and/or speed or	11	36,7
Technical gestures or Flexibility	3	10
Endurance, strength, speed and/or flexibility or Technical gestures	2	6,7
Flexibility, technical gestures and/or speed, endurance or strength		
Strength and technical gestures	1	3,3
Training time per day during confinement		
None	1	3,3
30 to 60 minutes	15	50,0
60 to 90 minutes	13	43,3
More than 90 minutes	1	3,3
Do you train under the guidance of a professional in the sport?		
Yes	4	13,3
No	9	30,0
Sometimes	17	56,7
Injuries during this time of confinement		
Yes	7	23,3
No	23	76,7

In relation to the players' mean VO2max, this was 43,60 *ml/kg/min* ±4,75 *ml/kg/min*; regarding the perceived exertion during the test (*RPE*), it was observed that there was a proportional perception of exertion according to the stages of the VO2max test, the players' mean perceived exertion was 16, which indicated that towards the end of the test the athletes made a maximum effort (Very hard classification) (figure 1). Regarding explosive strength, a mean of 32,88 *cm* ±3,28 *cm* was found. On the power side a mean of 516,73 *w* ±5,89 w was found and for strength a mean of 1507,6 *N* ± 83,4 *N*.

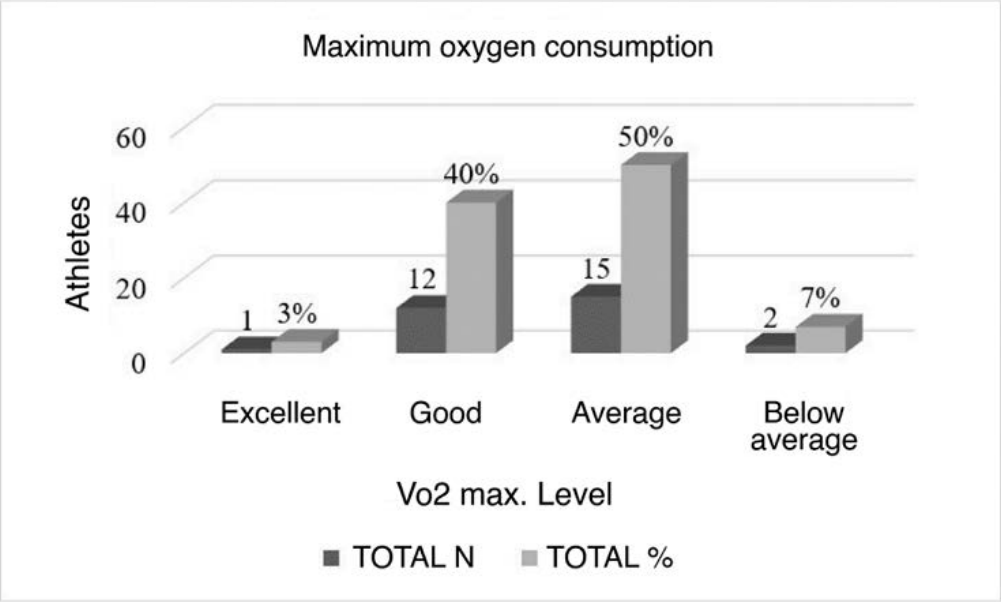

Figure 1. Maximum oxygen uptake (VO2max) of the athletes

Regarding the contextual intelligence questionnaire, it was found that 56,7 % of the futsal players easily intuit the actions of their opponents, 60 % agree that they react quickly to changes in the competition, 36,7 % totally agree that they easily detect the weak points of their opponents, while 43,3 % of the players act with determination in complex situations during the competition (Table 2).

Table 2. Contextual Intelligence in Sport Questionnaire (CISQ) of futsal players

Contextual Intelligence in Sport Questionnaire (CISQ)		
1. I easily sense the actions of my opponent(s).	**N**	**%**
Disagree	1	3,3
Neither agree nor disagree	6	20,0
Agree	17	56,7
Strongly agree	6	20,0
2. I usually choose the appropriate technique for each competition situation.		
Neither agree nor disagree	5	16,7
Agree	18	60,0
Strongly agree	7	23,3
3. I react quickly to changes in the competition.		
Disagree	1	3,3
Neither agree nor disagree	6	20,0
Agree	18	60,0
Strongly agree	5	16,7
4. When I compete, I know how to be in the right place at the right time.		
Neither agree nor disagree	7	23,3
Agree	11	36,7
Strongly agree	12	40,0
5. I tend to be good at deciding on the competition.		
Disagree	2	6,7
Neither agree nor disagree	4	13,3
Agree	18	60,0
Strongly agree	6	20,0
6. I quickly adapt my performance to the circumstances of the competition.		
Disagree	1	3,3
Neither agree nor disagree	5	16,7
Agree	15	50,0
Strongly agree	9	30,0
7. I catch the tricks of my opponent(s).		
Neither agree nor disagree	4	13,3
Agree	19	63,3
Strongly agree	7	23,3
8. I like to take the initiative in competition.		
Disagree	2	6,7
Neither agree nor disagree	2	6,7
Agree	16	53,3
Strongly agree	10	33,3
9. I am alert to the possible actions of my opponent(s).		
Neither agree nor disagree	1	3,3
Agree	13	43,3
Strongly agree	16	53,3
10. I am able to surprise my opponents with sudden attacking actions.		
Strongly Disagree	1	3,3
Neither agree nor disagree	2	6,7
Agree	10	33,3
Strongly agree	17	56,7
11. I easily detect my opponent(s)' weaknesses.		
Neither agree nor disagree	5	16,7
Agree	14	46,7
Strongly agree	11	36,7
12. My main strength is in my intelligence for competition.		
Disagree	1	3,3
Neither agree nor disagree	2	6,7
Agree	22	73,3
Strongly agree	5	16,7
13. I quickly sense the best tactic to use in competition.		
Disagree	2	6,7
Neither agree nor disagree	3	10,0
Agree	22	73,3
Strongly agree	3	10,0
14. I alternate, without hardly thinking about it, changes of pace with sudden attacks when I compete.		
Strongly Disagree	1	3,3
Disagree	2	6,7
Neither agree nor disagree	3	10,0
Agree	12	40,0
Strongly agree	12	40,0
15. I am able to stay ahead of the intentions of my opponent(s).		
Neither agree nor disagree	4	13,3
Agree	19	63,3
Strongly agree	7	23,3
16. I have a knack for deceiving my opponents when competing.		
Disagree	1	3,3
Neither agree nor disagree	2	6,7
Agree	22	73,3
Strongly agree	5	16,7
17. I take advantage of and learn from defeats.		
Neither agree nor disagree	2	6,7
Agree	10	33,3
Strongly agree	18	60,0
18. I have a special instinct to detect the solution of complicated situations in competition.		
Disagree	1	3,3
Neither agree nor disagree	5	16,7
Agree	18	60,0
Strongly agree	6	20,0
19. I am accurate in analyzing competitive situations.		
Neither agree nor disagree	7	23,3
Agree	19	63,3
Strongly agree	4	13,3
20. I have a facility for picking up the style of play of my opponent(s).		
Neither agree nor disagree	1	3,3
Agree	20	66,7
Strongly agree	9	30,0
21. I conceal my intentions well in competition.		
Disagree	2	6,7
Neither agree nor disagree	5	16,7
Agree	16	53,3
Strongly agree	7	23,3
22. I always find the opportunity to outperform my opponents in competition.		
Disagree	1	3,3
Neither agree nor disagree	6	20,0
Agree	17	56,7
Strongly agree	6	20,0
23. I do not hesitate in complex situations and act with determination.		
Disagree	1	3,3
Neither agree nor disagree	4	13,3
Agree	12	40,0
Strongly agree	13	43,3

When analyzing the results of the Stroop test, it was found that the minimum number of responses was 131 and the maximum was 203 total responses, with a maximum of 197 correct responses, 43 % of the soccer players were in the range between 140 to 158 correct responses, while 53 % of the athletes had between 2 to 10 incorrect responses. The average reaction time reached a minimum of 1,10 seconds (s), a maximum of 1,73 s and a mean of 1,41 s (Figure 2).

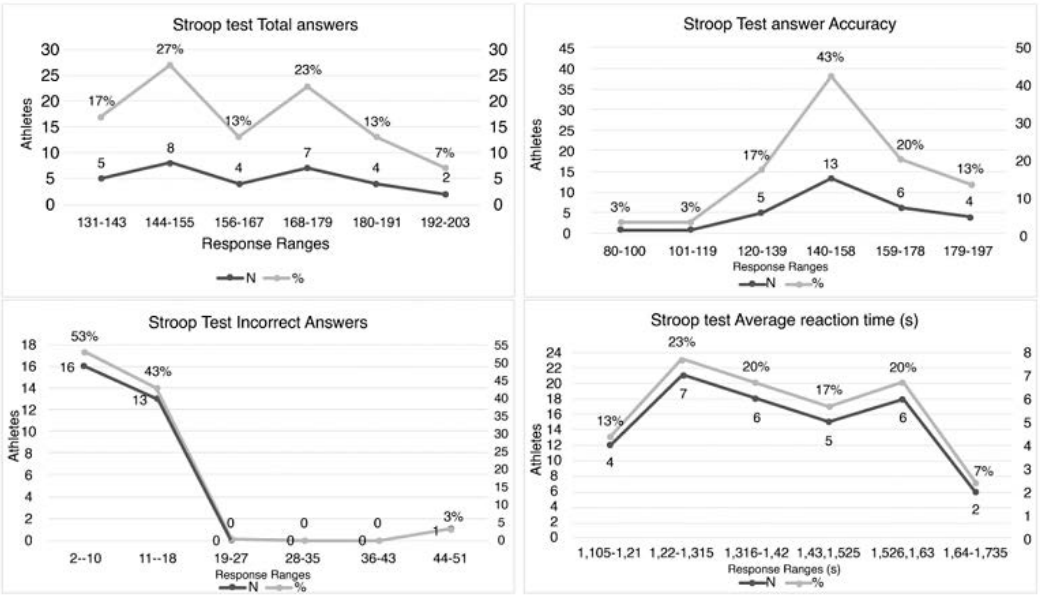

Figure 2. Stroop test of futsal players during confinement by COVID-19

A statistically significant association was found between years of futsal practice with ease of detecting the weak points of my opponents and ease of deceiving my opponents when competing. On the other hand, an association between training under professional guidance, total responses and average reaction time for the Stroop test was found. In addition, a statistical relationship was established between *BMI* and explosive strength (*N*) and power (*W*) (Table 3).

Table 3. Association between sports experience, training under professional guidance, body mass index (BMI), Stroop test, contextual intelligence and explosive strength

Variables	Sig.
Years of practice* I easily detect my opponent(s)' weaknesses.	0,038*
Years of practice* I have a knack for deceiving my opponents when competing.	0,027*
Undergoes training under professional guidance* Stroop Test Total Responses	0,016*
Performs training under professional guidance* average reaction time on the Stroop Test	0,005*
BMI * Explosive force strength(N)	0,002*
BMI* Explosive strength power (W)	0,003*
BMI * Years of futsal practice	0,005*

With reference to the correlations between the variables, a statistically significant relationship was found between VO2max and the intuition to detect the actions of my opponent and the quick reaction to changes in the competition. Likewise, statistical significance was found with taking the initiative in the competition, although the latter presented a negative correlation. On the other hand, the *BMI* showed a statistical relationship with the performance with determination and a negative correlation with the facility to intuit the actions of my opponents. Finally, a positive correlation was found between incorrect answers in the Stroop test and the liking to take initiative during competition (Table 4).

Table 4. Correlations between study variables

Variables	Sig.	Value
VO2max * I can easily sense the actions of my opponents.	0,016*	0,437
VO2max * I react quickly to changes in competition.	0,012*	0,455
VO2max * I like to take the initiative in competition.	0,017*	-0,433
I easily intuit the actions of my opponents * body mass index	0,031*	-0,394
I do not hesitate in complex situations and I act with determination * Body mass index	0,027*	0,403
I like to take the initiative in competition * Incorrect Answers Stroop Test	0,033*	0,391

Discussion

The present research showed that futsal players reported low values of VO2max and lower limb explosive strength. It also found a significant relationship between aerobic fitness, contextual intelligence and decision making. As well, an association was reported between the performance of training under professional guidance and the total responses and the average reaction time for the Stroop test, results that influence the player's performance at the time of his return to competition. In this regard, Spyrou et al., (2021) mentioned that the pandemic brought negative changes in neuromuscular performance, which should be taken into account for periods of reduced training by coaches and athletes for the planning and implementation of efficient strategies for the return to competition after detraining phases.

In relation to body mass index, this study found that 36 % of the futsal players were overweight. Regarding the above, Nikolaidis et al., (2019) reported a prevalence of overweight of 25 % in the different groups of soccer players participating in their research, a situation related to a decrease in performance in specific situations, such as sprinting and jumping during the game. On this, Rubio- Arias et al., (2015) state that an adequate selection of food and liquids consumed, taking into account the requirements of sports practice, can significantly benefit the health of the athlete, providing sufficient caloric intake, maintaining an adequate body weight and maximizing sports performance.

Additionally, on this subject, Sekulic et al., 2021 stated that a reduction in body mass can significantly favor relative strength, producing better responses in acceleration and deceleration actions, jumps and agility. This situation should be taken into account given the results found in the present study where a statistically significant association was found between BMI and explosive strength. In the same way, the confinement measures taken to mitigate the transmissibility of COVID-19 could have contributed negatively to the athletes' diet, as stated by Pillay et al. (2020), who found a significant increase in the consumption of carbohydrates, soft drinks, red meat and processed foods during confinement.

Regarding the characteristics of training during confinement, it was found that most of the athletes trained more than 30 minutes a day and between 3 to 5 days a week, with work on different capacities such as endurance, strength and/or speed. On this subject, during confinement, soccer, field hockey, rugby and netball athletes reported that 61 % trained daily, while 71 % performed strength training with their own body weight, and 89% trained more than 30 minutes daily (Pillay et al., 2020). These results that differ from those reported by futsal players in the city of Popayan. It is also important to highlight that only 13 % of the players performed their training under professional guidance, a situation that should be reviewed, since training guided by sports professionals can generate safe, specific exercise programs with favorable stimuli that can benefit the components related to health and sports skills (Días et al., 2017).

On the other hand, the means found in the evaluation of contextual intelligence were 7.6 for tactical intelligence, 7,8 points for anticipatory and competitive intelligence. However, Ruiz et al, (2014) found an average of anticipatory intelligence of 7.04 points at local level, of 7,15 points at national level and of 7,39 points at international level. In tactical intelligence, the average was 6,86 points at local level, 6,92 points at national level and 7,22 points at international level. In competitive intelligence, the local average was 7,14 points, the national average was 7,26 points and the international average was 7,50 points, values below those found by the present research. It is important to highlight that contextual intelligence in sport stands out

for the relevance it has on the player's decision making in the game, where he must be able to interpret, dominate the context, understand the competition, have reading of the game to decide, anticipate and compete, which allows him to achieve the objectives set (Ruiz et al., 2014). For this, it is important to provide sufficient stimuli for cognitive adaptation with training, however, the perceptual-motor demands could hardly be reproducible during the confinement given the conditions of space to perform the training, which could generate a decrease in the perceptual-cognitive orientation of the game (Luna et al., 2021).

In relation to decision making, an average response time of 1,41 seconds was reported, which shows a reaction time worse than that found in the study by Goenarjo et al. (2020), who found average reaction times of 0,72 seconds in physically active people, while inactive people marked an average time of 0,78 seconds. As stated by Huijgenet al., (2015) "the nature and orientation of the practice environments, of the teaching tasks, constitute a determining variable in the development of executive functions." These practice environments were affected by the restriction measures during confinement, which could bring a negative effect on cognitive abilities due to the cessation of training in the playing field, the emotional load and the stress generated by the confinement (Erazo, 2021). The execution of trainings under professional guidance presented statistically significant association with the total number of responses and the average reaction in the Stroop test. This shows that the cognitive ability of athletes can be favored thanks to planning, organization and execution of trainings supervised by suitable and trained personnel (Yanagisawa et al., 2010).

The maximum oxygen consumption also assessed in this study, showed results that fall far short those reported by other investigations, such as Alvarez et al., 2009. That research found higher VO2max averages at different levels of competition in futsal players (62,9 *ml/kg/min* in professionals, 55,26 *ml/kg/min* in semi-professionals). Similarly, Barcelos et al., (2017) found VO2max values of 55,7 *ml/kg/min* in preseason, 56,6 *ml/kg/min* before competition and 56,2 ml/kg/min after competition. For its part, the jump height shows a detriment in its values, in comparison with the data shown by Grazioli et al., (2020) in soccer players after 63 days of confinement, which presented values of 41,90 cm. Nevertheless, it is important to highlight that these athletes also showed a decrease in neuromuscular performance, although the values are above those found in the futsal players of the present study. The above, allows establishing that the confinement by COVID-19 generated deficiencies in the capacities related to power and aerobic capacity, a situation that should be taken into account by sports professionals once training is restarted for the planning process.

Regarding VO2max and contextual intelligence, this study found statistically significant relationship with the facility to intuit opponents' actions, quick reaction to changes in the competition and taking the initiative in the competition. According to Cuaspa-Burgos (2019), futsal is a sport with a high dynamic of physical, motor, technical, tactical and cognitive demand. This requires an adequate VO2max that allows competing, minimizing technical and tactical errors, and a better cognitive response raising the levels of attention, concentration and decision making during the competition. In other words, a sufficient aerobic capacity has a positive impact on the cognitive response of athletes, in this case it would mean a better expression of the player in terms of anticipating, reading plays, dominating the context and flexibility to adapt to the dynamics of the game. Schmidt et al. (2019) stated in their paper that soccer involves a high physical and mental demand, where neuronal activation in the prefrontal cortex plays an important role in motor function in high intensity requirements. Therefore, it has been found that physiological adaptations of physical exercise can regulate the response of central and peripheral catecholamines favoring the activation of the *PFC* for attention and executive control, which will translate into better decision making during the game.

A correlation between VO2max and the daily time allocated by the athletes for training during confinement was also found. This result demonstrates the importance of maintaining daily training times that allow stimulating aerobic capacity despite not training in the usual proportions and conditions. About this, Martinez et al., (2020) found that confinement increased physical inactivity and sedentary behaviors, which could generate losses in cardiorespiratory fitness and muscle strength.

This study presented limitations for the assessment of VO2max, due to the established confinement and the space available at the players' homes for the development of measurement tests for this parameter. However, the results of this research can contribute to the assessment of this capacity with simple tests adapted to the specific context of the athlete, which will allow having data closer to the reality of the soccer player, generating a better decision making in tele-directed training. In addition, it should be noted that the sample of 30 athletes may be small, however, these athletes were part of the training processes for high performance, given their characteristics and their participation in federated competitions at the national level.

It is relevant to highlight the importance of controlling the body mass index to favor sports performance. Even so, for future studies it is important to contemplate the evaluation of body composition that allows discriminating aspects such as lean mass, fat percentage and body distribution. Yet, it is necessary to remember that given the measures imposed during confinement to maintain a distance of at least two meters, to avoid close contact and the ease of measuring the *BMI*, the option of taking this variable as a reference for this study was viable given the conditions imposed by the COVID-19 pandemic.

Conclusions

COVID-19 brought about different changes in the usual training activities of the athletes, such as the reduction in the space to develop exercise, the lack of professional orientation and the reduction of the daily and weekly stimuli to which the athletes were accustomed before the restrictions implemented for the control of the pandemic, as well as a decrease in the values of aerobic capacity and explosive strength.

Another important aspect that should be highlighted hast to do with the significantly low values reported for cognitive functions such as decision making and contextual intelligence; relevant aspects and factors in the sports performance of futsal players. Additionally, this research found a significant relationship between aerobic fitness and aspects related to cognitive capacity, contextual intelligence and decision making. This implies greater attention by coaches and other exercise professionals for the inclusion of exercises that train initiative, decision making, anticipation and mental speed in situations of high physical demand, allowing the soccer player to perform in competition with possibilities of achieving success.

Conflict of interest

No potential conflict of interest was reported by the authors.

Financing

No financial support was received by the authors.

Acknowledgements

We thank the Universidad del Cauca, Master's program in Sport and Physical Activity and the Physiotherapy program.

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Toma de decisiones, inteligencia contextual, consumo máximo de oxígeno y fuerza explosiva en deportistas de futsal durante el covid-19

Decision-making, contextual intelligence, maximum oxygen consumption and explosive strength in futsal players during COVID-19

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Título abreviado:
Variables psicológicas y fisiológicas en futsal

Cómo citar el artículo:
Peña-Tovar, D.S., Rodríguez-Duque, A.F., & Villaquiran-Hurtado, A.F. (2022). Toma de decisiones, inteligencia contextual, consumo máximo de oxígeno y fuerza explosiva en deportistas de futsal durante el Covid-19. *Cultura, Ciencia y Deporte, 17*(53), 31-54. https://doi.org/10.12800/ccd.v17i53.1855

Recibido: 10 marzo 2022 / Aceptado: 20 mayo 2022

Resumen

La presente investigación buscó determinar la relación entre el consumo máximo de oxígeno, la fuerza explosiva, la toma de decisiones y la inteligencia contextual en deportistas de fútbol sala durante el aislamiento por Covid-19. Estudio descriptivo, realizado con 30 deportistas de futbol sala de la ciudad de Popayán durante el confinamiento por Covid-19, en donde se evaluó las características de entrenamiento, el índice de masa corporal, la capacidad aeróbica, la fuerza explosiva de miembros inferiores, la inteligencia contextual y la toma de decisiones. El promedio de VO2máx de los deportistas fue de 43,60 ml/kg/min, la media en la altura de salto fue de 38,22 cm; el tiempo de reacción promedio para la prueba de Stroop fue de 1,41 s. Además, se encontró relación estadística entre el VO2máx, la intuición para detectar las acciones de mi oponente (p= 0,016), la reacción rápida a los cambios en la competición (p= 0,012) y tomar la iniciativa (p= 0,017). Durante el aislamiento, los deportistas presentaron niveles de sobrepeso, tiempos de reacción lentos para la toma de decisiones, y valores bajos en Vo2 máx. y fuerza explosiva. El VO2 máx. está relacionado con una mejor respuesta cognitiva y toma de decisiones.

Palabras clave: Covid-19, deportes, consumo de oxígeno, fuerza muscular, equipos de deporte. (DeCS), (DeCS).

Abstract

The present study search to determine the relationship between maximum oxygen consumption, explosive force, decision-making and contextual intelligence in futsal athletes during isolation by Covid-19. Descriptive study, carried out with 30 indoor soccer athletes from the city of Popayan during the confinement by Covid-19, where training characteristics, body mass index, aerobic capacity, explosive strength of lower limbs, contextual intelligence and decision making. The average VO2max of the athletes was 43.60 ml/kg/min, the average jump height was 38.22 cm; the average reaction time for the Stroop test was 1.41 s. In addition, a statistical relationship was found between VO2max, the intuition to detect the actions of my opponent (p= 0.016), the quick reaction to changes in the competition (p= 0.012) and taking the initiative (p= 0.017). During the lockdown, the athletes presented levels of overweight, slow reaction times for decision making and low values in Vo2 max. and explosive force. The VO2 max. is related to a better cognitive response and decision making.

Keywords: Covid-19, sports, oxygen consumption, muscle strength, sport teams, (MeSH).

Introducción

El futbol sala se caracteriza por la alta demanda física, fisiológica, biomecánica, neuromuscular, cognitiva y bioquímica generada por la intermitencia de intensidad moderada y vigorosa que exigen en el jugador respuestas eficaces desde un punto de vista físico, técnico, táctico y psicológico durante los dos tiempos de 20 minutos que dura un juego (Spyrou et al., 2020). Las reglas de este deporte fueron diseñadas buscando mantener una alta intensidad en el juego, jugándose entre un 75 a 85% del tiempo total programado, en donde el jugador constantemente está cumpliendo tareas defensivas y ofensivas enmarcadas en diferentes patrones de juego, realizando esfuerzos de alta y máxima intensidad cada 43 a 56 segundos, respectivamente (Naser et al., 2017).

Los deportistas de futsal deben presentar una condición aeróbica óptima para poder tolerar las demandas fisiológicas de alta intensidad presentadas tanto en entrenamiento como en competencia, el nivel en el consumo máximo de oxígeno (VO2max) ha sido relacionado con un mayor número de sprint realizados, mayor distancia recorrida, mayor contacto y participación con balón, con menor fatiga y menos stress cardiovascular durante el juego (Matzenbacher et al., 2014). Por su parte la capacidad de salto es un gesto básico y determinante en la práctica deportiva (Portilla et al., 2019), así mismo Sekulic et al., (2021) plantean que medir el rendimiento del salto es esencial para la valoración de la potencia de los miembros inferiores, la cual está relacionada con acciones de juego específicas de alta intensidad como el sprint, saltos y cambios de dirección.

Para final del año 2019 y principios del 2020 el mundo se vio afectado por la pandemia por COVID-19, lo que generó por parte de los gobiernos nacionales y locales la adopción de medidas de aislamiento y distanciamiento social para la reducción del contagio, lo cual afecto negativamente la participación de los deportistas en las diferentes competencias organizadas, generando que los deportistas de futbol sala se vieran obligados a un aislamiento a largo plazo (Spyrou et al., 2022). En el deporte, el confinamiento produjo efectos negativos sobre las variables fisiológicas, emocionales, de entrenamiento, en los patrones de sueño y el estilo de vida de los atletas (Mon-Lopez et al., 2020). La disminución en el rendimiento deportivo inducido por periodos de desentrenamiento prolongado durante el proceso de aislamiento pudo ocasionar cambios en el rendimiento aeróbico (Bisciotti, 2020), la capacidad de salto y la composición corporal (Grazioli et al., 2020). Además, la detención de los entrenamientos específicos para el futbol sala y/o la adaptación de estos en espacios reducidos y limitados en casa, la falta de motivación para continuar con el proceso de preparación por parte del deportista, dificultades en el manejo y control de las intensidades y cargas de trabajo también pudieron influir en el detrimento total o parcial de las adaptaciones fisiológicas y cognitivas (Sarto et al., 2020).

Respecto a las variables cognitivas, la inteligencia contextual le permite al deportista saber cuándo tomar la iniciativa, reconocer cuáles son sus aspectos fuertes y débiles, dándole la posibilidad de poder adaptarse y plantear una oportuna respuesta ante situaciones exigentes en el componente fisiológico y psicológico (Pérez et al., 2014). Adicionalmente, el conjunto de operaciones cognitivas que son esenciales para la toma de decisiones en entornos complejos como un partido de futbol sala deben ser tenidas en cuenta en los procesos de valoración, entendiendo que la función cognitiva ha sido relacionada con la aptitud aeróbica, y que un adecuado entrenamiento genera adaptaciones fisiológicas y de rendimiento que favorecen la cognición y la función ejecutiva (Hansen et al., 2004). Adicionalmente, la memoria, la atención, la captación de información, la anticipación y las habilidades para la toma de decisiones pueden estar moduladas por las características individuales y el contexto deportivo (Huertas et al., 2019).

Por su parte, la interacción con el entorno a través de estímulos suficientes y necesarios para mejorar la toma de decisiones, y la atención son indispensables para el desarrollo de la inteligencia contextual, que le permita al jugador recoger información de su entorno, procesar, seleccionar y ejecutar respuestas motrices acordes al juego, fundamentales para el éxito deportivo (Guerrero, 2020). Estos argumentos, confirman la relevancia que tiene la toma de decisiones y la inteligencia contextual, como elementos esenciales para determinar la respuesta que puedan dar los deportistas frente a las condiciones de los partidos (Salazar y Montoya, 2015), situación que debe ser considerada por los entrenadores para la evaluación y seguimiento, más aún durante el proceso de confinamiento que trajo cambios notorios y sustanciales en la forma de entrenarse. Por lo anterior, la presente investigación buscó determinar la relación entre el consumo máximo de oxígeno, la fuerza explosiva, la toma de decisiones y la inteligencia contextual en deportistas de fútbol sala de la ciudad de Popayán durante el aislamiento por Covid-19.

Método

Diseño de estudio

Estudio descriptivo de corte transversal.

La presente investigación se realizó bajo los parámetros y recomendaciones establecidas para investigación en humanos dada por la Declaración de Helsinki (World Medical Asociation - AMM, 2013) y la resolución 8430 (Ministerio de Salud, 1993), esta investigación fue catalogada como de riesgo mínimo y contó con la aprobación del Comité de Ética de la Vicerrectoría de investigaciones de la Universidad del Cauca y registro en el sistema de investigaciones con código de identificación No. 5666.

Participantes

En este estudio participaron 30 deportistas de futbol sala de la ciudad del Popayán, con una muestra que fue seleccionada de manera intencional de una población de 40 deportistas registrados en el club y quienes cumplieron con los criterios de inclusión: pertenecer como deportista de futbol sala adscrito a un club profesional con reconocimiento vigente por parte de la liga Caucana de Futbol, haber participado como jugador en competencias nacionales en el año 2019, encontrarse realizando el aislamiento obligatorio en la ciudad de Popayán, manifestar mediante la firma del consentimiento informado la participación voluntaria en el estudio. Para esta investigación se excluyeron los futbolistas que no finalizaron completamente las pruebas, presentaron alguna lesión musculoesquelética en el momento de la evaluación y quienes solicitaron el retiro voluntario; es importante mencionar que 10 deportistas no fueron tenidos en cuenta por encontrarse realizando su aislamiento obligatorio por fuera de la ciudad y/ o no haber participado en competencias oficiales durante el 2019, aunque estos hacían parte de los entrenamientos tele dirigidos durante el aislamiento.

Procedimiento

Para la ejecución de la investigación, inicialmente se informó a las directivas, cuerpo técnico y jugadores del club sobre los objetivos y alcance del proyecto, una vez se contó con la aprobación, se procedió a iniciar el proceso de recolección de datos y evaluaciones respectivas con los futbolistas en el domicilio de cada uno de ellos. Estas valoraciones se realizaron en el mes de septiembre, adoptando y acatando por parte de los evaluadores las medidas de restricción y de bioseguridad dadas por el gobierno nacional y municipal durante ese mes.

Como primer paso para la toma de datos, se realizó una encuesta para tomar los datos sociodemográficos (edad, sexo, estrato socio económico y escolaridad), deportivos (años de práctica, tiempo de práctica por sesión diaria, frecuencia semanal de práctica, entre otras), y de entrenamiento durante el confinamiento por COVID 19 (tipo de entrenamiento, lugar de entrenamiento, espacio de entrenamiento (abierto, cerrado), lesiones musculo-esqueléticas, signos y síntomas de COVID 19), ajustada mediante prueba piloto. Posteriormente, se procedió a realizar el cuestionario de inteligencia contextual (CIC) percibida en el deporte, el cual tiene una estructura de tres dimensiones (inteligencia anticipatoria, inteligencia táctica e inteligencia competitiva), compuesto por 23 ítems, donde cada ítem presentaba una escala tipo Likert de 1 a 10, validado por Ruiz et. al (2014).

Una vez contestados los dos cuestionarios anteriores, los evaluadores se desplazaban a la casa del deportista para realizar la toma de medidas antropométricas (Stewart et al., 2011), para continuar con la prueba de Stroops, la cual es una prueba de velocidad mental (Afsaneh et al., 2012), considerada como una medida psicométrica confiable para determinar el rendimiento en cuanto a atención selectiva al introducir una interferencia, en donde las palabras insertadas en la identificación de colores actúan como un distractor para el individuo (Araya y Sáenz, 2019), partiendo de la premisa que los individuos pueden leer palabras mucho más rápido de lo que pueden identificar y nombrar colores, generando el efecto Stroops (Golden, 1999). Esta prueba ha sido validada, presentando una alta confiabilidad para diversos grupos poblacionales, siendo aplicada exitosamente como medida psicométrica (Ahmed et al., 2015). El resultado de cada prueba mostró la puntuación total, el número total de intentos acertados e intentos perdidos y el tiempo promedio por respuesta. (Suresh et al., 2018).

Adaptándose a las disposiciones de aislamiento y utilizando los recursos disponibles en cada sitio de confinamiento del jugador para la evaluación del consumo máximo de oxígeno, se utilizó el Chester Step Test (Heydenreich et al., 2019), el cual permitió evaluar la capacidad aeróbica del deportista. El test consta de 5 etapas, 1º etapa: 15 pasos/min, 2º etapa: 20 pasos/min, 3º etapa: 25 pasos/min, 4º etapa: 30 pasos/min y 5º Etapa: 35 pasos/min; donde el evaluado debía subir y bajar un escalón de 30 cm de altura; para marcar el ritmo de ejecución de la prueba se utilizó un audio que determinó los pasos por minuto que ejecutó el evaluado al subir y al bajar, el test marca una velocidad establecida por el latido del metrónomo de dicho audio grabado previamente donde la velocidad inicial es de 15 pasos por minuto y cada 2 minutos el tiempo aumentó en 5 pasos por minuto. Al finalizar cada etapa se tomó la frecuencia cardiaca (FC) y el rango de esfuerzo percibido (RPE) en escala de Borg de 6-20. Para hallar el VO2máx. se utilizó la siguiente fórmula:

VO2máx= Altura del escalón (m) × número de ciclos × peso (kg) × 0,16357.21

Posteriormente, se evaluó la fuerza explosiva de miembros inferiores por medio de del salto vertical Counter Movement Jump (CMJ) a través de la aplicación movil My Jump 2 (Haynes et al., 2019). La aplicación es una herramienta móvil que aprovecha la cámara del celular, capaz de grabar a 120Hz, lo que permite medir con precisión el rendimiento del salto, con una alta validez y confiabilidad en los datos, con una excelente correlación entre la aplicación y las plataformas de contacto, convirtiéndose en una herramienta fácil de usar y con un coste económico mucho menor a las plataformas de salto (Balsalobre et al., 2014).

Análisis estadístico

Para el análisis estadístico se realizó el análisis descriptivo con distribuciones de frecuencia y porcentaje, y medidas de tendencia central y de dispersión para las variables cuantitativas. Posteriormente, se realizó el análisis inferencial con pruebas no paramétrica de U de Mann Whitney para dos muestras independientes, la prueba de Wilcoxon para dos muestras relacionadas y la prueba de Kruskal-Wallis para varias muestras independientes, asumiendo el valor de $p<0,05$ como estadísticamente significativo. Así mismo se utilizaron correlaciones bivariadas entre variables cuantitativas y ordinales. Se utilizó Microsoft Excel para recolección de datos y el análisis se realizó usando el software SPSS versión 24.

Resultados

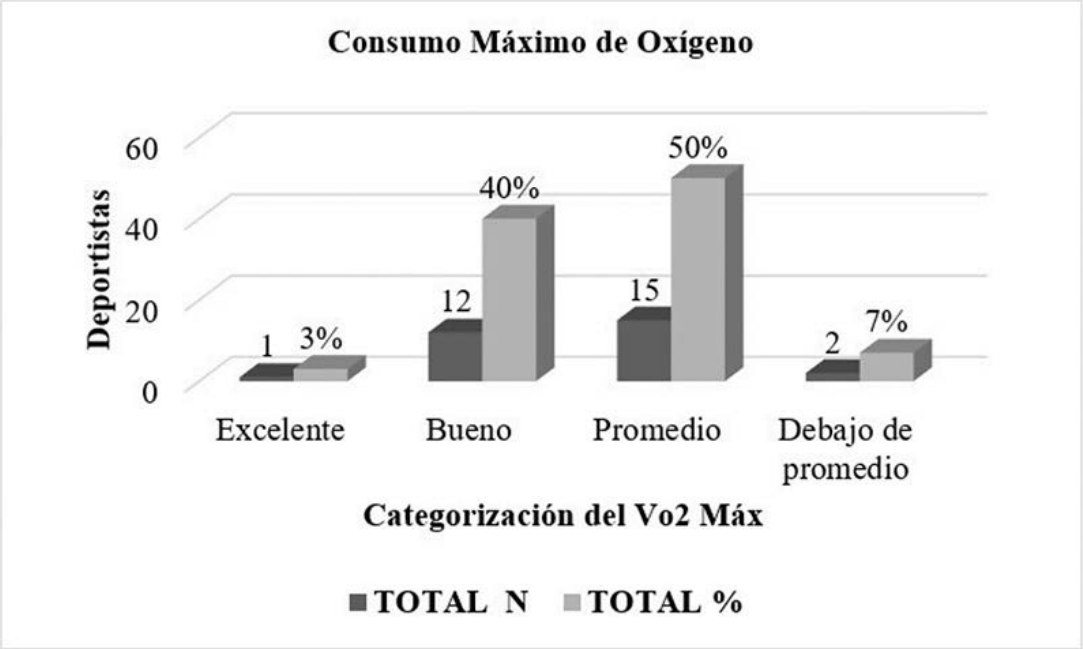
Con relación a las variables sociodemográficas y antropométricas, la edad media de los deportistas fue de 25 años, mientras que el peso corporal fue de 70,22 ±8,78 kg. En cuanto a la estatura la media fue de 170,7 ±6,21 cm, con una media de IMC de 24,07 ±2,51 kg/m2. Sin embargo, se reflejó que el 36,6% de los deportistas se encuentran en sobrepeso.

Tabla No 1. Características de entrenamiento durante el confinamiento por Covid-19

	N	%
Lugar de confinamiento		
Casa	28	93,3
Apartamento	1	3,3
Habitación	1	3,3
Ha realizado entrenamiento durante el confinamiento		
Si	29	96,7
No	1	3,3
Días de entrenamiento durante el confinamiento		
1 – 3	5	16,7
3 - 5	21	70
Más de 5	4	13,3
Tipo de espacio para el entrenamiento durante el confinamiento		
Ninguno	1	3,3
Abierto	4	13,3
Cerrado	9	30
Abierto y Cerrado	16	53,3
Tipo de entrenamiento realizado durante el confinamiento		
Ninguno	1	3,3
Resistencia y/o fuerza o velocidad	12	40
Resistencia, fuerza y/o velocidad o Gestos técnicos o flexibilidad	11	36,7
Resistencia, fuerza, velocidad y/o flexibilidad o Gestos técnicos	3	10
Flexibilidad, gestos técnicos y/o velocidad, resistencia o fuerza	2	6,7
Fuerza y Gestos técnicos	1	3,3
---Tiempo de entrenamiento por día durante el confinamiento		
Ninguno	1	3,3
De 30 a 60minutos	15	50,0
De 60 a 90 minutos	13	43,3
Más de 90 minutos	1	3,3
¿Realiza sus entrenamientos bajo orientación de algún profesional en el deporte?		
Si	4	13,3
No	9	30,0
Algunas veces	17	56,7
Lesiones durante este tiempo de confinamiento		
Si	7	23,3
No	23	76,7

Con relación a la media de VO2máx de los deportistas fue de 43,60 ml/kg/min ±4,75 ml/kg/min; en cuanto al esfuerzo percibido durante la prueba (RPE) se observó que hubo una percepción de esfuerzo proporcional de acuerdo con las etapas que tuvo la prueba de VO2Máx, la media del esfuerzo percibido de los deportistas fue de 16, lo que indicó que hacia el final de la prueba los deportistas realizaron un máximo esfuerzo (clasificación Muy duro) (figura 1). En cuanto a la fuerza explosiva se encontró una media de 32,88 cm ±3,28 cm. Por el lado de la potencia se encontró una media de 516,73 w ±5,89 w y para la fuerza una media de 1507,6 N ± 83,4 N.

Figura No 1. Consumo máximo de oxígeno (VO2máx) de los deportistas



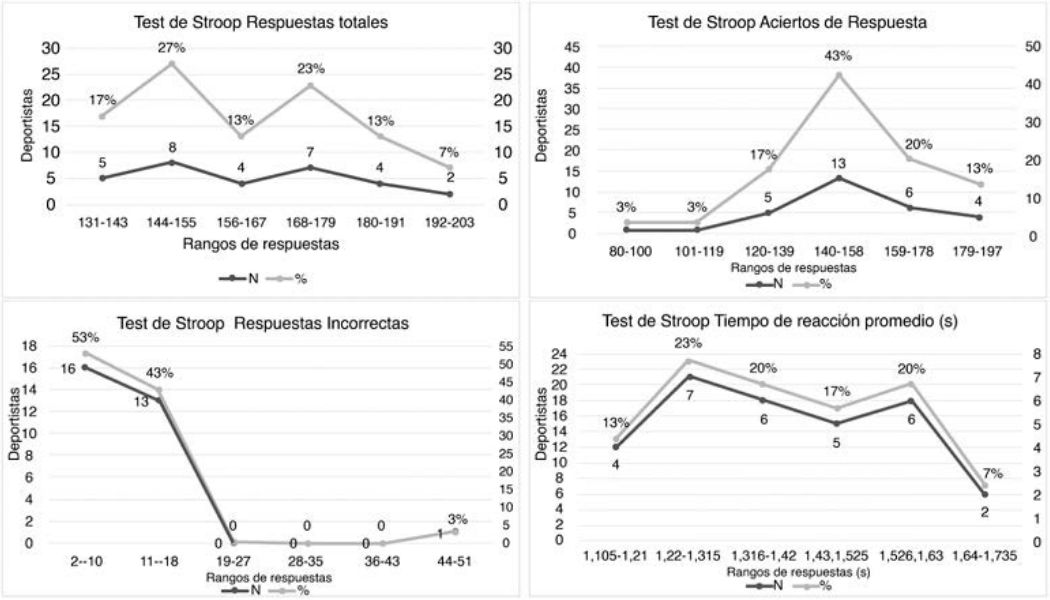
Respecto al cuestionario de inteligencia contextual, se encontró que el 56,7% de los futbolistas intuyen con facilidad las acciones de sus oponentes, el 60% dicen estar de acuerdo con reaccionar rápidamente a los cambios en la competición, el 36,7% está totalmente de acuerdo con que detecta con facilidad los puntos débiles de sus oponentes, mientras que el 43,3% de los deportistas actúa con determinación ante situaciones complejas durante la competencia (tabla 2).

Tabla No 2. Cuestionario de Inteligencia Contextual en el Deporte (ICD) de los deportistas de futbol sala

Cuestionario Inteligencia Contextual en el Deporte (ICD)		
1. Intuyo con facilidad las acciones de mi(s) oponente(s).	**N**	**%**
En desacuerdo	1	3,3
Ni de acuerdo ni en desacuerdo	6	20,0
De acuerdo	17	56,7
Totalmente de acuerdo	6	20,0
2.Suelo elegir la técnica apropiada para cada situación de la competición.		
Ni de acuerdo ni en desacuerdo	5	16,7
De acuerdo	18	60,0
Totalmente de acuerdo	7	23,3
3. Reacciono rápidamente a los cambios en la competición		
En desacuerdo	1	3,3
Ni de acuerdo ni en desacuerdo	6	20,0
De acuerdo	18	60,0
Totalmente de acuerdo	5	16,7
4. Cuando compito sé estar en el lugar adecuado en el momento oportuno		
Ni de acuerdo ni en desacuerdo	7	23,3
De acuerdo	11	36,7
Totalmente de acuerdo	12	40,0
5. Suelo ser bueno/a al decidir en la competición		
En desacuerdo	2	6,7
Ni de acuerdo ni en desacuerdo	4	13,3
De acuerdo	18	60,0
Totalmente de acuerdo	6	20,0
6. Adapto rápidamente mi actuación a las circunstancias de la competición		
En desacuerdo	1	3,3
Ni de acuerdo ni en desacuerdo	5	16,7
De acuerdo	15	50,0
Totalmente de acuerdo	9	30,0
7. Capto los engaños de mi(s) oponente(s).		
Ni de acuerdo ni en desacuerdo	4	13,3
De acuerdo	19	63,3
Totalmente de acuerdo	7	23,3
8. Me gusta tomar la iniciativa en la competición.		
En desacuerdo	2	6,7
Ni de acuerdo ni en desacuerdo	2	6,7
De acuerdo	16	53,3
Totalmente de acuerdo	10	33,3
9. Estoy alerta ante las posibles acciones de mi(s) oponente(s).		
Ni de acuerdo ni en desacuerdo	1	3,3
De acuerdo	13	43,3
Totalmente de acuerdo	16	53,3
10. Soy capaz de sorprender a mis oponentes con acciones de ataque repentinas		
Totalmente en desacuerdo	1	3,3
Ni de acuerdo ni en desacuerdo	2	6,7
De acuerdo	10	33,3
Totalmente de acuerdo	17	56,7
11. Detecto con facilidad los puntos débiles de mi(s) oponente(s).		
Ni de acuerdo ni en desacuerdo	5	16,7
De acuerdo	14	46,7
Totalmente de acuerdo	11	36,7
12. Mi fortaleza principal está en mi inteligencia para la competición		
En desacuerdo	1	3,3
Ni de acuerdo ni en desacuerdo	2	6,7
De acuerdo	22	73,3
Totalmente de acuerdo	5	16,7
13. Intuyo con rapidez cuál es la mejor táctica para emplear en la competición		
En desacuerdo	2	6,7
Ni de acuerdo ni en desacuerdo	3	10,0
De acuerdo	22	73,3
Totalmente de acuerdo	3	10,0
14. Alterno, sin apenas pensarlo, cambios de ritmo con ataques repentinos cuando compito		
Totalmente en desacuerdo	1	3,3
En desacuerdo	2	6,7
Ni de acuerdo ni en desacuerdo	3	10,0
De acuerdo	12	40,0
Totalmente de acuerdo	12	40,0
15. Soy capaz de ir por delante de las intenciones de mi(s) oponente(s).		
Ni de acuerdo ni en desacuerdo	4	13,3
De acuerdo	19	63,3
Totalmente de acuerdo	7	23,3
16. Tengo facilidad para engañar a mis oponentes al competir		
En desacuerdo	1	3,3
Ni de acuerdo ni en desacuerdo	2	6,7
De acuerdo	22	73,3
Totalmente de acuerdo	5	16,7
17. Saco partido y aprendo de las derrotas		
Ni de acuerdo ni en desacuerdo	2	6,7
De acuerdo	10	33,3
Totalmente de acuerdo	18	60,0
18. Tengo un instinto especial para detectar la solución de las situaciones complicadas en competición		
En desacuerdo	1	3,3
Ni de acuerdo ni en desacuerdo	5	16,7
De acuerdo	18	60,0
Totalmente de acuerdo	6	20,0
19. Soy preciso/a analizando las situaciones de competición		
Ni de acuerdo ni en desacuerdo	7	23,3
De acuerdo	19	63,3
Totalmente de acuerdo	4	13,3
20. Tengo facilidad para captar el estilo de juego de mi(s) oponente(s).		
Ni de acuerdo ni en desacuerdo	1	3,3
De acuerdo	20	66,7
Totalmente de acuerdo	9	30,0
21. Disimulo bien mis intenciones en la competición		
En desacuerdo	2	6,7
Ni de acuerdo ni en desacuerdo	5	16,7
De acuerdo	16	53,3
Totalmente de acuerdo	7	23,3
22. Sé encontrar siempre la oportunidad para superar a mis oponentes en la competición		
En desacuerdo	1	3,3
Ni de acuerdo ni en desacuerdo	6	20,0
De acuerdo	17	56,7
Totalmente de acuerdo	6	20,0
23. No dudo ante las situaciones complejas y actuó con determinación		
En desacuerdo	1	3,3
Ni de acuerdo ni en desacuerdo	4	13,3
De acuerdo	12	40,0
Totalmente de acuerdo	13	43,3

Al analizar los resultados de la prueba de Stroop, se encontró que el mínimo número de respuestas fue de 131 y el máximo fue de 203 respuestas totales, con un máximo de 197 respuestas correctas, el 43% de los futbolistas se encontraron en el rango entre 140 a 158 respuestas correctas, mientras que el 53% de los deportistas tuvieron entre 2 a 10 respuestas incorrectas. Por su parte, el tiempo de reacción promedio alcanzó un mínimo de 1,10 segundos (s), un máximo de 1,73 s y una media de 1,41 s (Grafico 2).

Figura No 2. Test de Stroop deportistas de futbol sala durante el confinamiento por Covid-19



Se encontró asociación estadísticamente significativa entre años de práctica del fútbol sala con facilidad para detectar los puntos débiles de mis oponentes y facilidad para engañar a mis oponentes al competir. Por otro lado, se encontró asociación entre la realización de entrenamientos bajo orientación profesional, las respuestas totales y el tiempo de reacción promedio para la prueba de Stroop. Además, se estableció relación estadística entre el IMC con la fuerza explosiva fuerza (N) y potencia (W) (tabla 3).

Tabla No 3. Asociación entre experiencia deportiva, entrenamientos bajo orientación profesional, índice de masa corporal (IMC), test de Stroop, inteligencia contextual y fuerza explosiva

Variables	Sig.
Años de práctica* Detecto con facilidad los puntos débiles de mis oponentes	0,038*
Años de práctica* Tengo facilidad para engañar a mis oponentes al competir.	0,027*
Realiza entrenamientos bajo orientación profesional* Test Stroop Respuestas Totales	0,016*
Realiza entrenamientos bajo orientación profesional* tiempo promedio de reacción en el Test Stroop	0,005*
IMC * Fuerza explosiva fuerza(N)	0,002*
IMC* Fuerza explosiva potencia (W)	0,003*
IMC * Años de práctica de fútbol sala	0,005*

*p valor < 0,05

Con referencia a las correlaciones entre las variables, se encontró relación estadísticamente significativa entre el VO2máx y la intuición para detectar las acciones de mi oponente y la reacción rápida a los cambios en la competición, así mismo se encontró significancia estadística con tomar la iniciativa en la competición, aunque esta última presento una correlación negativa. Por otra parte, el IMC presento relación estadística con la actuación con determinación y una correlación negativa con la facilidad para intuir las acciones de mis oponentes. Por último, se encontró correlación positiva entre respuestas incorrectas de la prueba de Stroop y el gusto por tomar iniciativas durante la competición (tabla 4).

Tabla No 4. Correlaciones entre variables de estudio

Variables	Sig.	Valor
VO2máx * Intuyo con facilidad las acciones de mis oponentes	0,016*	0,437
VO2máx * Reacciono rápidamente a los cambios en la competición	0,012*	0,455
VO2máx * Me gusta tomar la iniciativa en la competición	0,017*	-0,433
Intuyo con facilidad las acciones de mis oponentes * índice de masa corporal	0,031*	-0,394
No dudo ante situaciones complejas y actúo con determinación * Índice de masa corporal	0,027*	0,403
Me gusta tomar la iniciativa en la competición * Respuestas Incorrectas Test Stroop	0,033*	0,391

*p valor < 0,05

Discusión

La presente investigación mostro que los futbolistas de sala reportaron valores bajos de VO2max y de fuerza explosiva de miembros inferiores, encontrándose también una relación significativa entre la condición aeróbica, la inteligencia contextual y la toma de decisiones. Así mismo, se reportó asociación entre la realización de entrenamientos bajo orientación profesional y las respuestas totales y el tiempo de reacción promedio para la prueba de Stroop, resultados que influyen sobre el rendimiento del atleta en el momento de realizar su vuelta a la competición. Al respecto, Spyrou et al., (2021) menciono que la pandemia trajo consigo cambios negativos en el rendimiento neuromuscular, lo que debe ser tenido en cuenta para periodos de reducción del entrenamiento por parte de los entrenadores y atletas para la planeación e implementación de estrategias eficientes para el retorno a la competencia después de fases de desentrenamiento.

Con relación al índice de masa corporal, este estudio encontró que el 36% de los futbolistas presento niveles de sobrepeso. Respecto a lo anterior Nikolaidis et al., (2019) reportaron una prevalencia de sobrepeso del 25% en los diferentes grupos de futbolistas participantes en su investigación, situación relacionada con una disminución del rendimiento en situaciones específicas, como esprintar y saltar durante el juego. Sobre esto, Rubio- Arias et al., (2015) manifiestan que una selección adecuada de los alimentos y líquidos consumidos, teniendo en cuenta los requerimientos de la práctica deportiva, pueden beneficiar notablemente la salud del atleta, suministrando el aporte calórico suficiente, manteniendo un adecuado peso corporal y maximizando el rendimiento deportivo.

Adicionalmente sobre este tema, Sekulic et al., 2021 afirmaron que una reducción de la masa corporal puede favorecer significativamente la fuerza relativa, produciendo mejores respuestas en acciones de aceleración y desaceleración, saltos y agilidad, situación que debe ser tenida en cuenta dado los resultados encontrados en el presente estudio donde se encontró asociación estadísticamente significativa entre el IMC y la fuerza explosiva. Igualmente, las medidas de aislamiento tomadas para mitigar la transmisibilidad del Covid-19 pudieron contribuir negativamente en la alimentación de los deportistas, tal y como lo afirma Pillay et al., (2020), quienes encontraron un aumento significativo en el consumo de carbohidratos, gaseosas, carnes rojas y alimentos procesados durante el confinamiento.

Respecto a las características de entrenamiento durante el confinamiento, se encontró que la mayoría de los deportistas entrenaban más de 30 minutos diarios y entre 3 a 5 días a la semana, con trabajos de las diferentes capacidades como resistencia, fuerza y/o velocidad. Sobre este tema, deportistas de futbol, hockey, rugby y netball durante el confinamiento, reportaron que el 61% entrenaban diariamente, mientras que el 71% realizaban entrenamientos de la fuerza con su propio peso corporal, así mismo el 89% entrenaban más de 30 minutos diarios (Pillay et al., 2020), resultados que difieren con lo reportado por los deportistas de futbol sala de la ciudad de Popayán. También es importante resaltar que tan solo el 13% de los deportistas realizaron su entrenamiento bajo orientación profesional, situación que debe revisarse, puesto que el entrenamiento orientado por profesionales del deporte puede generar programas de ejercicio seguros, específicos y con estímulos favorables que pueden beneficiar los componentes relacionados con la salud y las habilidades deportivas (Días et al., 2017).

Por su parte, las medias encontradas en la evaluación de la inteligencia contextual fueron de 7,6 para inteligencia táctica, 7,8 puntos para inteligencia anticipatoria y competitiva; no obstante Ruiz et al., (2014) encontraron una media de inteligencia anticipatoria a nivel local de 7,04 puntos, a nivel nacional de 7,15 puntos e internacional de 7,39 puntos; en la de inteligencia táctica la media a nivel local fue de 6,86 puntos, a nivel nacional de 6,92 puntos e internacional de 7,22 puntos; y en la inteligencia competitiva la media local fue de 7,14 puntos, a nivel nacional de 7,26 puntos e internacional de 7,50 puntos, valores por debajo de los encontrados por la presente investigación. Es importante resaltar que la inteligencia contextual en el deporte se destaca por la relevancia que tiene sobre la toma de decisiones del jugador en el juego, donde debe ser capaz de interpretar, dominar el contexto, comprender la competencia, tener lectura del partido para decidir, anticipar y competir que le permita alcanzar los objetivos trazados (Ruiz et al., 2014). Para ello, es importante brindar con el entrenamiento los estímulos suficientes para la adaptación cognitiva, sin embargo, las exigencias perceptivo- motrices difícilmente durante el confinamiento pudieron ser reproducibles dadas las condiciones de espacio para realizar el entrenamiento, lo que pudo generar una disminución de la orientación perceptivo-cognitiva del juego (Luna et al., 2021).

Con relación a la toma de decisiones, se reportó un tiempo promedio de respuesta de 1,41 segundos, lo que muestra un tiempo de reacción peor de lo encontrado en el estudio de Goenarjo et al. (2020), quienes encontraron tiempos de reacción promedio de 0,72 segundos en personas físicamente activas, mientras que personas inactivas marcaron una media de tiempo de 0,78 segundos. Como lo afirma Huijgenet al., (2015) "la naturaleza y orientación de los entornos de práctica, de las tareas de enseñanza, constituyen una variable determinante en el desarrollo de las funciones ejecutivas"; estos entornos de practica se vieron afectados por las medidas de restricción durante el aislamiento, lo que pudo traer un efecto negativo sobre las capacidades cognitivas debido al cese de entrenamientos en el campo de juego, la carga emocional y el estrés generado por el confinamiento (Erazo, 2021).

La realización de los entrenamientos bajo orientación profesional presentó asociación estadísticamente significativa con el total de respuestas y el promedio de reacción en la prueba de Stroop, lo que evidencia que la capacidad cognitiva de los deportistas se puede ver favorecida gracias a la planificación, organización y ejecución de entrenamientos supervisados por personal idóneo y capacitado (Yanagisawa et al., 2010).

El consumo máximo de oxígeno valorado también en este estudio, mostro resultados muy por debajo de lo reportado por otras investigaciones, como la de Álvarez et al., (2009), quienes encontraron medias más altas del VO2máx en diferentes niveles de competición en jugadores de futbol sala (62,9 ml/kg/min en profesionales, 55,26 ml/kg/min en semiprofesionales). De la misma manera, Barcelos et al., (2017) encontró valores de Vo2máx de 55,7 ml/kg/min en pretemporada, 56,6 ml/kg/min antes de la competencia y de 56,2 ml/kg/min después de la competición. Por su parte, la altura del salto muestra un detrimento en sus valores, en comparación con los datos mostrados por Grazioli et al., (2020) en futbolistas después de 63 días de confinamiento, los cuales presentaron valores de 41,90 cm; no obstante, es importante resaltar que estos deportistas también demostraron una disminución del rendimiento neuromuscular, aunque los valores están por encima de lo encontrado en los futbolistas de sala de este estudio. Lo anterior, permite establecer que el confinamiento por Covid-19 generó deficiencias en las capacidades relacionadas con la potencia y la capacidad aeróbica, situación que debe ser tenida en cuenta por los profesionales del deporte una vez se reinicien los entrenamientos para el proceso de planificación.

En cuanto al VO2máx y la inteligencia contextual, este estudio encontró relación estadísticamente significativa con la facilidad para intuir acciones de los oponentes, la reacción rápida a los cambios en la competencia y tomar la iniciativa en la competencia. Según, Cuaspa-Burgos (2019) el futbol sala es un deporte con una dinámica alta de exigencia física, motriz, técnica, táctica y cognitiva, el cual requiere de un VO2máx adecuado que permita competir, minimizar los errores técnicos y tácticos, y una mejor respuesta cognitiva elevando los niveles de atención, concentración y toma de decisiones durante la competencia. Es decir que, una capacidad aeróbica suficiente incide positivamente sobre la respuesta cognitiva de los deportistas, en este caso supondría una mejor expresión del jugador en términos de anticipar, leer jugadas, dominar el contexto y flexibilidad para adaptarse a las dinámicas del juego. Schmidt et al., (2019) plantearon en su texto que el futbol supone una alta demanda tanto física como mental, en donde la activación neuronal en la corteza prefrontal juega un papel importante en la función motora en exigencias de alta intensidad, por lo cual se ha encontrado que las adaptaciones fisiológicas del ejercicio físico pueden regular la respuesta de las catecolaminas centrales y periféricas favoreciendo la activación del CPF para la atención y el control ejecutivo, lo que se va a traducir en una mejor toma de decisiones durante el juego.

También se encontró correlación entre el VO2max y el tiempo diario destinado por los deportistas para entrenar durante el confinamiento. Este resultado demuestra la importancia de mantener los tiempos de entrenamiento diarios que permitan estimular la capacidad aeróbica a pesar de no entrenar en las proporciones y condiciones

habituales. Sobre esto, Martinez et al., (2020) encontraron que el confinamiento aumento las conductas de inactividad física y sedentarismo, lo que pudo generar perdidas de la aptitud cardiorrespiratoria y de fuerza muscular.

Este estudio presentó limitaciones para la valoración del VO2max, producto del confinamiento establecido y por el espacio disponible en casa de los atletas para el desarrollo de pruebas de medición para este parámetro, sin embargo, los resultados de esta investigación pueden contribuir a la valoración de esta capacidad con pruebas sencillas y adecuadas al contexto especifico del deportista, lo que permitirá tener datos más cercanos a la realidad del futbolista, generando una mejor toma de decisiones en entrenamientos tele dirigidos. Además, cabe resaltar que la muestra de 30 atletas puede ser pequeña, no obstante, estos deportistas hacían parte de los procesos de entrenamiento para el alto rendimiento, dadas sus características y la participación de estos en competencias federadas a nivel nacional.

Es importante destacar la importancia que tiene el control sobre el índice de masa corporal para favorecer el rendimiento deportivo, sin embargo para próximos estudios es importante contemplar la valoración de la composición corporal que permita discriminar aspectos como la masa magra, el porcentaje de grasa y la distribución corporal; no obstante es necesario recordar que ante las medidas impuestas durante el confinamiento para mantener una distancia de al menos dos metros, evitar el contacto estrecho y la facilidad de la toma del IMC, la opción de tomar como referencia esta variable para este estudio fue viable dadas las condiciones impuestas por la pandemia por Covid-19.

Conclusiones

El Covid-19 trajo consigo diferentes cambios en las actividades habituales en el entrenamiento de los deportistas, como la reducción en el espacio para desarrollar ejercicio, la poca orientación profesional y la reducción de los estímulos diarios y semanales a los cuales estaban acostumbrados los atletas antes de las restricciones implementadas para el control de la pandemia, así como también se encontró una disminución en los valores de la capacidad aeróbica y la fuerza explosiva.

Otro aspecto importante que se debe resaltar son los valores significativamente bajos reportados en cuanto a las funciones cognitivas como la toma de decisiones y la inteligencia contextual; aspectos y factores relevantes en el desempeño deportivo del futbolista de sala. Adicionalmente, esta investigación halló relación significativa entra la condición aeróbica y aspectos relacionados con la capacidad cognitiva, la inteligencia contextual y la toma de decisiones, lo que supone una mayor atención por parte de los entrenadores y demás profesionales del ejercicio para la inclusión de ejercicios que entrenen la iniciativa, la capacidad de decidir, la anticipación y la rapidez mental ante situaciones de alta exigencia física, permitiendo al futbolista rendir en competencia con posibilidades de lograr el éxito.

Conflicto de intereses

Los autores declaramos no tener ningún conflicto de intereses.

Financiación

La presente investigación no contó con ninguna fuente de financiación.

Agradecimientos

Agradecemos a la Universidad del Cauca, al programa de Maestría en Deporte y Actividad Física y al programa de Fisioterapia.

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CULTURA, CIENCIA Y DEPORTE

Methods for estimating biological maturation in developing and growing athletes: A literature review

Métodos de estimación de la maduración biológica en deportistas en etapa de desarrollo y crecimiento: Revisión bibliográfica

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Short title:
Estimation of maturation in growing athletes: Literature review

How to cite this article:
Albaladejo-Saura, M., Vaquero-Cristóbal, R., & Esparza-Ros, F. (2022). Methods for estimating biological maturation in developing and growing athletes: A literature review. *Cultura, Ciencia y Deporte, 17*(53), 55-75. https://doi.org/10.12800/ccd.v17i53.1925

Received: 28 march 2022 / Accepted: 30 may 2022

Abstract

The indicators related to biological maturation have been studied for decades. The changes produced by maturation have a significant effect on the performance of young athletes. The aim of this literature review was to analyze the most commonly used methods of estimating biological maturation in sports science. Four main methods were identified that address different indicators of biological maturation: radiographic methods, which estimate biological age through bone development; anthropometric methods, which estimate the rate of biological maturation through changes in growth velocity and proportionality; sexual maturation methods, based on the manifestation of male and female sexual characteristics; and dental maturation methods, which estimate biological age through tooth development. The "gold standard" for estimating the maturational state are the methods based on radiography of the hand and wrist; however, their limitations mean that their use in the assessment of young athletes is conditioned. Widely-used alternatives are anthropometric methods, which, although not free of limitations, have been shown to have sufficient reliability and validity. Sexual or tooth maturation do not seem to be as applicable in this field.

Keywords: Puberty, growth, physical exercise, maturational development, performance.

Resumen

Los indicadores relacionados con la maduración biológica han sido estudiados desde hace décadas. Los cambios que produce la maduración afectan de forma trascendental al rendimiento de los jóvenes deportistas. El objetivo de esta revisión bibliográfica fue analizar los métodos de estimación de la maduración biológica más empleados en ciencias del deporte. Se han identificado cuatro métodos principales que abordan indicadores de la maduración biológica distintos: los métodos radiográficos, que estiman la edad biológica a través del desarrollo óseo; métodos antropométricos, que estiman el ritmo de la maduración biológica a través de cambios en la velocidad de crecimiento y la proporcionalidad; métodos de maduración sexual, basados en la manifestación de los caracteres sexuales masculinos y femeninos; y métodos de maduración dental, que estiman la edad biológica a través del desarrollo dental. El “gold standard” para estimar el estado madurativo son los métodos basados en radiografía de la mano y muñeca, sin embargo, sus limitaciones hacen que su empleo en la valoración de deportistas jóvenes se encuentre condicionado. Una alternativa muy utilizada son las antropométricas, que aunque no están exentas de limitaciones, han mostrado tener suficiente fiabilidad y validez. La maduración sexual o dental parecen no ser tan aplicables en este ámbito.

Palabras clave: Pubertad, crecimiento, ejercicio físico, desarrollo madurativo, rendimiento.

Introduction

Conceptual approach to the term maturation, chronological age, biological age and peak height velocity.

Maturation, in relation to human growth, refers to the time and process of change from childhood to reach the adult maturational state (Malina & Bouchard, 1991). These processes have been extensively studied in their different stages, but special attention has been traditionally paid to the endocrine, structural, physiological and psychological changes that occur during adolescence, due to the rapidity with which they occur around puberty (Malina & Bouchard, 1991).

For both boys and girls, the onset of puberty is associated with increased activity of the sex, adrenal and thyroid glands, resulting in increased production of the hormones that catalyze pubertal changes (Beunen et al., 2006). More specifically, in the case of boys, there is a dramatic increase in testosterone concentration, becoming 30 times higher than the values of previous stages, which favors the development of sexual characteristics, the increase in bone structure, mostly influenced by the growth hormone (GH), as well as the increase in body mass and muscle mass (Handelsman et al., 2018; Malina & Bouchard, 1991). In contrast, the onset of puberty in girls is associated with an increase in estrogen concentrations, which is closely associated to the adipose tissue present before the onset of this stage and to its distribution in later stages, and to the development of female sexual characteristics as well (Biro et al., 2014; Garnett et al., 2004).

However, differences according to sex are observed, with the onset of the prepubertal stage having been identified between the ages of 8.2-10.3 years in girls, while in boys it was found between 10.3 and 12.1 years of age, with the age at peak height velocity (APHV) observed at 11.4-12.2 and 13.8-14.4 years respectively (Beunen & Malina, 1988; Beunen et al., 2006; Malina & Bouchard, 1991). The APHV has been defined as the age at which there is a dramatic increase in the rate of growth in terms of adolescent height and body mass (Malina & Bouchard, 1991). It is characterized by an increase in height at a rate of approximately 9 cm/year and 10.3 cm/year, and an increase in body mass of 8.3 kg/year and 9 kg/year in girls and boys, respectively (Kelch & Beitins, 1994; Tanner, 1990).

Maturation, growth and development are often compared with the chronological age of the individual, understood as the time elapsed from birth to a specific day (Lloyd et al., 2014), but not all individuals with the same chronological age manifest the changes associated with maturation simultaneously, there being evidence of different maturation rates among individuals (Marshall & Tanner, 1968, 1969, 1970). On the other hand, biological age has been defined as the age corresponding to the changes observed during the development of biological maturation (Malina & Bouchard, 1991), being able to give rise to differences between chronological age and biological age. It is the gap between biological age and chronological age that lead to different maturation rates.

Factors associated with maturation

These biological maturation processes and the indicators that are manifested during their development have been shown to have a high level of dependence on genetics (Thomis & Towne, 2006), but there are also factors that can favor variations in the time in which maturation occurs (Beunen et al., 2006). Nutrition is one of the factors that can affect the rate of maturation, and it has been observed that adequate nutrition does not have an important effect on the maturation process, but that malnutrition can delay skeletal development in adolescents (Malina & Bouchard, 1991). Another factor that could modify the rate of maturation is the amount of adipose tissue present before the pubertal stage, as a relationship has been observed between overweightness and obesity with an earlier onset of maturation, with this relationship being more marked in girls (Beunen et al., 2006).

There is a great debate about the influence of the systematic practice of physical exercise as a modifier of the rate of maturation. In this sense, while on the one hand it has been observed that elite female athletes in aesthetic disciplines tend to show a later maturational process, which could be associated with low levels of adipose tissue and low energy availability over long periods of time (Beunen & Malina, 1996), most authors conclude that there is no evidence that the systematic and continuous practice of physical exercise has a relevant effect on the rate of maturation of children and adolescents (Beunen & Malina, 1996).

Influence of biological maturation on athletic performance

In sports science, the study of biological maturation in relation to sports performance has aroused the interest of both coaches and the scientific community for decades, due to the influence it has on variables directly related to performance (Albaladejo-Saura et al., 2021).

In the different sports modalities, when it comes to training stages, athletes have been grouped according to their chronological age to try to create a standard training process and a competition system that is equitable for all participants (Gutiérrez-Díaz del Campo, 2013). In spite of this, the differences in the pace of individual maturation have led to the observation that more mature athletes have higher values in anthropometric variables such as height, body mass, and variables related to bone structure and muscle mass, as well as better results in physical performance variables such as upper and lower body strength and power, movement speed or agility, in different individual and collective sports disciplines, such as soccer, basketball, volleyball, handball, canoeing or tennis, (Albaladejo-Saura et al. , 2022a; Albaladejo-Saura et al., 2022b; Albaladejo-Saura et al., 2021; Carvalho et al., 2017; Matthys et al., 2012; Söğüt et al., 2019).

The differences caused by different maturation rates have been shown to create an advantage in competitions and selection processes during the adolescent stage for more mature athletes with respect to their peers of the same age category, although these differences tend to equalize towards the end of the maturational process (Dugdale, McRobert et al., 2021; Dugdale, Sanders et al., 2021; Vaeyens et al., 2008). This is why an increasing number of sports talent identification programs are advocating for the inclusion of biological maturation variables, such as APHV or maturity offset with respect to chronological age, as part of the characteristics to be assessed in athletes (Johnston et al., 2018), although there is no consensus on which method should be used for their assessment.

Introduction to methods for estimating biological maturation

Due to this interest in knowing the differences in biological maturation, numerous methods have been developed to estimate the biological maturation gap with respect to chronological age or to identify the maturational stage in which the individual is found (Malina et al., 2015). Among the most commonly used methods, we find those based

on the development of secondary sexual characteristics, giving rise to classifications according to the stage of sexual maturation (Marshall & Tanner, 1969, 1970); those based on skeletal development during childhood and adolescence, to establish a classification of skeletal age (Greulich & Pyle, 1959; Tanner et al., 1975); those that use anthropometric measures to estimate APHV as a measure of somatic maturation (Mirwald et al., 2002; Moore et al., 2015); or the study of dental maturation to assess the stage at which the individual is found (Demirjian & Goldstein, 1976; Demirjian et al., 1973).

As a result, there is an extensive debate about the suitability of these different methods for estimating biological maturation in the field of study of sport sciences. Therefore, the aim of the present research is to carry out a literature review of the most commonly used methods of estimating biological maturation in sport sciences.

Methods for the evaluation of maturation

In order to evaluate biological maturation, different indicators that undergo changes in the course of maturation can be used. Among the most commonly used indicators in sports science are skeletal maturation, assessed by radiographic methods; somatic maturation (based on growth velocity), assessed by anthropometric methods; sexual maturation, assessed by methods of secondary sexual characteristics development; and dental maturation, assessed by dental radiographs.

Study of skeletal maturation

The assessment of skeletal age is one of the most widely used indicators for the study of biological maturation. These methods are based on the taking of radiographs at different points in bones considered of interest and the comparison of these radiographs with pre-established reference models, governed by the principle of progressive calcification of the epiphyses of the bones studied, in the course of maturation (Greulich & Pyle, 1959; Roche et al., 1988; Tanner et al., 1975).

In this regard, there are three models that have been the most widely used over the years:

1. *Greulich & Pyle method*: The method described by Greulich and Pyle (1959) is a method based on an atlas of standardized reference images, taken from a population of Caucasian boys and girls, at different stages of maturation from birth to adult skeletal development, separated from each other in time periods of a year or half a year. This method involves radiographing the individual's left hand and wrist and then comparing them to reference images to determine their skeletal age. Thus, if the radiograph taken coincides with a skeletal age higher than the individual's chronological age, he or she will be categorized as an early maturer, while if it coincides with a lower chronological age, he or she will be categorized as a late maturer. This method is still used according to the protocol originally described, and was validated in a population of Caucasian American children (Greulich & Pyle, 1959).
2. *Tanner-Whitehouse 1, 2 & 3*: The method proposed by Tanner & Whitehouse (1975) is based on the radiographic assessment of the left hand and wrist, and the categorization of 13 or 20 bones in different regions of interest. Afterwards, a series of criteria are applied related to the description and shape of the bones analyzed. Finally, a skeletal age value is obtained, resulting from the assessments of the maturation of each individual bone, which is then compared to the chronological age of the individual assessed. Thus, if the skeletal age result is greater than the chronological age of the individual, he or she will be classified as early maturing, while if it is less, he or she will be classified as late maturing. This method, which has been revised three times (TW1, TW2 and TW3), has been validated in a population of children of British origin (TW1 and TW2) and in European, South American, North American and Japanese populations (Tanner et al., 1975; Tanner et al., 2001).
3. *Fels study protocol:* This method, proposed by Roche et al. (1988), is based on radiography of the left hand and wrist, with reference indicators in the ulna, radius, carpus, metacarpus and phalanges of the first and fifth fingers. In this method, a graduation is attributed to each bone according to the age and sex of the participants, including ratios between the length and width of the long bones and the ossification of the measured bones. These values are used to estimate the skeletal age of each individual, and then, when compared with the chronological age, to classify individuals as early or late maturers. This method is still used according to the protocol originally described, and was validated in a population of Caucasian American children who were followed longitudinally for different maturational indicators (Roche et al., 1988).

Study of somatic maturation

Another of the most commonly used indicators for assessing biological maturation is the study of somatic maturation. This is based on the identification of the peak height velocity (PHV) resulting from the increase in the concentration of GH, thyroid hormone, and androgens, and the changes they cause in height, weight, and proportionality of the different body segments (Malina & Bouchard, 1991). These methods are characterized by the possibility of directly observing the onset of PHV in longitudinal studies, characterized by a growth of approximately 9 cm/year in girls and 10.3 cm/year in boys, through continuous anthropometric measurements and their comparison with reference values (Kelch & Beitins, 1994). However, in cases in which cross-sectional designs make it impossible to take repeated measurements, there is the possibility of estimating APHV by means of anthropometric measurements, which are subsequently introduced into regression formulas. Among the methods of estimation using anthropometric measurements, the most commonly used are:

1. *Mirwald et al. method*: the method proposed by Mirwald et al. (2002) is based on the different growth ratios that exist between the trunk-encephalic height and lower limb length, as well as the effect of this growth on the total height of the individual, and the body mass around the PHV. Thus, two equations differentiated by sex were created in which chronological age, body mass, height, and sitting height of the individual, and the length of the lower limb are introduced as variables for the calculation. These formulas result in the biological maturation lag, which, subtracted from the chronological

age, provides an estimate of the APHV. The prediction equations were developed in the population included in the Saskatchewan Pediatric Bone Mineral Accrural Study (113 boys and 115 girls) (Mirwald et al., 2002).

2. *Moore et al. method:* The method proposed by Moore et al. (2015) is based on the same principles that identify the change in velocity of the growth rate of adolescents, by studying the proportionality between trunk and lower limb in increasing anthropometric variables, to create regression equations for the estimation of APHV. In it, two formulas differentiated by sexes were proposed, in which age and sitting height in the case of boys, and age and height, in the case of girls, were included as independent variables to estimate biological maturation lag and subsequently the APHV. The validity of the formulas was compared with populations from two external studies, the Harpenden Growth Study (419 British boys and 282 British girls) and the HBS-III study (515 Canadian boys and 556 Canadian girls) (Moore et al., 2015).

The resulting formulas for each method can be observed in Table 1.

Table 1. Methods of estimating maturation by studying the age at which the peak height velocity occurs through anthropometric variables

Authors	Equation (maturity offset)	Validity indicators	Validation population
Mirwald et al. (2002)	Boys = -9.232+0.0002708*(LLL*SH)-0.001663*(Age*LLL)+0.007216*(Age*SH)+0.02292*(BM/H)	R^2 = .891 *SEE* = 0.592	228 participants for the Saskatchewan Pediatric Bone Mineral Accrural Study (113 Boys; 115 Girls)
	Girls = -9.37+0.0001882*(LLL*SH)-0.0022*(Age*LLL)+0.005841*(Age* SH)-0.002658*(Age*BM)+0.07693*(BM/H)	R^2 = .890 *SEE* = 0.569	
Moore et al. (2015)	Boys = -8.128741+(0.0070346*(Age*SH))	R^2 = .906 *SEE* = 0.514	1071 participants for the HBS-III study (515 Boys; 556 Girls)
	Girls = -7.709133+(0.0042232*(Age*H))	R^2 = .898 *SEE* = 0.528	

LLL: Lower limb length; SH: sitting height; H: height; BM: body mass; SEE: standard estimated error.

Study of sexual maturation

The evaluation of sexual maturation as an indication of biological maturation is based on the gradual development of male and female secondary sexual characteristics that begin with the increase in sex hormones produced during the prepubertal stage (Marshall & Tanner, 1969, 1970).

Within the study of sexual maturation, the most widely used is the one proposed by Marshall and Tanner (1969, 1970). In it, a classification of five stages was made based on two scales for each sex, focused on the development of pubic hair in both boys and girls, genital development in the case of boys and the development of breast tissue in the case of girls, with images and description of each of the stages and the proposed scales. This methodology has been proposed to be utilized during a physical examination or to be self-completed by the subjects (Marshall & Tanner, 1969, 1970).

Study of dental maturation

The study of dental maturation has also been considered as an indicator of biological maturation due to the different stages through which the development of permanent teeth pass through, from their calcification, which marks the beginning of maturation, until the apical end of the dental root canal is completely closed, which marks its end (Demirjian & Goldstein, 1976; Demirjian et al., 1973).

In this sense, Dermirjian & Goldstein (1976) developed a classification system using panoramic radiography for dental maturation, dividing the process into eight phases that can be applied to each tooth. In this methodology, each tooth is classified according to a scale of eight values to subsequently calculate a joint index among all the teeth analyzed, in which the maximum sum of the values is 100. By means of this value, the subject is attributed a biological age based on his or her dental maturation, which is subsequently compared with the chronological age to establish the maturational gap. For this, they include both images and a description of the characteristics that the teeth should have in order to be included in each of the proposed groups. This method was developed with a sample of 1446 Canadian boys and 1482 Canadian girls.

Considerations for the use of biological maturation assessment methods with adolescent athletes.

It should be noted that all the methods described above have been developed and validated in the first instance in a clinical context, in populations of different ages and not specifically athletes. A summary of the main characteristics and the advantages and disadvantages of each method can be found in Table 2.

Table 2. Summary of the characteristics of the main methods for estimating biological maturation and their suitability for the field of study of sports science

Kind of method	Measuring speed	Economic cost	Ease of implementation	Suitability to the field of sports science	
				Advantages	Disadvantages
Skeletal maturation: X-ray of hand and wrist according to Greulich & Pyle (1969)	*	***	*	Considered the "gold standard" for the estimation of biological maturation in sports science, in contexts where access is available.	It cannot be adapted to field research, the need for specialized personnel, the time and cost of its application and the radiation exposure of participants.
Skeletal maturation: X-ray of hand and wrist according to Tanner & Whitehouse (1975)	*	***	*	Considered the "gold standard" for the estimation of biological maturation in sports science, in contexts where access is available.	It cannot be adapted to field research, the need for specialized personnel, the time and cost of its application and the radiation exposure of participants.
Skeletal maturation: X-ray of hand and wrist according to Roche et al. (1988)	*	***	*	Considered "gold standard" for the estimation of biological maturation in sports science, in contexts where access is available.	It cannot be adapted to field research, the need for specialized personnel, the time and cost of its application and the radiation exposure of participants.
Somatic maturation: Anthropometric measurements according to Mirwald et al. (2002)	**	**	**	Easy to implement, adaptable to field work and requiring little training for researchers.	Its limitations should be taken into account in order to avoid introducing excessive error in the estimation, it may underestimate or overestimate the value of the maturity offset in early or late maturers respectively, and its use is advised for classifying athletes according to their maturation rate.
Somatic maturation: Anthropometric measurements according to Moore et al. (2015)	**	**	**	Easy to implement, adaptable to field work and requiring little training for researchers.	Its limitations should be taken into account in order not to introduce excessive error in the estimation, it may underestimate or overestimate the value of the maturity offset in early or late maturers respectively, and its use is advised for classifying athletes according to their maturation rate.
Somatic maturation: Anthropometric measurements according Sherar et al. (2005)	**	**	***	Easy to implement, adaptable to field work and requiring little training for researchers.	It requires repeated anthropometric measurements over a period of three to 18 months over several years and subsequent individual analysis of the growth curves to obtain the result of the APHV.
Sexual maturation: Sexual characteristics according to Marshall & Tanner (1969, 1970)	***	*	***	It is an easy to implement method that does not require specific facilities, has a low cost, is quick to perform and can be self-completed by the subject.	It may be considered invasive for the privacy of the individual, decontextualized from the clinical setting. It may lose reliability when it is self-completed by the subjects.
Dental maturation: Dental radiography according to Demirjian & Goldstein (1976)	*	***	*	It has similar reliability and validity to hand and wrist radiographic methods for assessing the subject's biological maturation.	It is extremely specific in terms of the fields of study covered. It cannot be adapted to field research, requires highly specialized personnel and exposes its participants to radiation.

*: low; **: medium; ***: high.

Methods based on skeletal maturation

Methods based on radiographs have been widely used in athlete populations (Carling et al., 2012; Figueiredo et al., 2009; Gouvea et al., 2016; Söğüt et al., 2019; Valente-Dos-Santos et al., 2014). In them, the objective is to obtain the value of the subject's biological age at the time of measurement, using skeletal maturation as an indicator of the subject's biological maturation, which will later be compared with the chronological age, to find the maturational gap. These methods have been considered the "gold standard" for the estimation of

biological maturation, due to the large amount of data available, the reproducibility of the methods, the possibility of performing the study from infancy to late adolescence or adulthood, and the consistency in the results with respect to the developmental curves observed in longitudinal studies (Malina et al., 2015). However, due to differences in the skeletal maturation assessment criteria used to analyze biological maturation, these methods have their own advantages and disadvantages, making it impossible to identify one of them as the "gold standard" among the different skeletal maturation methods (Malina et al., 2015). On the other hand, none of the three methods described in this review can be underlined as the most utilized in sports science, as these methods have been used to assess the biological maturation of young athletes regardless of the sports discipline (Albaladejo-Saura et al., 2021; Malina, 2011).

These methods have been used both to analyze the biological maturation of participants descriptively, and to classify them as early maturers, on-time, or late, using the difference between skeletal age and chronological age (Carling et al., 2012). When attempting to classify adolescent athletes based on the biological age assessed by these methods, the most common procedure is to subtract skeletal maturation - chronological age, and use the result to establish a range of ±1 year (difference from >-1 to < +1) to classify athletes whose maturation is considered on-time, while if the difference is positive and greater than one year (difference>+1) they would be considered early maturers, and if the difference is negative and greater than one year (difference<-1), late maturers (Carling et al. , 2012; Figueiredo et al., 2009). There are other proposals for the classification of biological maturation based on skeletal age, such as classification into more mature or less mature, or on-time maturers group, depending if the result of the subtraction between skeletal age and chronological age is positive or negative, although these methods are less employed (Söğüt et al., 2019).

Despite the benefits of radiography-based methods, it should be noted that they are not without limitations. The three most employed methods, proposed by Greulich & Pyle (1959), Tanner & Whitehouse (1975) and Roche et al. (1988) are based on the same principles to categorize bone maturation, but due to differences in the methodology used to obtain skeletal maturation, they are not considered to be interchangeable with each other (Malina et al., 2015).

On the other hand, they are expensive, time-consuming to implement and not adaptable to measurements outside the laboratory context, which limits their use in the context of sports science (Malina et al., 2015; Towlson et al., 2021). Furthermore, these methods need to be employed by specialized personnel with the necessary qualifications to perform them, otherwise their validity and reliability decreases (Lloyd et al., 2014; Towlson et al., 2021). As these methods are based on the use of X-rays, some authors argue that they are invasive methods whose use is not justified in adolescents, since they consider that radiation should only be applied to growing individuals in the context of a clinical diagnosis, not being justified in sports science research (Gómez-Campos et al., 2013). However, other authors do advocate its use, justifying that, with current techniques and instruments, the radiation to which the individual is subjected during the assessment is minimal, and would not involve an amount that is considered harmful to health (Malina et al., 2015). These limitations make it an accessible method mainly for sports with a high level of economic income or access to adequate facilities, as is the case of soccer (Carling et al., 2012; Figueiredo et al., 2009; Gouvea et al., 2016; Valente-Dos-Santos et al., 2014).

Methods based on somatic maturation

Somatic maturation estimation methods based on anthropometric measurements are among the most widely used in the assessment of adolescent athletes due to their low invasiveness, ease of use, the possibility of performing measurements in both laboratory and field investigations, the low cost of the equipment needed for their implementation, and the relatively little training needed by the researchers (Albaladejo-Saura et al., 2022a, 2022b, 2022c; Arede et al., 2019; Guimarães et al., 2019; Hammami et al., 2018). In them, the indicator of biological maturation is the growth rate and the age at which the increase in growth velocity occurs, compared to the chronological age of the subject. These methods do not allow estimating the subject's biological age at the time of measurement, but are indicative of the rate of biological maturation (Drenowatz et al., 2010; Drenowatz et al., 2013).

These methods, similarly to radiological methods, have been used descriptively in populations of adolescent athletes (Albaladejo-Saura et al., 2022c) or to classify them as early, on-time, or late maturers (Albaladejo-Saura et al., 2022a; Albaladejo-Saura et al., 2022b; Arede et al., 2019; Guimarães et al., 2019; Hammami et al., 2018).

In this case, there are some remarkable differences between the methods based on PHV observation and those that perform their estimation through formulas. In the case of the PHV observation method, several measurement sessions, spaced between 3 and 18 months apart, are necessary to establish the growth rate of the individual, over the years in which the PHV is theoretically produced in order to identify it in relation to the observed growth curves (Kelch & Beitins, 1994; Malina & Bouchard, 1991; Sherar et al., 2005; Tanner, 1990).

However, this method also has limitations. The main limitation found is that it is available only for longitudinal experimental designs of long duration, due to the need to space the measurements over a long period of time (Kelch & Beitins, 1994; Malina & Bouchard, 1991; Sherar et al., 2005; Tanner, 1990). On the other hand, due to the methodology used, the age range in which this method is applicable is reduced to the years around the PHV, and an individualized study of the growth curve must be carried out due to individual variations (Sherar et al., 2005).

In contrast, in the formulas developed by Mirwald et al. (2002) and Moore et al. (2015), it is only necessary for anthropometric measurements to be assessed only once, since, in the proposed formulas, one of the prediction variables is the chronological age of the subject at the time of assessment. These formulas give as a result the time in years remaining until the individual assessed reaches the PHV (if the result is negative) or the time in years that has passed since the individual passed the PHV (if the result is positive), called the maturity offset. The maturity offset, subtracted from the individual's chronological age is used to calculate the APHV (APHV = chronological age - maturity offset) (Mirwald et al., 2002; Moore et al., 2015). This value can be used directly to categorize athletes into early, on-time or late maturers, according to different criteria.

Traditionally, the ranges indicated by Malina & Bouchard (1991), in which PHV is typically observed, 11.4-12.2 years of age for girls and 13.8-14.4 for boys, have been used to classify athletes as early maturers, when their APHV was within the indicated range; early maturers when their APHV was below the indicated range; and late maturers when their APHV was above the indicated range. However, this evaluation criterion has the limitation that the estimation of APHV can be altered by chronological age, as observed in recent research (Malina, Coelho-E-Silva, et al., 2021; Towlson et al., 2021), so it would only be valid for

populations in a reduced age range, which was around the theoretical APHV.

Currently, due to the heterogeneity that could be found in the groups of adolescents evaluated in sports science in terms of chronological age, the most widely used classification methods base their criteria for the calculation of the APHV, establishing ranges that define the groups as early maturers, on-time, or late maturers, on the mean and standard deviation (SD) of the group with respect to this variable (Figueiredo et al., 2009; Hammami et al., 2018; Mirwald et al., 2002; Moore et al., 2015). Thus, some authors propose a range of ±1 year in APHV with respect to the mean of the group, into which the athletes whose APHV is considered on-time would be placed, while if the APHV has a difference greater than one year both below and above that of the mean, would be considered early and late maturers, respectively (Hammami et al., 2018; Mirwald et al., 2002; Moore et al., 2015). The establishment of the criterion of a range of ±1 year with respect to the group's APHV to classify athletes into the different maturation groups is because the samples used to validate the formulas by Mirwald et al. (2002) and Moore et al. (2015) showed a *SD* ≈ 1 year when their biological maturation was assessed by radiography. But the establishment of this range has certain limitations when the samples are homogeneous. If the *SD* of the group's APHV is less than 1 year, almost all the athletes would be classified as maturing on time. That is why when the *SD* of the APHV of the group is less than 1 year, some authors have proposed the use of ranges of ±0.5 years of the APHV, with those within this range considered on-time maturers, below that range early maturers and above that range, late maturers (Albaladejo-Saura et al., 2022a, 2022b; Arede et al., 2019; Drenowatz et al., 2010; Guimaraes et al., 2019; Wickel & Eisenmann, 2007).

However, the APHV estimation formulas also have limitations that should be taken into account. On the one hand, despite being widely used methods in sports science and having good validity indices (R. = .896 - .890) (Albaladejo-Saura et al., 2021; Mirwald et al., 2002; Moore et al., 2015), it has been observed that they usually introduce a certain degree of error that limits their use at certain times since they are based on regression equations (standard error= 0.542-0.569 years) (Malina et al., 2016; Malina, Coelho-E-Silva, et al., 2021). On the other hand, it has been observed that the equations tend to underestimate the value of the maturation lag for early maturers, while overestimating it for late maturers (Towlson et al., 2021). Because of these limitations, some authors have recommended using these methods only in adolescent populations, limiting their use in child populations (Malina, Coelho-E-Silva, et al., 2021; Towlson et al., 2017; Towlson et al., 2021), to control for the effect of chronological age on the estimates, as it has been observed that the estimation of somatic maturation changes in a stable manner with advancing age. Further recommendations have also been made for using anthropometry-based methods to classify athletes into early, time or late maturers, rather than as a descriptive measure of biological maturation, as they indicate the rate of maturation, and allow for the comparison between individuals, but not the calculation of biological age (Malina, Coelho-E-Silva, et al., 2021). Despite these limitations, its use has been recommended on the adolescent athlete population when the "gold standard" method is impossible to use (Towlson et al., 2021).

Methods based on sexual maturation

Methods based on the development of secondary sexual characteristics have also been used in studies conducted in the athlete population (Figueiredo et al., 2009; Matta et al., 2014). In these methods, the indicator of biological maturation is the degree of development of the secondary sexual characteristics as compared to the scale proposed at the time of assessment. However, they are less used than methods based on skeletal or somatic maturation (Albaladejo-Saura et al., 2021). The method described by Marshall & Tanner (1962) classifies the development of secondary sexual characteristics into five stages, with stage 1 being attributed to a time before puberty (prepubertal), stages 2-4 are considered pubertal development, and stage 5 adult development (Gómez-Campos et al., 2013). The stages of sexual maturation have also been related to other indicators of biological maturation, such as the "gold standard" (Figueiredo et al., 2009). Thus, it was observed that participants classified as late maturers aged between 11 and 12 years old were mostly classified in the pre-pubertal stage (88%) from the method described by Marshall and Tanner (1969, 1970), while those classified as early and on time maturers aged 13 and 14 years old of chronological age were found between stages 3 and 4 of the aforementioned method.

This method has the advantage of being easy to apply, since it based on the use of a set of images with which to compare the current state of the individual's characteristics, as well as the possibility of the subject himself carrying out the evaluation (Marshall & Tanner, 1969, 1970).

The specific characteristics of the evaluation of sexual maturation make it necessary to take into account the possible drawbacks when intending to use this methodology. It should be considered that its use is limited to the prepubertal and pubertal stages, since no categories are detailed for the classification of the characteristics of individuals outside that range (Marshall & Tanner, 1969, 1970). On the other hand, one of the main limitations when its use is intended in the field of sports science is that it is an invasive technique for the participant due to the aspects that are assessed for classification, for which ethical and cultural aspects must be taken into account (Gómez-Campos et al., 2013). This is because this methodology was originally developed for the clinical context, for the physical examination of the patient by health personnel (Marshall & Tanner, 1968). To try to solve this problem, it has sometimes been advocated for self-assessment by the participant, a fact that could decrease the validity and reliability of the instrument (Gómez-Campos et al., 2013).

Methods based on dental radiographs

Methods based on dental maturation are widely used in clinical, dental, forensic, and anthropological contexts (De Donno et al., 2021), with the most widely used being the one proposed by Demirjian & Goldstein (1976), while in sports assessment contexts its use is less widespread (Albaladejo-Saura et al., 2021; Beunen et al., 2006; Johnston et al., 2018; Malina, Martinho, et al., 2021). This method uses tooth development as an indicator of biological maturation. It shares the advantages of skeletal age estimation methods, counting on a high reproducibility, a wide range of implementation ages from infancy to adulthood, and consistency in the results with respect to observed growth curves (De Donno et al., 2021; Demirjian & Goldstein, 1976; Demirjian et al., 1973; Gómez-Campos et al., 2013).

However, it also has similar limitations. They use X-rays for assessment, which implies radiation exposure that would not be justified in sports science studies (Gómez-Campos et al., 2013), their use requires a lot of time, specific facilities, qualified personnel, and entails a high economic expense (De Donno et al., 2021; Malina et al., 2015), reasons why their use in studies in young athletes could be scarce.

Limitations and future lines of research

The present research is not without limitations. Within it, the methods most commonly used in the assessment of different indicators of biological maturation in the sports context were reviewed. However, there are other methods for assessing biological maturation that were not analyzed, such as radiographic methods of bone structures other than the hand and wrist, or methods based on the analysis of hormone concentration, which are more commonly used in the clinical context. On the other hand, methods that are less commonly used or lack sufficient validation have not been analyzed either.

Future reviews of biological maturation estimation methods could address the inclusion of the different methods regardless of the context in which they are used.

The lines of research derived from the present review could be aimed at analyzing the validity, reliability and adequacy of the different estimation methods with respect to the developmental growth curves observed in longitudinal studies, as well as the inclusion of variables related to performance and health that may be affected by individual differences in maturational development.

Conclusions

In the field of sports, when evaluating growing athletes, it is essential to take into account their maturational state, due to the great influence of biological maturation on numerous variables directly associated with performance. Many methods for estimating maturation exist that have been proven to be useful tools for assessing the maturation process in adolescents, such as bone, somatic, sexual and dental maturation. In this sense, the method endorsed by the scientific literature as the "gold standard" for the estimation of biological maturation in populations of adolescent athletes is the bone maturation method, which is based on the performance of hand and wrist radiographs. However, it has many limitations, among which we find the economic cost, the time and facilities required for its implementation, the need for highly qualified evaluators, and the radiation to which the subjects are exposed. All of these limitations may condition its use in most situations applicable to studies in sports science. In the event that the use of the radiographic method is not possible, the assessment of somatic maturation through formulas that use anthropometric variables for its calculation are a widely used, as they have been proven to be reliable and valid options, and are easy to use and adapt to field research. However, it should be taken into account that these methods can introduce a certain error in the estimation, leading to the underestimation or overestimation of the value of the maturity offset in early or late maturers respectively. Also, their use is advisable to only classify athletes according to their rate of maturation, since the methods for estimating somatic maturation based on anthropometry can only indicate the rate of biological maturation, but not of biological age, which is one of their main limitations. Finally, the assessment of sexual characteristics and dental development are less used methods for estimating maturation in sports science, mainly because of their clinical nature, the ethical implications, and the difficulty in their application.

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Métodos de estimación de la maduración biológica en deportistas en etapa de desarrollo y crecimiento: Revisión bibliográfica

Methods for estimating biological maturation in developing and growing athletes: A literature review

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Título abreviado:
Estimación de la maduración en deportistas en crecimiento: Revisión bibliográfica

Cómo citar el artículo:
Albaladejo-Saura, M., Vaquero-Cristóbal, R., & Esparza-Ros, F. (2022). Métodos de estimación de la maduración biológica en Ciencias del Deporte: Revisión bibliográfica. *Cultura, Ciencia y Deporte, 17*(53), 55-75. https://doi.org/10.12800/ccd.v17i53.1925

Recibido: 28 marzo 2022 / Aceptado: 30 mayo 2022

Resumen

Los indicadores relacionados con la maduración biológica han sido estudiados desde hace décadas. Los cambios que produce la maduración afectan de forma trascendental al rendimiento de los jóvenes deportistas. El objetivo de esta revisión bibliográfica fue analizar los métodos de estimación de la maduración biológica más empleados en ciencias del deporte. Se han identificado cuatro métodos principales que abordan indicadores de la maduración biológica distintos: los métodos radiográficos, que estiman la edad biológica a través del desarrollo óseo; métodos antropométricos, que estiman el ritmo de la maduración biológica a través de cambios en la velocidad de crecimiento y la proporcionalidad; métodos de maduración sexual, basados en la manifestación de los caracteres sexuales masculinos y femeninos; y métodos de maduración dental, que estiman la edad biológica a través del desarrollo dental. El "gold standard" para estimar el estado madurativo son los métodos basados en radiografía de la mano y muñeca, sin embargo, sus limitaciones hacen que su empleo en la valoración de deportistas jóvenes se encuentre condicionado. Una alternativa muy utilizada son las antropométricas, que aunque no están exentas de limitaciones, han mostrado tener suficiente fiabilidad y validez. La maduración sexual o dental parecen no ser tan aplicables en este ámbito.

Palabras clave: pubertad, crecimiento, ejercicio físico, desarrollo madurativo, rendimiento.

Abstract

The indicators related to biological maturation have been studied for decades. The changes produced by maturation have a transcendental effect on the performance of young athletes. The aim of this literature review was to analyze the most commonly used methods of estimating biological maturation in sports science. Four main methods have been identified that address different indicators of biological maturation: radiographic methods, which estimate biological age through bone development; anthropometric methods, which estimate the rate of biological maturation through changes in growth velocity and proportionality; sexual maturation methods, based on the manifestation of male and female sexual characteristics; and dental maturation methods, which estimate biological age through dental development. The "gold standard" for estimating the maturational state are the methods based on radiography of the hand and wrist; however, their limitations mean that their use in the assessment of young athletes is conditioned. A widely used alternative are anthropometric methods, which, although not free of limitations, have been shown to have sufficient reliability and validity. Sexual or dental maturation do not seem to be as applicable in this field.

Keywords: puberty, growth, physical exercise, maturational development, performance.

Introducción

Aproximación conceptual al término de maduración, edad cronológica, edad biológica y pico máximo de crecimiento

La maduración, en relación al crecimiento humano, se refiere al tiempo y al proceso de cambio desde la niñez hasta alcanzar el estado madurativo adulto (Malina & Bouchard, 1991). Estos procesos han sido ampliamente estudiados en sus diferentes etapas, pero tradicionalmente se ha prestado especial atención a los cambios endocrinos, estructurales, fisiológicos y psicológicos que se producen durante la adolescencia, debido a la rapidez con la que estos se suceden en torno a la pubertad (Malina & Bouchard, 1991).

Tanto en el caso de los chicos como de las chicas, el inicio de la pubertad se asocia a un aumento de la actividad de las glándulas sexuales, adrenales y tiroidea, que se traduce en un aumento de la producción de las hormonas que catalizan los cambios puberales (Beunen et al., 2006). Más concretamente, en el caso de los chicos, se produce un aumento drástico en la concentración de la testosterona, llegando a ser 30 veces superior a los valores de etapas anteriores, lo que favorece el desarrollo de los caracteres sexuales, así como el aumento de la estructura ósea, influenciada por la hormona de crecimiento (GH), la masa corporal y la masa muscular mayoritariamente (Handelsman et al., 2018; Malina & Bouchard, 1991). En cambio, el inicio de la pubertad en las chicas se asocia un aumento en las concentraciones de estrógenos, que a su vez se encuentran estrechamente relacionados con el tejido adiposo presente antes del comienzo de esta etapa y con la distribución del mismo en etapas posteriores, además de influir en el desarrollo de los caracteres sexuales femeninos (Biro et al., 2014; Garnett et al., 2004).

Sin embargo, existen diferencias entre sexos, habiéndose identificado el inicio de la etapa prepuberal entre los 8.2-10.3 años en las chicas, mientras que en los chicos se encontró entre los 10.3 y los 12.1 años, observándose la edad a la que se produce el pico de crecimiento (EPVC) a los 11.4-12.2 y 13.8-14.4 años respectivamente (Beunen & Malina, 1988; Beunen et al., 2006; Malina & Bouchard, 1991). La EPVC ha sido definida como la edad a la que se produce un aumento drástico del ritmo de crecimiento en cuanto a la talla y la masa corporal de los adolescentes (Malina & Bouchard, 1991). Esta se caracteriza por un aumento de la talla a un ritmo aproximado de 9 cm/año y 10.3 cm/año, y un aumento de la masa corporal de 8.3 Kg/año y 9 Kg/año en niñas y niños respectivamente (Kelch & Beitins, 1994; Tanner, 1990).

Tanto la maduración, como el crecimiento y el desarrollo suelen ser comparados con la edad cronológica del individuo, entendida como el tiempo transcurrido desde el nacimiento hasta un día concreto (Lloyd et al., 2014), ya que no todos los individuos con la misma edad cronológica manifiestan los cambios asociados a la maduración de forma simultánea, existiendo evidencias de los diferentes ritmos de maduración entre individuos (Marshall & Tanner, 1968, 1969, 1970) Por otro lado, la edad biológica ha sido definida como la edad correspondiente al desarrollo de los cambios marcados por el desarrollo de la maduración biológica (Malina & Bouchard, 1991), pudiendo dar lugar a diferencias entre la edad cronológica y la edad biológica. Es el desfase entre la edad biológica y la edad cronológica lo que da lugar a los diferentes ritmos de maduración.

Factores asociados a la maduración

Y es que estos procesos de maduración biológica y los indicadores que se manifiestan durante su desarrollo han demostrado tener un alto nivel de dependencia respecto a la genética (Thomis & Towne, 2006), pero también existen factores que pueden favorecer variaciones en el tiempo en el que se produce la maduración (Beunen et al., 2006). La nutrición es uno de los factores que puede afectar al ritmo de la maduración, habiéndose observado que una adecuada nutrición no tiene grandes efectos sobre el proceso madurativo, pero que la desnutrición si puede retrasar el desarrollo esquelético de los adolescentes (Malina & Bouchard, 1991). Otro factor que podría modificar el ritmo de la maduración es la cantidad de tejido adiposo presente antes de la etapa puberal, ya que se ha observado una relación entre el sobrepeso y la obesidad con un inicio más temprano de la maduración, siendo esta relación más marcada en las chicas (Beunen et al., 2006).

Hay más debate sobre la influencia de la práctica sistemática de ejercicio físico como modificador del ritmo de maduración. En este sentido, mientras que por un lado se ha observado como las atletas femeninas de élite de disciplinas estéticas suelen mostrar un proceso madurativo más tardío, lo que podría estar asociado a los bajos niveles de tejido adiposo y a la baja disponibilidad de energía durante largos periodos de tiempo (Beunen & Malina, 1996), la mayoría de los autores concluyen que no existe evidencia de que la práctica sistemática y continuada de ejercicio físico tenga un efecto relevante sobre el ritmo de maduración de los niños y adolescentes (Beunen & Malina, 1996).

Influencia de la maduración biológica en el rendimiento deportivo

En ciencias del deporte, el estudio de la maduración biológica en relación con el rendimiento deportivo ha sido un tema que ha despertado el interés tanto de los entrenadores como de la comunidad científica durante décadas, debido a la influencia que ésta tiene sobre variables directamente relacionadas con el rendimiento (Albaladejo-Saura et al., 2021).

En las distintas modalidades deportivas, cuando se trata de etapas de formación, se ha agrupado a los deportistas de acuerdo con su edad cronológica para tratar de confeccionar un proceso de formación estándar y un sistema de competición que resulte equitativo para sus participantes (Gutiérrez-Díaz del Campo, 2013). A pesar de esto, las diferencias en el ritmo de maduración individual hacen que se haya observado en distintas disciplinas deportivas, individuales y colectivas, como en fútbol, baloncesto, voleibol, balonmano, piragüismo o tenis, que los deportistas más maduros presentan mayores valores en variables antropométricas como la talla, la masa corporal y las variables relacionadas con la estructura ósea y la masa muscular, así como mejores resultados en variables de rendimiento físico como la fuerza y la potencia del tren superior e inferior, la velocidad de desplazamiento o la agilidad (Albaladejo-Saura et al., 2022a; Albaladejo-Saura et al., 2022b; Albaladejo-Saura et al., 2021; Carvalho et al., 2017; Matthys et al., 2012; Söğüt et al., 2019).

Estas diferencias ocasionadas por los distintos ritmos de maduración han demostrado ocasionar una ventaja en las competiciones y procesos de selección que ocurren durante la etapa adolescente para los deportistas más maduros respecto a sus pares de la misma categoría de edad, aunque estas diferencias tiendan a igualarse hacia el final del proceso madurativo (Dugdale, McRobert, et al., 2021; Dugdale, Sanders, et al., 2021; Vaeyens et

al., 2008) Es por ello que cada vez más programas de identificación de talento deportivo abogan por la inclusión de variables de maduración biológica, como la EPVC o el desfase madurativo respecto a la edad cronológica, como parte de las características a evaluar en los deportistas (Johnston et al., 2018), aunque no existe consenso sobre qué método utilizar para su evaluación.

Introducción a los métodos de estimación de la maduración biológica

Debido a este interés en conocer las diferencias en la maduración biológica, se han desarrollado numerosos métodos con el objetivo de estimar el desfase de maduración biológica respecto a la edad cronológica o identificar el estadio madurativo en el que se encuentra el individuo (Malina et al., 2015). Dentro de los métodos más empleados, se encuentran aquellos basados en el desarrollo de los caracteres sexuales secundarios, dando lugar a clasificaciones en función del estadio de maduración sexual (Marshall & Tanner, 1969, 1970); los basados en el desarrollo esquelético durante la niñez y adolescencia, para establecer una clasificación de la edad esquelética (Greulich & Pyle, 1959; Tanner et al., 1975); aquellos que emplean medidas antropométricas para estimar la EPVC como medida de la maduración somática (Mirwald et al., 2002; Moore et al., 2015); o el estudio de la maduración dental para evaluar el estadio en el que se encuentra el individuo (Demirjian & Goldstein, 1976; Demirjian et al., 1973).

Como consecuencia de esto, existe un extenso debate acerca de la idoneidad de los distintos métodos para estimar la maduración biológica en el campo de estudio de las ciencias del deporte. Por lo tanto, el objetivo de la presente investigación es realizar una revisión bibliográfica sobre los métodos de estimación de la maduración biológica más empleados en ciencias del deporte.

Métodos para la evaluación de la maduración

Para realizar una evaluación de la maduración biológica se puede atender a distintos indicadores que experimentan cambios en el transcurso de ésta. Dentro de los indicadores más comúnmente utilizados en ciencias del deporte se encuentran la maduración esquelética, evaluada por medio de métodos radiográficos; la maduración somática (basada en la velocidad del crecimiento), evaluada por medio de métodos antropométricos; la maduración sexual, evaluada por medio de métodos de desarrollo de caracteres sexuales secundarios; y la maduración dental, evaluada a través de radiografías dentales.

Estudio de la maduración esquelética

La valoración de la edad esquelética es uno de los indicadores más empleados como estudio de la maduración biológica. Estos métodos se basan en la realización de radiografías de puntos óseos considerados de interés y la comparación de estas radiografías con modelos de referencia preestablecidos, rigiéndose por el principio de la progresiva calcificación de las epífisis de los huesos estudiados con el transcurso de la maduración (Greulich & Pyle, 1959; Roche et al., 1988; Tanner et al., 1975).

En este sentido, existen tres modelos que han sido los más utilizados a lo largo de los años:

1. *Greulich & Pyle method*: El método descrito por Greulich y Pyle (1959) es un método basado en un atlas de imágenes de referencia estandarizadas, tomadas en una población de niños y niñas caucásicos, en diferentes etapas de maduración desde el nacimiento hasta el desarrollo esquelético adulto, separadas entre sí en periodos de tiempo de un año o medio año. Este método implica la radiografía de la mano y muñeca izquierdas del individuo, para posteriormente ser comparada con las imágenes de referencia para determinar la edad esquelética que le corresponde. De este modo, si la radiografía tomada coincide con una de edad esquelética superior a la edad cronológica del individuo, será categorizado como madurador temprano, mientras que, si coincide con una de edad cronológica inferior, será categorizado como madurador tardío. Este método sigue siendo utilizado de acuerdo al protocolo descrito originalmente, y fue validado en una población de niños americanos caucásicos (Greulich & Pyle, 1959).
2. *Tanner-Whitehouse 1, 2 & 3*: El método propuesto por Tanner & Whitehouse (1975) está basado en la valoración mediante radiografía de la mano y la muñeca izquierdas, y la categorización de 13 o 20 huesos en diferentes regiones de interés, para posteriormente aplicar una serie de criterios relativos a la descripción y forma de los huesos analizados. Finalmente se obtiene un valor de edad esquelética, resultante de las valoraciones de la maduración de cada hueso de forma individual, que posteriormente es comparado a la edad cronológica del individuo valorado. De este modo, si el resultado de la edad esquelética es mayor a la edad cronológica del individuo, será clasificado como madurador temprano, mientras que si es menor será clasificado como madurador tardío. Este método, que ha sido revisado en tres ocasiones (TW1, TW2 y TW3), ha sido validado en una población de niños de origen británico (TW1 y TW2) y en poblaciones europeas, sudamericanas, norteamericanas y japonesas (Tanner et al., 1975; Tanner et al., 2001).
3. *Fels study protocol*: Este método propuesto por Roche et al. (1988) se basa en la radiografía de mano y muñeca izquierdas, proponiendo indicadores de referencia en los huesos cúbito, radio, carpo, metacarpo y falanges del primer y quinto dedo. En este método se atribuye una graduación a cada hueso de acuerdo con la edad y el sexo de los participantes, incluyendo ratios entre la longitud y la anchura de los huesos largos y la osificación de los huesos medidos. Estos valores se utilizan para estimar la edad esquelética de cada individuo, para posteriormente, al ser comparada con la edad cronológica, clasificar a los individuos como maduradores tempranos o tardíos. Este método sigue siendo utilizado de acuerdo al protocolo descrito originalmente, y fue validado en una población de niños americanos caucásicos a los que se les realizó un seguimiento longitudinal de distintos indicadores madurativos (Roche et al., 1988).

Estudio de la maduración somática

Otro de los indicadores más empleados para valorar la maduración biológica es el estudio de la maduración somática. Esta se basa en la identificación del pico de velocidad de crecimiento (PVC) resultante del aumento en la concentración de GH, hormona tiroides y andrógenos

y los cambios que provocan en la talla, el peso y la proporcionalidad de los distintos segmentos corporales (Malina & Bouchard, 1991). Estos métodos se caracterizan por la posibilidad de observar de forma directa el inicio del PVC en estudios longitudinales, caracterizado por un crecimiento de aproximadamente 9 cm/año en las chicas y de 10,3 cm/año en los chicos, mediante la realización de medidas antropométricas de forma continuada y su comparación con valores de referencia (Kelch & Beitins, 1994). Sin embargo, en los casos en los que los diseños transversales imposibiliten la toma de medidas repetidas existe la posibilidad de estimar la EPVC mediante medidas antropométricas, introducidas posteriormente en fórmulas de regresión. Dentro de los métodos de estimación mediante medidas antropométricas, los más empleados son:

1. *Método de Mirwald et al.*: El método propuesto por Mirwald et al. (2002) está basado en las diferentes ratios de crecimiento existentes entre la talla tronco-encefálica y la longitud del miembro inferior, así como el efecto que tiene este crecimiento sobre la talla total del individuo y la masa corporal entorno al PVC. De este modo, se crearon dos ecuaciones diferenciadas por sexos en las que se introducen como variables para el cálculo la edad cronológica, la masa corporal, la talla y la talla sentado del individuo y la longitud del miembro inferior. Estas fórmulas dan como resultado el desfase de la maduración biológica, que restado a la edad cronológica aporta la estimación de la EPVC. Las ecuaciones de predicción fueron desarrolladas en la población incluida en el estudio Saskatchewan Pediatric Bone Mineral Accrural Study (113 chicos y 115 chicas) (Mirwald et al., 2002).
2. *Método de Moore et al.*: El método propuesto por Moore et al. (2015) se basa en los mismos principios que identifican el cambio de velocidad en el ritmo de crecimiento de los adolescentes, mediante el estudio de la proporcionalidad entre el tronco y el miembro inferior, para crear ecuaciones de regresión para la estimación del EPVC. En él se proponen dos fórmulas diferenciadas por sexos, en las que se incluyen como variables independientes la edad y la talla sentado en el caso de los chicos y la edad y la talla en el caso de las chicas, para estimar desfase de la maduración biológica y posteriormente el EPVC. La validez de las fórmulas fue comparada con las poblaciones de dos estudios externos, el Harpenden Growth Study (419 chicos y 282 chicas britanicos) y el HBS-III study (515 chicos y 556 chicas canadienses) (Moore et al., 2015).

Se pueden observar las fórmulas resultantes de cada método en la tabla 1.

Tabla 1. Métodos de estimación de la maduración mediante estudio de edad a la que se produce el pico de velocidad de crecimiento a través de variables antropométricas

Autores	Fórmula (desfase madurativo)	Indicadores de validez	Población de validación
Mirwald et al. (2002)	Chicos=-9.232+0.0002708*(LMI*TS)-0.001663*(Edad*LMI)+0.007216*(Edad*TS)+0.02292*(MC/T)	R^2= .891 *SEE* = 0.592	228 participantes del estudio Saskatchewan Pediatric Bone Mineral Accrural Study (113 chicos; 115 chicas)
	Chicas=-9.37+0.0001882*(LMI*TS)-0.0022*(Edad*LMI)+0.005841*(Edad* TS)-0.002658*(Edad*MC)+0.07693*(MC/T)	R^2= .890 *SEE* = 0.569	
Moore et al. (2015)	Chicos=-8.128741+(0.0070346*(Edad*TS))	R^2= .906 *SEE* = 0.514	1071 participantes del estudio HBS-III (515 chicos; 556 chicas)
	Chicas=-7.709133+(0.0042232*(Edad*T))	R^2= .898 *SEE* = 0.528	

LMI: Longitud del miembro inferior; TS: Talla sentado; T: Talla; MC: Masa corporal; SEE: Error estándar estimado.

Estudio de la maduración sexual

La evaluación de la maduración sexual como indicativo de la maduración biológica se basa en el paulatino desarrollo de los caracteres sexuales secundarios masculinos y femeninos que se inician con el aumento de las hormonas sexuales que se producen durante la etapa prepuberal (Marshall & Tanner, 1969, 1970).

Dentro del estudio de la maduración sexual, el más empleado es el propuesto por Marshall y Tanner (1969, 1970). En él se confeccionó una clasificación de cinco estadios basándose en dos escalas para cada sexo, centradas en el desarrollo de vello púbico tanto en los chicos como en las chicas, el desarrollo genital en el caso de los chicos y el desarrollo del tejido mamario en el caso de las chicas, contando con imágenes y descripción de cada uno de los estadios y las escalas propuestas. Esta metodología se ha propuesto para ser desarrollada durante un examen físico o para ser autocumplimentada por los sujetos (Marshall & Tanner, 1969, 1970).

Estudio de la maduración dental

El estudio de la maduración dental también ha sido considerado como un indicador de la maduración biológica debido a los diferentes estadios por los que pasa el desarrollo de los dientes definitivos desde su calcificación, marcando el inicio de la maduración, hasta que el extremo apical del canal radicular dental está completamente cerrado, marcando el final (Demirjian & Goldstein, 1976; Demirjian et al., 1973).

En este sentido, Dermirjian & Goldstein (1976), desarrollaron un sistema de clasificación, mediante el empleo de radiografía panorámica, de la maduración dental dividiendo el proceso en ocho fases que es posible aplicar a cada pieza dental. En esta metodología, se clasifica cada pieza dental en una escala de ocho valores para posteriormente calcular un índice conjunto entre todos los dientes analizados en el que la suma máxima de los valores es 100. Mediante este valor se le atribuye al sujeto una edad biológica basada en su maduración dental, que posteriormente se compara con su edad cronológica para establecer su desfase madurativo. Para ello, incluyen

tanto imágenes como una descripción de las características que deben reunir las piezas dentales para ser incluidas en cada uno de los grupos propuestos. Este método fue confeccionado con una muestra de 1446 chicos y 1482 chicas canadienses.

Consideraciones en el uso de los métodos de valoración de la maduración biológica en deportistas adolescentes

Cabe destacar que todos los métodos descritos con anterioridad han sido desarrollados y validados en primera instancia en un contexto clínico, en poblaciones de distintas edades no específicamente deportistas. Se puede encontrar un resumen de las características principales y las ventajas e inconvenientes de cada método en la tabla 2.

Tabla 2. Resumen de las características de los principales métodos de estimación de la maduración biológica y su adecuación al campo de estudio de las ciencias del deporte

Tipo de método	Rapidez de medición	Coste económico	Facilidad de implementación	Adecuación al ámbito de ciencias del deporte	
				Ventajas	Inconvenientes
Maduración esquelética: Radiografía de mano y muñeca según Greulich & Pyle (1969)	*	***	*	Considerado "gold standard" para la estimación de la maduración biológica en ciencias del deporte, en contextos en los que se tenga acceso a su utilización.	No cuenta con la capacidad de adaptarse a investigaciones de campo, a la necesidad de personal especializado, al tiempo y al coste de su aplicación y a la radiación a la que se exponen los participantes
Maduración esquelética: Radiografía de mano y muñeca según Tanner & Whitehouse (1975)	*	***	*	Considerado "gold standard" para la estimación de la maduración biológica en ciencias del deporte, en contextos en los que se tenga acceso a su utilización.	No cuenta con la capacidad de adaptarse a investigaciones de campo, a la necesidad de personal especializado, al tiempo y al coste de su aplicación y a la radiación a la que se exponen los participantes
Maduración esquelética: Radiografía de mano y muñeca según Roche et al. (1988)	*	***	*	Considerado "gold standard" para la estimación de la maduración biológica en ciencias del deporte, en contextos en los que se tenga acceso a su utilización.	No cuenta con la capacidad de adaptarse a investigaciones de campo, a la necesidad de personal especializado, al tiempo y al coste de su aplicación y a la radiación a la que se exponen los participantes
Maduración somática: Medidas antropométricas según Mirwald et al. (2002)	**	**	**	Método de fácil implementación, adaptable a trabajos de campo y que requiere poca formación por parte de los investigadores	Se deben tener en cuenta sus limitaciones para no introducir excesivo error en la estimación. Puede subestimar o sobreestimar el valor del desfase madurativo en los maduradores temprano o tardíos respectivamente. Es recomendable su uso para clasificar a los deportistas según su ritmo de maduración.

Maduración somática: Medidas antropométricas según Moore et al. (2015)	**	**	**	Método de fácil implementación, adaptable a trabajos de campo y que requiere poca formación por parte de los investigadores	Se deben tener en cuenta sus limitaciones para no introducir excesivo error en la estimación. Puede subestimar o sobreestimar el valor del desfase madurativo en los maduradores temprano o tardíos respectivamente. Es recomendable su uso para clasificar a los deportistas según su ritmo de maduración.
Maduración somática: Medidas antropométricas según Sherar et al. (2005)	**	**	***	Método de fácil implementación, adaptable a trabajos de campo y que requiere poca formación por parte de los investigadores	Requiere la realización de medidas antropométricas de forma repetida en lapsos de tiempo de entre tres y 18 meses durante varios años y el posterior análisis individual de las curvas de crecimiento para poder obtener el resultado de la EPVC.
Maduración sexual: Caracteres sexuales según Marshall & Tanner (1969, 1970)	***	*	***	Es un método fácil de implementar que no requiere instalaciones específicas, tiene un coste bajo, es rápido de realizar y puede ser autocumplimentado por el sujeto.	Puede ser considerado invasivo para la privacidad del individuo descontextualizado del ámbito clínico. Puede perder fiabilidad cuando se realiza de forma autocumplimentada por los sujetos.
Maduración dental: Radiografía dental según Demirjian & Goldstein (1976)	*	***	*	Tiene una fiabilidad y validez similar a los métodos radiográficos de mano y muñeca para evaluar la maduración biológica del sujeto.	Cuenta con extrema especificidad en cuanto a campos de estudio abarcados. No es posible adaptarlo a investigaciones de campo, precisa de personal altamente especializado y expone a radiación a sus participantes.

*: bajo; **: medio; ***: alto.

Métodos basados en la maduración esquelética

Los métodos basados en radiografías han sido ampliamente utilizados en población deportista (Carling et al., 2012; Figueiredo et al., 2009; Gouvea et al., 2016; Söğüt et al., 2019; Valente-Dos-Santos et al., 2014). En ellos, el objetivo es obtener el valor de la edad biológica del sujeto en el momento de la medición, sirviéndose de la maduración esquelética como indicador de la maduración biológica del sujeto, que posteriormente será comparada con la edad cronológica para conocer el desfase madurativo. Estos métodos han sido considerados el "gold standard" para la estimación de la maduración biológica, debido a la gran cantidad de datos disponibles, a la reproducibilidad de los métodos, a la posibilidad de realizar el estudio desde la infancia hasta la adolescencia tardía o la adultez y a la consistencia en los resultados respecto a las curvas de desarrollo observadas en estudios longitudinales (Malina et al., 2015). Sin embargo, debido a las diferencias en los criterios de valoración de la maduración esquelética de los que se sirven para analizar la maduración biológica, estos métodos cuentan con ventajas e inconvenientes propios que hacen que no se pueda identificar uno de ellos como "gold standard" dentro de los métodos de maduración esquelética (Malina et al., 2015). Por otro lado, ninguno de los tres métodos descritos en la presente revisión puede destacarse como el más empleado en ciencias del deporte, ya que estos métodos se han empleado para valorar la maduración biológica de deportistas jóvenes independientemente de la disciplina deportiva (Albaladejo-Saura et al., 2021; Malina, 2011).

Estos métodos se han usado tanto para analizar la maduración biológica de los participantes de forma descriptiva, como para clasificarlos como maduradores tempranos, en tiempo, o tardíos, utilizando para ello la diferencia entre la edad esquelética y edad cronológica (Carling et al., 2012). Cuando se pretende clasificar a los deportistas adolescentes en base a la edad biológica evaluada mediante estos métodos, el procedimiento más habitual es restar maduración esquelética – edad cronológica y con el resultado establecer un rango de ±1 año (diferencia de >-1 a <+1) en el que se situarían los deportistas cuya maduración se considera en tiempo, mientras que si la diferencia es positiva y mayor a un año (diferencia>+1) se considerarían maduradores tempranos, y si la diferencia es negativa y mayor a un año (diferencia<-1), maduradores tardíos (Carling et al., 2012; Figueiredo et al., 2009). Existen otras propuestas de clasificación de la maduración biológica en función de la edad esquelética, como la clasificación en más maduros o menos maduros, sin grupo de maduradores en tiempo, atendiendo a si el resultado de la resta entre la edad esquelética y la edad cronológica es positivo o negativo, que son menos empleados (Söğüt et al., 2019).

A pesar de los beneficios de los métodos basados en radiografía, cabe destacar que no están exentos de limitaciones. Los tres métodos más empleados, propuestos por Greulich & Pyle (1959), Tanner & Whitehouse (1975) y Roche et al. (1988) están basados en los mismos principios para categorizar la maduración ósea, pero debido a las diferencias en la metodología empleada para obtener la maduración esquelética se considera que no son intercambiables entre sí (Malina et al., 2015).

Por otro lado, resultan métodos con un alto coste económico, que conllevan una gran cantidad de tiempo para poder ser implementados y no son adaptables a mediciones fuera del contexto de laboratorio, lo que limita su uso en el contexto de ciencias del deporte (Malina et al., 2015; Towlson et al., 2021). Además, estos métodos precisan ser empleados por personal especializado que cuente con la cualificación necesaria para llevarlos a cabo, ya que de otra forma su validez y fiabilidad desciende (Lloyd et al., 2014; Towlson et al., 2021). Al tratarse de métodos basados en el empleo de rayos-X, algunos autores defienden que son métodos invasivos cuyo uso no está justificado en adolescentes, puesto que consideran que sólo se debería aplicar radiación a individuos en crecimiento en el contexto de un diagnóstico clínico, no estando justificado en la investigación en ciencias del deporte (Gómez-Campos et al., 2013). Sin embargo, otros

autores sí abogan por su uso, justificando que, con las técnicas e instrumentos actuales, la radiación a la que se somete al individuo durante la valoración es mínima, y no supondría una cantidad perjudicial para la salud (Malina et al., 2015). Estas limitaciones hacen que sea un método accesible principalmente para deportes con un alto nivel de ingresos económicos o acceso a las instalaciones adecuadas, como es el caso del fútbol (Carling et al., 2012; Figueiredo et al., 2009; Gouvea et al., 2016; Valente-Dos-Santos et al., 2014).

Métodos basados en la maduración somática

Los métodos de estimación de la maduración somática basados en las medidas antropométricas son unos de los más usados en la valoración de deportistas adolescentes debido a que son métodos poco invasivos, a su facilidad de uso, la posibilidad de realizar las mediciones tanto en investigaciones de laboratorio como de campo, el bajo coste del material necesario para su implementación y el relativo poco entrenamiento que se necesita por parte de los investigadores (Albaladejo-Saura et al., 2022a, 2022b, 2022c; Arede et al., 2019; Guimarães et al., 2019; Hammami et al., 2018). En ellos, el indicador de la maduración biológica es el ritmo de crecimiento y la edad a la que se produce el incremento en la velocidad del crecimiento, en comparación con la edad cronológica del sujeto. Estos métodos no permiten la estimación de la edad biológica del sujeto en el momento de la medición, sino que son indicativo del ritmo de la maduración biológica (Drenowatz et al., 2010; Drenowatz et al., 2013).

Estos métodos, de forma similar a los métodos radiológicos, se han utilizado de forma descriptiva en poblaciones de deportistas adolescentes (Albaladejo-Saura et al., 2022c) o para clasificarlos como maduradores tempranos, en tiempo o tardíos (Albaladejo-Saura et al., 2022a; Albaladejo-Saura et al., 2022b; Arede et al., 2019; Guimarães et al., 2019; Hammami et al., 2018).

En este caso, existen algunas diferencias remarcables entre los métodos basados en la observación del PVC y los que realizan su estimación a través de fórmulas. En el caso del método de observación del PVC, es necesaria la realización de varias sesiones de medición, espaciadas entre sí entre 3 y 18 meses para poder establecer la velocidad de crecimiento del individuo, a lo largo de los años en los que se produce de forma teórica el PVC para poder identificarlo en relación a las curvas de crecimiento observadas (Kelch & Beitins, 1994; Malina & Bouchard, 1991; Sherar et al., 2005; Tanner, 1990).

Sin embargo, este método también cuenta con limitaciones. La principal limitación encontrada es que es un método disponible únicamente para diseños experimentales longitudinales de larga duración, debido a la necesidad de espaciar en el tiempo las mediciones realizadas (Kelch & Beitins, 1994; Malina & Bouchard, 1991; Sherar et al., 2005; Tanner, 1990). Por otro lado, debido a la metodología empleada, el rango de edad en el que este método es aplicable se reduce a los años entorno al PHV, teniendo además que realizarse un estudio individualizado de la curva de crecimiento debido a las variaciones individuales (Sherar et al., 2005).

Por el contrario, en las fórmulas desarrolladas por Mirwald et al. (2002) y Moore et al. (2015), sólo es necesario que se evalúen las medidas antropométricas una única vez, ya que, en las fórmulas propuestas, una de las variables de predicción es la edad cronológica del sujeto en el momento de la valoración. Estas fórmulas ofrecen como resultado el tiempo en años que falta hasta que el individuo valorado alcance el PVC (si el resultado es negativo) o el tiempo en años que ha pasado desde que el individuo ha pasado el PVC (si el resultado es positivo), denominado desfase madurativo. El desfase madurativo, restado a la edad cronológica del individuo es utilizado para calcular la EPVC (EPVC = edad cronológica – desfase madurativo) (Mirwald et al., 2002; Moore et al., 2015). Este valor se puede utilizar directamente para categorizar a los deportistas en maduradores tempranos, en tiempo o tardíos, de acuerdo con diferentes criterios.

Tradicionalmente se han usado los rangos indicados por Malina & Bouchard (1991) en los que típicamente se observa el PVC, a los 11,4-12,2 para las chicas y 13,8-14,4 para los chicos, para clasificar a los deportistas como maduradores tempranos, cuando su EPVC se encontraba dentro del rango indicado; maduradores tempranos cuando su EPVC era menor al rango indicado; y tardíos cuando su EPVC era superior al rango indicado. Sin embargo, este criterio de evaluación cuenta con la limitación de que, como se ha observado en investigaciones recientes, la estimación de la EPVC puede verse alterada por la edad cronológica (Malina, Coelho-E-Silva, et al., 2021; Towlson et al., 2021), por lo que solo sería valido para poblaciones en un rango de edad reducido, que se encontrase en torno a la EPVC teórica.

Actualmente, debido a la heterogeneidad que es posible encontrar en los grupos de adolescentes evaluados en ciencias del deporte en cuanto a la edad cronológica, los métodos de clasificación más utilizados basan su criterio en el cálculo de la EPVC, estableciendo los rangos que marcan la agrupación como maduradores tempranos, en tiempo o tardíos en la media y la desviación estándar (*DT*) del grupo respecto a esta variable (Figueiredo et al., 2009; Hammami et al., 2018; Mirwald et al., 2002; Moore et al., 2015). De esta forma, hay autores que proponen un rango de ±1 año en la EPVC respecto a la media del grupo, en el que se situarían los deportistas cuya EPVC se considera en tiempo, mientras que si la EPVC tiene una diferencia mayor a un año tanto por debajo como por encima del de la media se considerarían maduradores tempranos y tardíos, respectivamente (Hammami et al., 2018; Mirwald et al., 2002; Moore et al., 2015). El establecimiento del criterio de un rango de ±1 año respecto a la EPVC del grupo para clasificar a los deportistas en los distintos grupos de maduración se debe a que las muestras en las que fueron validadas las fórmulas de Mirwald et al. (2002) y Moore et al. (2015) mostraron una *DT* ≈ 1 año cuando se evaluó su maduración biológica mediante radiografía. Pero el establecimiento de este rango tiene ciertas limitaciones cuando las muestras son homogéneas, ya que, si la *DT* de la EPVC del grupo es menor a 1 año, casi todos los deportistas serían clasificados como maduradores en tiempo. Es por ello que cuando la *DT* de la EPVC del grupo sea menor a 1 año, algunos autores han propuesto la utilización de rangos de ±0,5 años de la EPVC, encontrándose dentro de este rango los considerados maduradores en tiempo, por debajo de ese rango los maduradores tempranos y por encima de ese rango los maduradores tardíos (Albaladejo-Saura et al., 2022a, 2022b; Arede et al., 2019; Drenowatz et al., 2010; Guimaraes et al., 2019; Wickel & Eisenmann, 2007).

Sin embargo, las fórmulas de estimación del EPVC también cuentan con limitaciones que se deben tener en cuenta. Por un lado, a pesar de ser métodos muy utilizados en ciencias del deporte y contar con buenos índices de validez (*R.* = .896 - .890) (Albaladejo-Saura et al., 2021; Mirwald et al., 2002; Moore et al., 2015), se ha observado que suelen introducir cierto grado de error que limita su uso en ocasiones ya que están basados en ecuaciones de regresión (*error estándar* = 0.542-0.569 años) (Malina et al., 2016; Malina, Coelho-E-Silva, et al., 2021). Por otro lado, se ha observado que las ecuaciones tienden a subestimar el valor del desfase de la maduración para los maduradores tempranos, mientras

que lo sobrestiman para los maduradores tardíos (Towlson et al., 2021). Debido a estas limitaciones, algunos autores han recomendado utilizar estos métodos solamente en población adolescente, limitando su uso en población infantil (Malina, Coelho-E-Silva, et al., 2021; Towlson et al., 2017; Towlson et al., 2021), controlar el efecto de la edad cronológica en las estimaciones ya que se ha observado que la estimación de la maduración somática cambia de forma estable con el avance de la edad, y utilizar los métodos basados en antropometría para clasificar a los deportistas en maduradores tempranos, en tiempo o tardíos, en lugar de como medida descriptiva de la maduración biológica, ya que indican el ritmo de maduración permitiendo la comparación entre individuos, pero no el cálculo de la edad biológica (Malina, Coelho-E-Silva, et al., 2021). A pesar de estas limitaciones, se ha recomendado su uso en población deportista adolescente cuando el método "gold standard" sea imposible de utilizar (Towlson et al., 2021)

Métodos basados en la maduración sexual

Los métodos basados en el desarrollo de caracteres sexuales secundarios también han sido empleados en los estudios realizados en población deportista (Figueiredo et al., 2009; Matta et al., 2014). En estos métodos, el indicador de la maduración biológica es el grado de desarrollo que los caracteres sexuales secundarios presentan en comparación con la escala propuesta en el momento de la valoración. Sin embargo, son menos usados que los métodos basados en la maduración esquelética o somática (Albaladejo-Saura et al., 2021). El método descrito por Marshall & Tanner (1962) clasifica en cinco estadios el desarrollo de los caracteres sexuales secundarios, atribuyéndosele al estadio 1 un tiempo anterior a la pubertad (prepúber), los estadios 2-4 se consideran el desarrollo de la pubertad, y el estadio 5 el desarrollo adulto (Gómez-Campos et al., 2013). Los estadios de maduración sexual se han relacionado también con otros indicadores de maduración biológica, como con el "gold standard" (Figueiredo et al., 2009). Así se observó que los participantes clasificados como maduradores tardíos de entre 11 y 12 años fueron mayoritariamente clasificados en el estadio pre-puberal (88%) del método descrito por Marshall y Tanner (1969, 1970), mientras que los clasificados como maduradores en tiempo y tempranos de 13 y 14 años de edad cronológica se encontraron entre los estadios 3 y 4 del mencionado método.

Este método cuenta con la ventaja de su facilidad de aplicación, al tratarse de un set de imágenes con el que comparar el estado actual de los caracteres del individuo, así como al proponer la posibilidad de que sea el propio sujeto el que realice la evaluación (Marshall & Tanner, 1969, 1970).

Las características específicas de la evaluación de la maduración sexual hacen que se deban tener en cuenta los posibles inconvenientes cuando se pretenda emplear esta metodología. Se debe tener en cuenta que su uso está limitado a la etapa prepuberal y puberal, ya que fuera de ese rango no se detallan categorías para la clasificación de las características de los individuos (Marshall & Tanner, 1969, 1970). Por otro lado, una de las limitaciones principales cuando se pretende su uso en el ámbito de ciencias del deporte es que se trata de una técnica invasiva para el participante debido a los aspectos que se valoran para la clasificación, en la que se deben tener en cuenta los aspectos éticos y culturales (Gómez-Campos et al., 2013). Esto es debido a que es una metodología originalmente desarrollada para ser llevada a cabo en el contexto clínico, en exploración física del paciente por parte de personal sanitario (Marshall & Tanner, 1968). Para tratar de solventar este problema, en ocasiones se ha abogado por la autovaloración por parte del participante, hecho que podría disminuir la validez y fiabilidad del instrumento (Gómez-Campos et al., 2013).

Métodos basados en radiografías dentales

Los métodos basados en la maduración dental son ampliamente utilizados en contextos clínicos, odontológicos, forenses y antropológicos (De Donno et al., 2021), siendo el más empleado el propuesto por Demirjian & Goldstein (1976), mientras que en contextos de valoración deportiva su uso está menos extendido (Albaladejo-Saura et al., 2021; Beunen et al., 2006; Johnston et al., 2018; Malina, Martinho, et al., 2021). Este método utiliza el desarrollo dental como indicador de la maduración biológica. Este método comparte las ventajas de los métodos de estimación de la edad esquelética, contando con una gran reproducibilidad, un amplio rango de edades de implementación desde la infancia hasta la etapa adulta, y la consistencia en los resultados respecto a las curvas de crecimiento observado (De Donno et al., 2021; Demirjian & Goldstein, 1976; Demirjian et al., 1973; Gómez-Campos et al., 2013).

Sin embargo, también cuenta con similares limitaciones. Utilizan rayos-X para la valoración, lo que implica la exposición a radiación que no estaría justificada en los estudios en ciencias del deporte (Gómez-Campos et al., 2013), su uso requiere mucho tiempo, instalaciones específicas, personal cualificado y conlleva un alto gasto económico (De Donno et al., 2021; Malina et al., 2015), razones por las que su uso en los estudios en deportistas jóvenes podría ser escaso.

Limitaciones y futuras líneas de investigación

La presente investigación no se encuentra exenta de limitaciones. En ella se han revisado los métodos más empleados en la valoración de distintos indicadores de la maduración biológica en el contexto deportivo. Sin embargo, existen otros métodos de valoración de la maduración biológica que no se han analizado, como los métodos radiográficos de estructuras óseas distintas a la mano y la muñeca, o los métodos basados en el análisis de la concentración hormonal, más empleados en el contexto clínico. Por otro lado, tampoco se han analizado los métodos menos empleados o que carecieran de suficiente validación.

Futuras revisiones sobre los métodos de estimación de la maduración biológica podrían abordar la inclusión de los distintos métodos, independientemente del contexto en el que sean utilizados.

Las líneas de investigación derivadas de la presente revisión podrían estar orientadas a analizar la validez, fiabilidad y adecuación de los distintos métodos de estimación respecto a las curvas de desarrollo observadas en estudios longitudinales, así como la inclusión de variables relacionadas con el rendimiento y la salud que puedan verse afectadas por las diferencias individuales en el desarrollo madurativo.

Conclusiones

En el ámbito deportivo, cuando se pretenden realizar evaluaciones de deportistas en edad de crecimiento, es indispensable tener en cuenta el estado madurativo de éstos, debido a la gran influencia que la maduración biológica tiene sobre numerosas variables asociadas de forma directa con el rendimiento. Existen métodos de estimación de la maduración que han mostrado ser herramientas útiles para llevar a cabo una valoración del proceso madurativo de los adolescentes, como son

la maduración ósea, somática, sexual y dental. En este sentido, el método avalado por la literatura científica como "gold standard" para la estimación de la maduración biológica en poblaciones de deportistas adolescentes es el método de maduración ósea, el cual se basa en la realización de radiografías de mano y muñeca, aunque se debe tener en cuenta que sus limitaciones, entre las que destacan el coste económico, el tiempo y las instalaciones requeridas para su implementación, la necesidad de evaluadores altamente cualificados y la radiación a la que se expone a los sujetos pueden condicionar su uso en la mayoría de las situaciones aplicables a los estudios en ciencias del deporte. En el caso de que el empleo del método radiográfico no se encuentre disponible, la valoración de la maduración somática a través de las fórmulas que emplean variables antropométricas para su cálculo son una opción ampliamente utilizada, fiable y válida, y además cuentan con las ventajas de su facilidad de aplicación y su adaptabilidad a investigaciones de campo. Sin embargo, se ha de tener en cuenta que estos métodos pueden introducir cierto error en la estimación, subestimar o sobreestimar el valor del desfase madurativo en los maduradores temprano o tardíos respectivamente, y que es recomendable su uso para clasificar a los deportistas según su ritmo de maduración, puesto que los métodos de estimación de la maduración somática basados en antropometría son un indicador del ritmo de la maduración biológica, pero no de la edad biológica, lo que constituye una de sus principales limitaciones. Por último, la valoración de los caracteres sexuales y del desarrollo dental son métodos de estimación de la maduración menos utilizados en ciencias del deporte, principalmente por su carácter clínico, por las implicaciones éticas, y por la dificultad en su aplicación.

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To Win or Not to Win: How to Success in the Asian Champions League

Ganar o no ganar: cómo triunfar en la Liga de Campeones asiática

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Short title:
Success in the Asian Champions League

How to cite this article:
Abdolmaleki, H., Soleimani, M., Khodadad Kashi, S., Mahmuodi, A., & Varmus, M. (2022). To Win or Not to Win: How to Success in the Asian Champions League. *Cultura, Ciencia y Deporte*, *17*(53), 77-87. https://doi.org/10.12800/ccd.v17i53.1854

Received: 10 march 2022 / Accepted: 11 may 2022

Abstract

In professional sports, predicting success factors is very vital and important and is always questionable. The failure of teams in the leagues has been a constant issue and progress and gaining status has been a challenge for all clubs; and managers, officials, sports federations and clubs, and even researchers, are trying to shed light on the various dimensions of this issue. The purpose of this study was providing a model of predicting the success of football clubs in the Asian Champions League. The present study is descriptive-correlational. Seven Asian countries that won the Asian Champions League (ACL) were analyzed between 2014 and 2019. At the level of descriptive statistics, mean and standard deviation, and at the level of inferential statistics, because the response variable (success) was a qualitative variable, the logistic regression model was used. Data analysis was performed using SPSS software. Findings showed that 80% of the success of clubs in the ACL is correctly identified using the research model and foreign players, the average value of each player, the total value of the club and the number of players in a team have a positive impact on the success of football clubs. The age of the players has a negative effect, in other words, the lower average age can contribute to the success of football clubs. Therefore, these factors are considered as a comparative advantage for the success of clubs and managers and stakeholders are suggested to put the necessary planning and investment on their agenda to achieve these things.

Keywords: value of clubs, players, football, performance, FDM.

Resumen

En los deportes profesionales, predecir los factores de éxito es muy vital e importante y siempre es cuestionable. El fracaso de los equipos en las ligas ha sido un tema constante y progresar y ganar estatus ha sido un reto para todos los clubes; y directivos, funcionarios, federaciones y clubes deportivos, e incluso investigadores, intentan arrojar luz sobre las diversas dimensiones de este problema. El propósito de este estudio fue proporcionar un modelo para predecir el éxito de los clubes de fútbol en la Liga de Campeones de Asia. El presente estudio es descriptivo-correlacional. Se analizaron siete países asiáticos que ganaron la Asian Champions League (ACL) entre 2014 y 2019. A nivel de estadística descriptiva, media y desviación estándar, y a nivel de estadística inferencial, porque la variable respuesta (éxito) fue una variable cualitativa. se utilizó el modelo de regresión logística. El análisis de datos se realizó con el software SPSS. Los hallazgos mostraron que el 80% del éxito de los clubes en la ACL se identifica correctamente utilizando el modelo de investigación y los jugadores extranjeros, el valor promedio de cada jugador, el valor total del club y la cantidad de jugadores en un equipo tienen un impacto positivo en El éxito de los clubes de fútbol. La edad de los jugadores tiene un efecto negativo, es decir, la menor edad media puede contribuir al éxito de los clubes de fútbol. Por lo tanto, estos factores se consideran una ventaja comparativa para el éxito de los clubes y se sugiere a los gerentes y partes interesadas que incluyan la planificación y la inversión necesarias en su agenda para lograr estas cosas.

Palabras clave: valor de clubes, jugadores, fútbol, rendimiento, FDM.

Introduction

Today, the sports industry is an important sector with an economic impact. The economy plays a decisive role in all activities that take place in society (Mohammadi et al., 2021). One of these activities is sport, and the most popular sport in most countries is football, to the extent that many countries in the world consider football as their national sport. Scholars consider obtaining financial resources for sport clubs necessary and vital (Shabani, 2016). Observations show that the sport is very widespread, organizationally; Albert and Koning (2008) report that 207 countries are members of International Federation of Association Football (FIFA) which is more than the number of Union Nations (UN) member states (192 countries) and in most countries, the largest sports federation is the Football Federation. Football has become a multibillion-dollar industry in recent decades, with more than 200 million athletes worldwide (Halicioglu, 2006). Many industries and individuals are also directly and indirectly beneficiary in this industry.

Regarding the high cost of sports teams and the acquisition of financial resources for sport clubs, scholars say that today, earning money is a factor for the survival and the key to the success of an organization and even society (Abdolmaleki & Babaei, 2021). Secure and stable income provides the necessary facilities to face the expenses of organizations and without it; they will face liquidation and destruction and will not be able to survive in a competitive environment. In fact, revenue generation and financial resources help in effective development and planning and are the driving force of sports organizations, sport clubs and leagues (Ehsani et al., 2008).

Football can be considered as one of the indicators of development at the international level, so the success of football clubs is very important. Therefore, in the world of scarce resources, sport clubs must identify what makes them successful and invest accordingly (Georgievski et al., 2019). But the failure of teams in the leagues has been a constant issue and the promotion and status has been a challenge for all sport clubs; and managers, officials, sports federations and sport clubs, and even researchers, are trying to shed light on the various dimensions of this issue.

Georgievski et al. (2019) in their research stated that the success of sport clubs in sports is a relative term. While some teams are always trying to win leagues, others are just happy to be in the competition. But before the start of each season, sports experts analyze the potential for low or higher-performing teams based on money spent, team members' experience, and other quantitative and qualitative perceptions. Football teams do not have the same characteristics. However, as mentioned, not all football clubs have the same goals and the same resources. Therefore, based on the resources at their disposal, they should be able to achieve their goals. Rohde and Breuer (2016) state that sports success is driven by team investments. Dimitropoulos and Limperopoulos (2014) also provided evidences in their research that team investments contribute to sports success.

Past studies show that in the Iranian Professional League, most football clubs at the end of their fiscal year do not have a positive balance sheet statement of financial and their expenses are more than their incomes. And most of them are financed with the help of governmental organizations and industries, and the sport clubs themselves have little income (Abdi et al., 2016). 65% of professional football clubs in Iran are dependent on direct assistance from the government or industrial organizations (Naderian et al., 2015). So, predicting the success of football clubs based on scientific studies can help managers and those involved in this important sport to work with more awareness and knowledge in this field. Therefore, with this aim, the present study provides a model of predicting the success of football clubs in the ACL.

Literature Review

Football clubs and financial issues

Sports and financial performance are believed to be interrelated. Football clubs with poor financial performance are in a bad position in terms of sporting success. On the other hand, there are only a limited number of football clubs that are financially good but have not had serious success in sports (Abdolmaleki et al., 2019). By carefully examining the different meanings of the two concepts of success in sports and economic factors, and by examining the top football clubs, it is clear that success in sports, especially football, requires a large budget. Analyzing the financial performance of football clubs can provide a new perspective on this issue (Sakinc et al., 2017).

Over the past 20 years, professional football clubs have grown increasingly from sport clubs to commercial companies. Compared to previous decades, the revenue that leagues and sport clubs receive from the sale of media rights and commercial products, as well as advertising and sponsorship, has increased significantly today (Frick & Prinz, 2006). Football clubs need a lot of money to be able to afford the necessary expenses and the inevitable expenses of this popular sport (García-Manso et al., 2020). Major and main expenses of football teams are salaries and bonuses of players and their transfer to sport clubs, human resources, construction and maintenance of sports facilities and spaces, travel expenses, insurance, taxes and services, and major and main incomes are sponsors, The right to television broadcasts, advertisements, player sales, sports equipment and game tickets (Morrow, 1999).

Football is becoming the most televised sport in the world. The amount of money paid for television broadcasting rights indicates the future progress and success of the game (Buraimo et al., 2010). Iranian football at all national and international levels is deprived of this right as one of the main sources of funding. Therefore, this issue can be considered by scholars in examining the success of Iranian teams, especially teams in domestic leagues and the ACL. In a world of scarce resources, sport clubs need to identify what makes them successful and invest accordingly (Georgievski et al., 2019). It seems that football clubs can be more successful if they have a comparative advantage, so it is necessary to examine their success in terms of the factors that are considered an advantage. On the other hand, sports success internationally at the elite level can be a sign of the general condition of a sport in a particular country and is often used by national governments, media and public to judge the work of sports governing bodies and sports executives (De Bosscher et al., 2011; Sotiriadou & De Bosscher, 2018). Thus, understanding the determinants of international success is of interest to many stakeholders, including public bodies and sports sponsors (De Bosscher et al., 2006).

Literature on Predicting success in sports

Since the nature of competition means, teams must try to outscore their opponents, and at the end of year collect more points, football clubs have been trying to develop

ways and plays to win (Majd et al., 2021). The application of economic theories to sports is not new. Many scholarly articles focus on the relationship between economics and sports, and the impact of economics on sports (Georgievski et al., 2019). However, there is no article for predicting the success of Asian football clubs in leagues, especially the ACL, based on factors that are considered an advantage.

In this regard, Jones and Cook (2015) stated that with the influence of foreign direct investment and change of ownership in the Premier Football League, sport clubs are able to have better players, which leads to richer and better teams with strong budgets and higher positions in the league. The results of Shabani (2016) study entitled "The relationship between the cost and rank in the Premier League football clubs" showed that there is a significant inverse relationship between cost and rank in the Iranian Premier League, meaning that with increasing costs of teams in the league their rank decreases. And predictions indicate that approximately 35% of rank changes in the Premier Football League are related to league costs. Gerhard and Mutz, (2017) tested the effect of a team's market value and the various characteristics of its composition on team performance using a sample of 12 European Football Premier League teams. Their research analysis showed that success in professional football is highly dependent on the market value of the players which accounts for two-thirds of the performance variance and at the beginning of the season; the next success can be predicted by knowing the market values of rival teams. Their research out of a total of 60 football seasons showed that the team with the highest market value won the national championship 38 times. Fifteen more times, the team with the second highest market value has won, and the team with the third highest value has won six times, and in just one of 60 seasons, Leicester City, who had little chance of winning, won the 2015-2016 English Premier League. In general, teams competing for the title can be predicted before the start of the season. Szymanski and Kuypers (1999) showed that team payroll and positive annual transfer costs contribute to sporting success. Gasquez and Royuela (2016) in their review of the determinants of international football concluded that economic, demographic, climatic, geographical and football institutions are good indicators of international football success. In this regard, the findings of Hoffman et al. (2002) show that economic, demographic, cultural and climatic variables are important. Lepschy et al. (2020) state that success is only significant for away teams and that the higher market value of sport clubs and teams seems to have a more positive effect on their success. Balsmeier et al. (2019) assessed the impact of foreign players on domestic players as positive. They perceived both the sporting and economic impact of foreign players as positive, because the foreign players can enhance not only the skills of domestic players, but also attract more fans to the matches of individual teams. Hardman and Iorwerth (2014) in their research showed that weakening national teams under the influence of a large number of foreign players is not necessarily correct. Schauberger and Groll (2018) in them consider two different types of random forests depending on the choice of response. One type of random forests predicts the precise numbers of goals, while the other type considers the three match outcomes -win, draw and loss- using special algorithms for ordinal responses. Results of Mirzaei et al. (2018) showed that, 232 indexes Including Per capita GDP, population, Age structure, The duration of the establishment of the Football Federation in the countries, The duration of the federation join to FIFA, World Cup hosting and Military cost could predict the success of countries in FIFA World Cup. In this analysis, indexes were classified into 5 elements: political, economic, social and cultural, technology and sport (PEST+S). Finally, it is possible for managers according to given facilities and resources of the country compared to other countries adopt appropriate policies and programs. Li et al. (2020) results revealed that there were no significant differences regarding the age at which players started playing tennis by players' career peak ranking levels. Results showed that 75% of the top 300 players started playing tennis between the ages of 3 to 7 years, whilst 21% started between 7 to 10 years, and 4% started later between 10 to 13 years. Results further showed that professional rankings between 14 and 18 years were not reliable in predicting a player's future ranking. The results of research by Valenti et al. (2020) show that highly specialized coaching has a significant and positive effect on international success in women's football, while financial support and human resources have no significant explanatory power for the success of women's national teams.

Research context

It has been 28 years since the last championship of an Iranian team in the ACL and since then no representative from Iran has achieved this success in these competitions. Of course, Sepahan football team in 2007, Zob-Ahan football team in 2010 and Persepolis football team in 2018 were able to reach the second place of this competition. Throughout the history of these competitions, Korean teams have won 11 championships, Japanese teams have won 7 championships, Saudi teams have won 4 championships, and Iranian teams have won only 3 championships. Esteghlal Tehran team won the championship twice in the 1970 and 1990 - 91 seasons and the Pas team won the championship in the 1992-93 seasons, but now the Pas team is not even in the Premier League. These results show the difference between Iranian and Asian club football. Although the matches in the ACL in Iran are the most watched matches and, in this respect, we have a record even in the world, but these results show that Iranian football is struggling with other problems. Experts cite investment in football, including attention to grassroots football, education, player building, and other factors as factors in success in football. The failure of Iranian teams in the AFC Champions League requires a grand strategy and the provision of scientific and practical solutions, and the present study seeks to provide a new perspective and examine the success of football clubs in the ACL.

Method

The current study involved two phases. In the first phase, we developed an initial set of factors and refined this list through applying Fuzzy Delphi method (FDM) with a panel of Football industry experts. This phase allowed us to identify the most important factors leading success in ACL. In the second phase, we collected data from www.transfermarkt.com, and present a Logistic Regression Model (LRM). We review the methods associated with each phase in the following sections.

Phase 1: Fuzzy Delphi Method (FDM)

The Delphi method is a research method that seeks to establish consensus on a complex problem amongst a group of experts in a particular field (Dalkey & Helmer, 1963). Experts' opinions are converged, typically via several rounds of questionnaires (Okoli & Pawlowski, 2004). The approach is well-established in studying sport organizations (e.g., Abdolmaleki et al., 2018; Anderson et al., 2019; Costa, 2005). The Delphi method is an effective process of establishing consensus expert opinions in a given field. However, the method does have several limitations including: 1) multiple survey cycles are time consuming for both participants and researchers;

2) multiple surveys are expensive to administer and analyze; 3) repeated expert cooperation is required before consensus emerges, needlessly increasing the difficulty of coordination and communication; 4) lack of complete consensus amongst experts makes it easy to misinterpret their collective position, especially for complex contexts; 5) the analytical process can weaken or exclude minority opinions (Hsu & Yang, 2000; Ishikawa et al., 1993).

To overcome these limitations, Murray et al. (1985) proposed integrating fuzzy set theory with the Delphi method. Fuzzy set theory enables representation of the uncertainty and imprecision in real world systems (Zadeh, 1965). The key underlying principle of fuzzy set theory is that while some sets have sharply-defined inclusion criteria, that is not the case in many applications, and it can be useful to consider set membership along a continuum from totally not a member to totally a member (Zadeh, 1965). Thus, fuzzy theory has the capacity to represent vague or imprecise data by incorporating a measure of uncertainty (Kahraman et al., 2004). Applied to the Delphi method, membership degree establishes the membership function of each expert's perspective on each study element. Further refining the FDM, Ishikawa et al. (1993) introduced the max-min algorithm and fuzzy integration, which allow compilation of expert opinions via fuzzy numbers.

Consistent with previous Fuzzy Delphi studies (e.g., Bouzon et al., 2016), we deployed a four-step approach to data analysis. In the first step, we established an initial list of factors affecting success in Football leagues. During this process, we identified factors potentially effective in the success in Football leagues. As an initial filtering step, five Football management experts (i.e., Managers of Football clubs with experience of international tournaments and events) evaluated each of the previous factors. The factors were discussed with each participant as part of a semi-structured interview. Most questions used the identified factor as a prompt and participants were asked if each factor was relevant to success in Football leagues. All factors were retained after this step.

The second step involved collecting expert opinions on the importance of each factor to success in Football leagues. We surveyed experts to determine the final version of the criteria. We sent each member of our expert panel the list of factors and asked them to indicate the importance of each from 1 (very insignificant) to 5 (very important). Arguably the most important decision in a Delphi study is the selection of expert panel lists. To be included, individuals were required to meet the following two criteria:

1: A university degree in management or sports management.

2: A minimum of five years of management or Football clubs with experience of international tournaments.

Diverse participants with disparate values are generally preferable (Hussler et al., 2011). Eighteen invitees accepted our invitation. The panelists all had expertise in Football management. This number was consistent with the widely accepted size of 12–20 participants for a Delphi panel (Abdolmaleki et al., 2020; Dalkey et al., 1970). Table 1 provides demographic characteristics and esports related experience of our expert panel.

Table 1. Demographic characteristics of expert panel

Characteristic		*n*
Age	Under 40	2
	40-49	3
	50-59	8
	60 or above	5
Gender	Male	11
	Female	7
Educational level	Bachelor	6
	MSc or higher	12
Years of experience	5 years	5
	6-15 years	6
	More than 15 years	7

In the third step, we organized the expert opinions collected from the questionnaires into estimates and established triangular fuzzy numbers to permit further evaluation. Triangular fuzzy numbers are established by allocating different weights (in the range between zero and one) to identify the minimum, maximum, and most likely value. A triangular fuzzy number is shown in Figure 1. The most likely value is best represented by the geometric average of the experts' opinions (Saaty, 1990), a common approach in practical studies using FDM (Wu & Fang, 2011). Thus, we adopted the geometric average for the most likely value score. That is, for each factor, we established a fuzzy number represented by the triple: $\tilde{A}$ = (LA, MA, UA) where LA represents the lower bound, MA the geometric mean, and UA the upper bound of expert opinions.

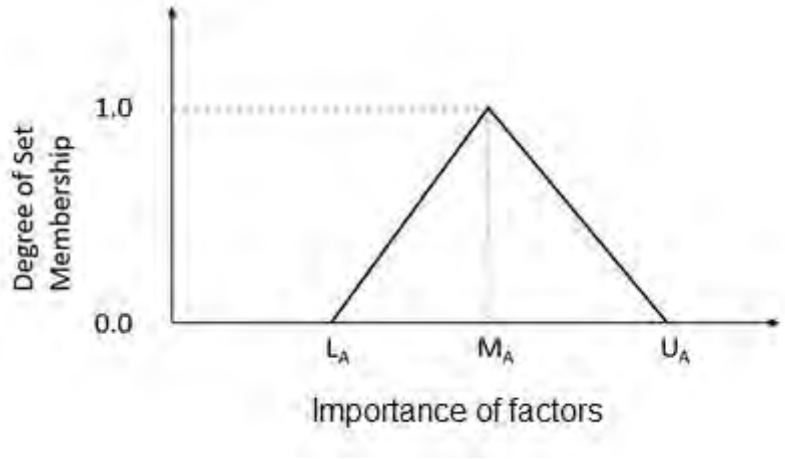

Figure 1. Triangular Fuzzy Number

Finally, in the fourth step, following previous studies (e.g., Abdolmaleki et al., 2018), we used de-fuzzification to filter the factors. De-fuzzification converts fuzzy numbers to crisp representations that can be evaluated relative to pre-established criteria (Hsu & Yang, 2000). Following Hsu and Yang (2000), we calculated the average Ã with MA, the geometric mean, weighted four times as much as the minimum (LA) and maximum (UA) values and adopted a threshold criterion D (Ã) of .7.

Phase 2: Logistic Regression Model (LRM)

In this phase data were selected from clubs in 7 Asian countries that had more prestigious leagues and had a history of winning the Asian Clubs League/Asian Champions League. For this purpose, the representatives of these 7 countries in the ACL between 2014 and 2019 were analyzed. These 7 countries included 4 countries in the West Asian region (Iran, UAE, Saudi Arabia and Qatar) and 3 countries in the East Asian region (Japan, South Korea and China). The required information on the research variables was retrieved from the website (www.transfermarkt.com) on May 15, 2020. This website has also been used in previous research such as Varmus et al. (2020). In order to analyze the data, at the level of descriptive statistics, mean and standard deviation, and at the level of inferential statistics, because the response variable (success) was a qualitative variable, the LRM was used. Data analysis was performed using SPSS (ver. 23) software.

Results

Restated, in order to identify the practices affecting success in ACL, we developed an initial list of factors. We then employed the Fuzzy Delphi method and an expert panel to reduce the number of factors, retaining those the experts deemed important. Results of this process are presented in Table 2. As can be seen in Table 2, we retained 5 factors, while two factors (foreign head coach and psychological factor) failed to meet our retention criterion and were subsequently deleted. Following the conclusion of the FDM, we progressed to phase 2 to present LRM with retained factors.

Table 2. Results of FDM

Factors		D(Ã)
Accepted factors	Age	.766
	Foreign players	.808
	The value of the player	.745
	Club market value	.720
	Number of players per season	.703
Deleted factors	Foreign head coach	.617
	Psychological factor	.578

Note: D(Ã) represents a de-fuzzified score based on the geometric mean of each indicator's triangular fuzzy number. If D(Ã) ≥ .7, then the factor was retained.

Based on results of FDM phase, the success factors of football clubs were included: age, number of team players per season, value of each player, market value of the club and number of foreign players. First, we looked at the status of each of these components among the clubs of these 7 countries, the results of which are given in Table 3 below.

Table 3. Descriptive status of research components among clubs

League	Component	Minimum	Maximum	Mean	Standard Deviation
Iran	Age	23.4	27.2	24.88	1.19
	Foreign players	2	7	4.06	1.33
	The value of the player[1]	110000	556000	361200	108225.42
	Club market value	2300000	17300000	11792000	3771741.16
	Number of players per season	29	44	34.42	3.66
Saudi Arabia	Age	24.5	28.9	46.16	1.07
	Foreign players	4	14	7.33	2.69
	The value of the player	219000	1590000	752400	485564.14
	Club market value	7680000	57250000	25496666.66	183459.19
	Number of players per season	27	48	38.23	4.75
UAE	Age	23.6	28.8	25.48	1.34
	Foreign players	4	10	6.46	2.68
	The value of the player	52000	1110000	475866.66	315981.66
	Club market value	2250000	41200000	17734000	12468437.18
	Number of players per season	32	50	37.41	6.89
Qatar	Age	23.6	27.9	25.28	1.18
	Foreign players	5	9	6.93	1.27
	The value of the player	137000	1620000	586200.0	338226.08
	Club market value	5080000	61530000	20518000	12837582.21
	Number of players per season	31	45	36.02	3.78
Japan	Age	23.2	27.1	24.9	1.18
	Foreign players	1	9	5.62	1.92
	The value of the player	348000	758000	516125.0	113117.56
	Club market value	11480000	34250000	1776437.0	2941865.55
	Number of players per season	31	44	36.71	4.06
South Korea	Age	23.9	27.4	25.56	0.88
	Foreign players	1	6	4.2	1.42
	The value of the player	213000	541000	401666.66	110133.46
	Club market value	9380000	23980000	15279333.33	4193909.64
	Number of players per season	34	45	38.41	5.69
China	Age	23	25.9	24.52	0.88
	Foreign players	3	7	5	1.13
	The value of the player	423000	2560000	1610666.66	746542.10
	Club market value	13130000	87080000	51884000	24936716.99
	Number of players per season	26	36	32.24	2.93

Note: [1] The value of the players and the market value of the clubs is in Euro

As can be seen in Table 3, in terms of age and total number of players, representatives of Iran are almost equal to other Asian countries. But there are differences with some Asian countries, especially Saudi Arabia, Qatar and China, about the components of player value and the market value of the club. In the following, we will examine the regression model of the research. First, in Table 4, the general test of the research is presented.

Table 4. General test of research

		χ^2	df	*P-Value*
Step one	Step	9.187	4	.01
	Block	9.187	4	.01
	Model	9.187	4	.01

The results of Table 4 show that according to the obtained level of significance (P-Value), the independent variables of the research have been statistically effective and are suitable for entering the model. Then, Table 5 summarizes the research model.

Table 5. Summary of research model

Step	2 Log likelihood	R^2 Cox and Snell	R^2 Nagelkerke
1	326.787	.249	.398

Table 5 shows the variability of the general model by predictor variables, which according to this table, approximately 40% of the changes related to the Fuzzy logic, are explained by the predictor variables in the research model. Alse, table 6 shows the goodness of the research model fit.

Table 6. Fit goodness test of Hosmer and Lemeshow

Step	χ^2	df	P-Value
1	10.829	8	.265

According to the results of Table 6, it can be said that the significance level is more than .05, so it can be said that the predicted classification is consistent with the observations. Table 7 shows the model validation and sensitivity analysis.

Table 7. Validation and sensitivity of the research model

Observed values			Predicted values		
			Success in the Asian Champions League		Correct percentage
			N0	yes	
Step1	Success in the ACL	No	102	0	100.0
		Yes	1	4	80.0
		Total percentage			99.0

As can be seen in this table, the sensitivity of the model (probability that an event occurred and correctly predicted) is equal to 80% and the rate of characterization (probability that an event did not occur and correctly predicted) is equal to 100%. Thus, 80% of the success of clubs in the ACL has been correctly identified with this model. In total, the accuracy of the research model is 99%. Finally, Table 8 shows the significance of each of the research variables in the model.

Table 8. Final research model

Step1		B	Standard Deviation	Wald	df	P-Value	Predict rate
	Constant number	-.310	.735	.002	1	.967	.970
	Age	-.61	.284	4.718	1	.030	.941
	Foreign players	1.022	.223	21.058	1	.000	2.778
	The value of the player	1.695	.225	56.60	1	.000	5.446
	The value of the club	1.950	.230	71.804	1	.000	7.028
	Number of players	.574	.242	5.644	1	.018	1.755

According to the results of Table 8, it can be stated that foreign players, the average value of each player, the total value of the club and the number of players in a team have a positive effect on the success of football clubs in the ACL and the age of players has a negative effect, in other words, the lower average age (according success clubs it should be between 24 -26 years) can contribute to the success of football clubs in the ACL. Also, the value of players has most effect on the success (B= 1.950) and on follow, there are the value of player (B= 1.695), foreign players (B= 1.022), age (B= -.610) and number of players (B= .574).

Discussion

In professional sports, predicting success factors is very vital and important and is always questionable. Although it is very difficult to find objective criteria and not all of them can be answered at the same time, this study has focused on the value of clubs and players and the number of foreign players and players and their age. According to the research findings, it can be said that the accuracy of the research model has a very high percentage and 80% of the success of clubs in the ACL can be correctly identified with this model. In fact, these findings show that the success of football clubs in the ACL is very predictable.

The results show that the value of the club can predict the success of football clubs in the ACL. Also, according Beta coefficient (B= 1.950) this factor is the most important factor in ACL success. As can be seen from Table 3, Saudi Arabia is better than other countries in this factor, and this could be a possible reason for the championship of its football clubs. As Al Hilal team won this competition last season (2021). It should be said that most researches in the field of identifying the components predicting success in international events Including football, among various variables, have considered the economic variable as the most important factor (Mirzaei et al., 2018). The relationship between income and financial growth indicates a growing gap between leading football clubs and their followers (Rohde & Breuer, 2016). Today, the sports industry, especially football clubs, will not be able to compete without generating revenue, so we must try to increase the value of clubs with more revenue on the way to success so that clubs can compete with their competitors. In Iran, most football clubs rely on government revenues, which is by no means enough. Therefore, it is suggested that due to the effectiveness of financial resources in the success of clubs, non-governmental and private resources should be attracted and teams should make optimal decisions about how to allocate their resources to increase their chances of success.

The results of this study showed that the number of foreign players can predict the success of football clubs in the ACL. Consistent with the results of the study, Varmus et al., (2020) concluded that there is a correlation between the presence of foreign players in competitions and the success of clubs in domestic and European competitions, and if a higher percentage of foreign players participate in league competitions, they are more successful in national and international leagues. They also point out that the teams under consideration have a relatively significant number of foreign players, and in these competitions these players are given more opportunities than domestic players. This represents a significant shift in club thinking. Therefore, it is suggested that this issue be carefully considered. In any case, it can be argued that foreign players are essential to the club's success in today's competitive environment. As Smith (2016) states, foreign players bring additional quality to the sport. Therefore, football clubs should pay special attention to this issue.

The results show that the number of players can predict the success of football clubs in the ACL which is consistent with the results of Mirzaei et al. (2018). Players are the core of football. A team that has particularly re-known players must necessarily support high spending on their salaries, which could be interpreted as an element causing a reduction in operating income. In contrast, a fleet of talented players is a resource that helps to increase not only the company's revenues but also the reputation, the number of fans and the general appeal of the club, thus producing a positive impact on the value of the soccer club. This result is consistent with the research of Mirzaei et al. (2018). In fact, players are one of the assets of clubs, which on the one hand affect the value of clubs and on the other hand improve sports performance and success, which in turn attracts more fame and fans and revenue from ticket sales, television broadcasting rights, financial support, and business increases (Tiscini & Strologo, 2016). The success of a professional club hinges largely on its ability of assembling the best team. Modern professional football is indeed a money game, in which larger investment spent on the acquisition of talented players generally yields better team performance and wealthy clubs are willing to pay millions of Euros for a qualified player. Therefore, professional clubs must maintain the exclusive resources of players in order to achieve better performance in domestic and international competitions (Liu et al., 2016). Football can attract foreign investors (Nauright & Ramfjord, 2010). But the most important sample of providing extensive resources in today's football business is transfers (Felipe et al., 2020). Therefore, according to the presented materials, it can be said that the players of the teams have an important role in the performance, success and value of the clubs and it is suggested that the decision regarding the transfers of the players be reasonable and cost-effective.

The results showed that the age of the players could predict the success of football clubs in the ACL. This result is not consistent with Li et al. (2020). One of the possible causes of consensus is the difference in sports. In this study, tennis players were evaluated, while we examined football players. In this regard, well-known clubs around the world today have policies in place to attract young players, so that these clubs identify talented young and very young players and by attracting and empowering them for many years, The club benefits from the existence of those players (Abdi et al., 2016). It is natural that these policies are in line with the goals of the clubs, which is ultimately the success of the teams. Therefore, the findings of this study confirm the effectiveness of the age of the players as one of the indicators of success of football clubs, which is consistent with the results of the present study.

The results showed that the value of the players could predict the success of football clubs in the ACL, which is consistent with the results of Gerhard and Mutz (2017). The results of their research indicate that success in professional football is highly dependent on the market value of the players and accounts for two-thirds of the variance in performance.

Success in sports is not easily possible and requires a lot of investment. Wealthy and industrialized countries are leading the way in the development of sports equipment and infrastructure investments in sports, and in fact this has led to the continued success of these countries in the international arena. However, in Iran, adequate investment has not been made in creating sports facilities, and of course, the limited resources allocated have not been used effectively (Khodadad Kashi & Karimnia, 2016). On the other hand, although financial and economic conditions are very effective on the success of countries, but it should not be considered a decisive role because some cases can be found that despite the high per capita income,

but not significant success is achieved. A clear example of such a claim is Qatar, which has a very high per capita income, but despite sufficient political will and large payments to change the citizenship of the world's top athletes, but cannot achieve significant success even in the ACL. In Qatar, the best sports facilities and equipment have been provided and the best sports coaches have been recruited for a considerable fee and in the field of sports diplomacy, they often accompany the votes of sports officials, sometimes corrupt, with numerous bribes, but it will be impossible for this country to have significant and continuous sporting success due to the lack of talented young people. Experience shows that athletes who change their nationality do not have a high motivation to try to gain a position under a foreign flag (Khodadad Kashi & Karimnia, 2016). Therefore, tying all the success of football clubs based on the specific factors raised in this study cannot be justified. In other words, although the economic factors and the value of the club and the foreign players of the teams and their number can be considered as a necessary condition for the success of the teams in the ACL, but they are not enough and different variables should be considered and examined. Therefore, comprehensive and complementary studies in this regard are the suggestions of this research for future studies.

Limitations and Future Directions

Though this work contributes success in Football leagues, like all works it is not exempt of limitations. Firstly, due to the Covid-19 virus pandemic and travel restrictions in Iran, access to some Football experts was not possible. It is suggested that after the end of the virus epidemic, a similar study be conducted that uses the opinions of other experts.

Second, this research was conducted among ACL, which is of lower quality than the European Champions League. We recommend that a similar study be done on the European Champions League and that the differences between these be compared.

Lastly, and related to the above, having focused the work on a specific sample and a single product, we have not taken into account the expense. Therefore, another limitation is related to the lack of information on the luxury spending of the participants and this information will be interesting in identifying future expenses.

Conclusion

In general, clubs need to identify the factors that make them successful and invest accordingly. The results of the research indicate that the value of clubs and players, the age of players and their number are factors influencing the success of football clubs in the Asian Champions League. Therefore, these factors are considered as a comparative advantage for the success of clubs, and it is suggested that football authorities, especially the football federation and clubs, optimally invest in these factors as a competitive advantage. Managers can increase team investment by attracting wealthy private majority investors. This strategy is done with the aim of increasing the quality of the team and thus increasing the sports success.

Acknowledgment

This work was supported by the [Slovak Research and Development Agency] under Project [Sustainability strategy of a sports organization in the conditions of the Slovak Republic], under Grant [APVV-20-0481].

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Intra-rater and intraday test-retest reliability for physical performance tests in young Chilean tennis players

Confiabilidad test-retest intraevaluador e intradía para pruebas de rendimiento físico en jóvenes tenistas chilenos

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Short title:
Reliability, physical performance and young tennis players

How to cite this article:
Luna-Villouta, P., Leao Ribeiro, I., Faúndez-Casanova, C., Vásquez-Gómez, J., Flores-Rivera, C., Vargas Vitoria R. (2022). Intra-rater and intraday test-retest reliability for physical performance tests in young Chilean tennis players. *Cultura, Ciencia y Deporte, 17*(53), 89-97. https://doi.org/10.12800/ccd.v17i53.1853

Received: 13 january 2022 / Accepted: 02 july 2022

Abstract

In tennis, the use of standardized tests seeks to provide a useful complement tool for performance monitoring, becoming a very valuable instrument for evaluating the athlete's physical condition. The aim of the study was to assess the intra-rater and intra-day test and retest reliability for physical performance in young Chilean tennis players. The sample size was of 86 young tennis players (15.4 ± 0.8 years old), male = 58; female = 28. Variables of physical performance were tested, 20 m. sprint test; modified agility test (MAT test); sit-and-reach test and shoulder flexibility; hand grip strength (HGS); horizontal jump (HJ), medicine ball throw (MBT), countermovement Jump (CMJ) and Abalakov (ABK). To examine the intra-rater and intra-day test-retest reliability, subjects performed the tests twice on the same day. Results showed excellent test-retest values of relative reliability (intraclass correlation coefficients; *ICC* between .80 - 1.00), respect to the absolute reliability, all the tests presented small values of standard error of measurements (*SEM*) and adequate values for the minimal detectable change (*MDC*). Physical performance tests used in this study reported high intra-rater and intraday test-retest reliability for all male and female individuals, except for agility in men, which shows moderate relative reliability.

Keywords: tennis, reliability, physical fitness, field tests, young boys.

Resumen

En tenis, el uso de pruebas estandarizadas busca brindar un complemento útil para monitorear el rendimiento, convirtiéndose en un instrumento muy valioso para evaluar la condición física del deportista. El objetivo del estudio fue evaluar la confiabilidad test-retest intraevaluador e intradía para pruebas de rendimiento físico en jóvenes tenistas chilenos. La muestra fue de 86 tenistas juveniles (15.4 ± 0.8 años), varones = 58; damas = 28. Se probaron las variables de rendimiento físico, sprint de 20 m; test de agilidad modificado (MAT test); test sit-and-reach y flexibilidad de hombros; fuerza prensión manual (HGS); salto horizontal (HJ), lanzamiento de balón medicinal (MBT), salto con contramovimiento (CMJ) y Abalakov (ABK). Para examinar la confiabilidad test-retest intraevaluador e intradía, los sujetos realizaron las pruebas dos veces el mismo día. Los resultados muestran excelentes valores test-retest de confiabilidad relativa (coeficiente de correlación intraclase; *ICC* entre .80-1.00), respecto a la confiabilidad absoluta, se presentaron valores pequeños de error estándar de medición (*SEM*) y valores adecuados para la mínima diferencia detectable (*MDC*). Las pruebas de rendimiento físico utilizadas reportan una alta confiabilidad intraevaluador e intradiaria test-retest para el total de la muestra y por sexo, excepto la agilidad en hombres, con una confiabilidad relativa moderada.

Palabras clave: tenis, confiabilidad, aptitud física, pruebas de campo, jóvenes.

Introduction

Tennis is a sport discipline that has proved a growing number of players, which reaches up to approximately 75 million people worldwide (Barber-Westin et al., 2010). It is a kind of sporting event that gives way to a large number of tournaments in different categories. Also, best tennis players have become sports icons and role models for generations. This is why tennis attracts a large amount of young people to practice it. This is also a source of motivation to reach the highest competitive level possible (Fernandez, 2006).

Tennis performance depends on several factors including morphological, technical and physical aspects, such as speed, flexibility, muscular strength and muscle power (Girard & Millet, 2009; Villouta et al., 2019). Evidence supports the argument that functional capacities are necessary to compete on higher levels (Myburgh et al., 2016). For example, high jump, maximum strength from the dominant limb and agility have been regarded as good predictors of tennis performance (Myburgh et al., 2016).

The use of standardized tests seeks to provide a useful complement to subjective training evaluations, becoming an attempt to evaluate the strengths and weaknesses of a certain player (Girard & Millet, 2009). Besides, they are valuable tools both for the selection of the suitable sport type for a subject according to their anatomical qualities and to control the training and competition programs (Pradas de la Fuente et al., 2013; Torres et al., 2006).

Therefore, it has become apparent that simple and easily accessible tests are needed. They should be carried out near the training centers and that should be related to the physical performance for a specific sport type in order to check the effect of training and competition has on the athlete (Alricsson et al., 2001).

Usefulness of the physical performance tests depends on their reliability, that is, the tests must be consistent and error free (Portney & Watkins, 2009). Thus, there is concern in conducting more reliable and valid physical performance tests (Alricsson et al., 2001). Physical performance tests have been reported in literature to show acceptable reliability indices (Burnstein et al., 2011). However, it is important to point out that test effectiveness also depends on the experience of the evaluator. Therefore, it is important to consider relative reliability data, through the intraclass correlation coefficients and absolute reliability, standard error of measurements, minimal detectable change and Bland-Almn with 95% limits of agreement. These data are important to identify the reliability of the evaluator's measurements and also contribute to evaluate the effectiveness of intervention programs in the sports environment, using highly reliable results (Bruton et al., 2000).

Thus, it is suggested that there is a reduced number of physical performance tests, especially tests applied in the field, that have demonstrated its reliability (Eriksson et al., 2015), even more, considering the use of low-cost instruments, (Eriksson et al., 2015; Vicente-Rodríguez et al., 2011), such as manual stopwatches or tape measures among others. When it comes to tennis, some studies have reported the reliability of physical performance tests in tennis (Sekulic et al., 2017; Stewart et al., 2014). These results show the need to have more evidence about the reliability of this type of measurement.

Having considered all this background, the objective of this study was to evaluate the intra-rater and intra-day test-retest reliability when testing physical performance in young Chilean tennis players.

Materials and Methods

Participants

This study is observational and cross-sectional, with analytical and reliability characteristics, which is based on the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (von Elm et al., 2014). The sample of this investigation corresponds to 86 young tennis players of both sexes (average age 15.4 ± 0.8 years old), divided into: male (n = 58) and female (n = 28), who attend tennis clubs in Chile. These clubs had taken part of national and/or international tournaments and had been certified by the Chilean Tennis Federation (FETECH) or the International Tennis Federation (ITF). The participants were selected by means of a non-probabilistic convenience sampling. The inclusion criteria were the following: 1) Competitive Chilean tennis players between 14 and 16 years old; 2) systematic training, consisting of a weekly minimum of 10 hours for at least the last 12 months; 3) Having participated in international tournaments in the last two years. On the other hand, the exclusion criteria were: 1) Failure to complete all the evaluations; 2) Failure to appear with appropriate clothing or sports sneakers for physical evaluations; 3) Having a physical injury that might prevent maximum performance of affects the result of the evaluations.

When it comes to the procedure, a letter of consent was sent to the directors of the tennis clubs, stating the purpose of the investigation, and inviting them to participate. Letters of consent forms were also sent to the subject's parents, informing about the objective of the study, the anonymous and voluntary nature of testing, and the characteristics of evaluations. After approval and signing, subjects' participation in the evaluations was confirmed. The ethics committee from the Universidad San Sebastián, Chile also approved the study project (Res. N° 51- 2018 - 20).

Instruments

Anthropometry. Body weight (kg) was measured using a mechanical scale (Seca 700, Hamburg, Germany), with a precision of 50 grams, ranging from 0 to 220 kg Height (cm) was measured according to the Frankfurt plane without shoes, using an aluminum stadiometer of Seca 220 brand (Hamburg, Germany), graduated in millimeters; its scale was (0.60 – 2.20 mm). For skin folds (triceps brachial and medial leg), measurement was done with a Harpenden Skinfold® (Baty International Ltd, West Sussex, UK) anthropometric forceps.

Sprint 20 m. It was carried out according to the protocol described by Martínez López (2011). The participant had to be in a high starting position behind the starting line, and, at the signal, would travel the distance in the shortest time possible. Measurements were recorded using a digital stopwatch (Casio Hs -70w -1DF).

Modified agility test (MAT test). This test involves moving and changing direction over a total distance of 20 m at maximum speed. For this test, four cones were arranged in the shape of a "T", the subject sprinted in a straight line to the first cone placed at 5 m, and then to a second cone placed 2.5 m to his left. This was done by moving laterally without crossing the feet. The subject then moves in the same manner to the right side to reach the third cone, placed at 5 m. They then return to the middle cone and finish at the starting position. The drill was considered

to have been completed correctly when the base of the cone was touched. Was carried out as indicated by Sasi et al. (2009). Measurements were recorded using a digital stopwatch (Casio Hs - 70w - 1DF).

Sit-and-reach test. It was carried out following the recommendations made by Vanhelst et al. (2016). At the beginning of the execution, the subject was sitting on the ground, barefoot, with his legs together and extended. Your feet should be close to the measuring box, with your hands and arms extended and together forward. At the signal, the athlete flexed the trunk forward, pushing with both hands, and the maximum distance was recorded. The value 0 (zero) was located at the height of the feet under the drawer.

Shoulder flexibility. It was carried out following the recommendations by Martínez López (2011). At the beginning of the test, the subject stood with the trunk straight and with the legs together and extended. With both hands he grasped a millimeter stick, placed horizontally in front of the body and with his arms outstretched. At the signal, he must have slowly raised the stick over his head and behind his back. The distance between the thumbs of each hand was measured.

Hand grip strength (HGS). It was carried out according to the protocol described by España-Romero et al. (2010). Dominant handgrip strength test was performed in a standing position, with the elbow extended, and the arm positioned with the dynamometer parallel to the subject's side. Participants were asked to perform a maximal voluntary contraction, squeezing the dynamometer as hard as possible, for 3 s. Was measured with a Jamar Sammons Preston manual hydraulic dynamometer (kg).

Medicine ball throw (MBT). It was carried out according to the protocol described by Martínez López (2011). Holding a 3 kg medicine ball, the players stood at a line facing the throwing direction with the feet side-by-side and slightly apart. After the ball was brought back behind their head with two hands, it was thrown forward as far as possible without moving the feet or cross the line, to perform overhead MBT. To measure the results, a Stanley Power Lock millimeter tape was used.

Horizontal jump (HJ). The athlete stood behind a line marked on the ground with feet slightly apart. A two-foot takeoff and landing task was used, with arm swing and knee flexion to provide forward momentum. Subject attempted to jump as far as possible, landing on both feet without falling backward, following the protocol by Vanhelst et al. (2016). To measure the results, a Stanley Power Lock millimeter tape was used.

Countermovement jump (CMJ). The subjects performed the jumps starting in a standing position with their hands on their hips; then, they flexed their knees using a self-selected depth and jumped as high as possible. Were performed with the Globus Ergo Jump platform (Bosco System), according to the recommendations proposed by Bosco and Padulles (1994).

Abalakov test (ABK). The subjects performed the jumps starting in a standing position with their hands and their arms free; then, they flexed their knees using a self-selected depth and jumped as high as possible, with the movement of their arms, following the protocol made by Bosco and Padulles (1994). Were performed with the Globus Ergo Jump platform (Bosco System),

Procedures

The anthropometric evaluations were performed in the morning, before any type of physical activity, in a specially equipped room, which allowed for individual and private measurements. Those that were performed by a trained evaluator following the standard procedures from Ross and Marfell-Jones (1991) (Norton et al., 1996). Percent Body fat was calculated with regression equations proposed by Slaughter et al. (1988).

The physical performance tests were carried out in the morning period, after the anthropometric ones, on tennis courts, on a clay surface. Those evaluated had to wear shorts, athletic shirt, and sports shoes, to match competition clothing. Two experienced evaluators (holding Masters in Sports Sciences, MSc.) were in charge of the evaluations. These evaluators had the necessary experience of 8 to 10 years collecting information, and they were experienced on taking the tests, through theoretical learning and through practice by carrying out pilot tests in 28 9 to 12-year-old subjects who played tennis on a regular basis. Tests were performed according to the following protocol: first, a 15-minute warm-up was carried out, with general physical exercises and stretching. Breaks between each test were 5 minutes.

The application sequence was: First the speed test (20 m sprint) that were executed following the recommendations by Martínez López (2011), secondly, the agility test, MAT test (Modified Agility Test) was carried out as indicated by Sasi et al. (2009). Third, the flexibility evaluation was performed, for the Sit and reach; Fourth is the Shoulder flexibility test, both test were executed twice for each subject following the recommendations by Martínez López (2011). Fifth, the Muscular Strength evaluations were carried out, hand grip strength (HGS). Sixth, the horizontal jump was performed with feet together and in seventh place, the medicine ball thrown with both hands over the. Finally Vertical Jumps were executed, first the Countermovement Jump Test (CMJ) and then the Abalakov (ABK), according to the recommendations made by Bosco and Padulles (1994).

Statistical Analysis

Statistical analysis was carried out using the IBM SPSS® Statistics version 17.0 and with Microsoft Excel® 2016 spreadsheets. Mean, standard deviation (*SD*) and confidence interval (*CI* 95%) were considered. The Kolmogorov-Smirnov test was used to determine the normal distribution of the variables. Relative intra-rater intra-day reliability in physical performance test was calculated using the randomized intraclass correlation coefficients model ($ICC_{2,1}$; "trial - to trial within day"). For all analyzes, *ICC* values were classified as follows: poor when below .20; just from .21 to .40; moderate from .41 to .60; good from .61 to .80 and very good .81 to 1.00. The standard error of measurements (*SEM*) and the minimal detectable change (*MDC*); with a confidence interval of 95%, were calculated for the absolute reliability considering mathematical equations, as follows:

$$SEM = SD\sqrt{1} - ICC$$

$$MDC = SEM * 1.64 * \sqrt{2}$$

Where: *SEM*, standard error of measurements. *SD*, standard deviation. *MDC*, minimal detectable change.

Finally, Bland-Altman graphs were made to visualize the difference against the average values of both the test and retest of physical performance tests, using a central continuous line in the images, which represents the average differences (systematic error), with dashed lines representing the upper and lower limits of 95%.

Results

Table 1 shows the characterization of the sample, the mean values, standard deviation (*SD*) and 95% confidence interval

(*CI* 95%) are presented, both for the total sample (n = 86), as well as for male (n = 58) and female (n = 28), respectively.

Table 1. Descriptive characterization of the Sample

Variables	Total (N = 86)				Male (N = 58)				Female (N = 28)			
	Mean	*SD*	*CI* 95%		Mean	*SD*	*CI* 95%		Mean	*SD*	*CI* 95%	
			LL	*UL*			*LL*	*UL*			*LL*	*UL*
Age (years)	15.4	0.8	15.3	15.6	15.4	0.8	15.2	15.6	15.3	0.8	15.0	15.6
Height (m)	171.2	7.9	169.6	173.0	174.2	7.6	172.0	176.1	164.9	3.7	163.5	166.3
Weight (kg)	59.7	10.1	57.6	61.9	64.3	7.9	62.2	66.4	50.1	6.9	47.6	52.8
∑ 2 skinfolds (mm)	21.6	6.3	20.4	22.9	21.1	5.6	19.7	22.6	22.8	7.5	20.2	25.5
FM (kg)	10.3	3.3	9.7	11.1	10.7	3.4	9.8	11.6	9.7	3.2	8.6	10.9
FFM (kg)	49.5	8.6	47.6	51.3	53.7	6.6	51.9	55.3	40.8	5.2	39.0	42.8
PBF (%)	17.3	4.4	16.4	18.2	16.5	4.1	15.5	17.6	19.0	4.6	17.4	20.7
Days training/week	4.6	0.8	4.5	4.8	4.6	0.8	4.3	4.8	4.8	0.7	4.5	5.0
Hours training/week	14.4	4.4	13.5	15.4	15.0	4.5	13.8	16.1	13.1	4.0	11.6	14.8

Note: *SD*- Standard deviation; *CI* - Confidence Interval; *LL* - Lower limit; UL - Upper Limit; ∑ 2 skinfolds – summation Triceps-Leg Medial skinfolds; FM – Fat Mass; FFM– Fat Free Mass; PBF – Percent Body Fat

In Table 2, the value obtained in test and retest for physical performance is shown, where no changes are observed for 20 m Speed and Agility, while the other tests shown small variations.

Table 2. Descriptive statistics test-retest

Variables		Total (N = 86)				Male (N = 58)				Female (N = 28)			
		Mean	SD	CI 95%		Mean	SD	CI 95%		Mean	SD	CI 95%	
				LL	UL			LL	UL			LL	UL
HJ (cm)	test	181.5	11.2	179.3	183.9	185.5	10.5	182.9	188.5	173.4	7.4	170.6	176.3
	retest	180.8	10.9	178.6	183.1	184.8	10.1	182.3	187.6	172.5	7.5	170.0	175.4
CMJ (cm)	test	24.2	4.4	23.2	25.1	25.8	3.8	24.7	26.6	20.8	3.6	19.5	22.0
	retest	24.0	4.4	23.1	25.0	25.7	3.8	24.7	26.6	20.6	3.6	19.2	21.9
ABK (cm)	test	30.9	4.9	29.9	31.9	32.7	4.2	31.6	33.7	27.3	41	25.7	28.7
	retest	30.7	4.9	29.7	31.8	32.5	4.2	31.4	33.5	27.1	4.1	25.4	28.5
HGS (kg)	test	36.0	8.1	34.1	37.6	39.4	7.0	37.5	41.2	28.9	5.1	27.1	30.8
	retest	35.5	8.1	33.7	37.1	38.9	7.1	37.2	40.7	28.4	4.9	26.6	30.2
MBT (m)	test	7.0	1.5	6.7	7.3	7.7	1.3	7.3	8.0	5.7	1.0	5.3	6.0
	retest	6.9	1.5	6.6	7.3	7.6	1.3	7.2	7.9	5.7	1.0	5.3	6.0
Speed 20 m (s)	test	4.0	0.3	3.9	4.0	3.9	0.3	3.8	4.0	4.1	0.3	4.0	4.2
	retest	4.0	0.3	3.9	4.1	3.9	0.3	3.8	4.0	4.2	0.3	4.1	4.2
Agility (s)	test	7.2	0.5	7.1	7.3	7.2	0.6	7.0	7.3	7.3	0.3	7.2	7.4
	retest	7.2	0.7	7.0	7.3	7.1	0.8	6.9	7.3	7.3	0.3	7.2	7.5
Sit and Reach (cm)	test	12.2	10.0	10.2	14.2	9.1	10.2	6.5	11.8	18.6	5.8	16.4	20.7
	retest	11.9	9.6	9.9	13.7	8.8	9.7	6.4	11.4	18.1	5.9	15.8	20.0
Shoulder Flexibility (cm)	test	94.4	8.3	92.6	95.9	97.8	5.6	96.4	99.2	87.4	8.6	84.3	90.3
	retest	94.9	8.0	93.2	96.4	98.3	5.2	97.0	99.6	88.0	8.5	84.9	91.0

Note: *SD*- Standard deviation; *CI* - Confidence Interval; *LL* - Lower limit; UL - Upper Limit; HJ – Horizontal Jump; CMJ- Vertical Jump Countermovement; ABK –Abalakov Jump; HGS – Handgrip Strength; MBT – Medicine ball throw

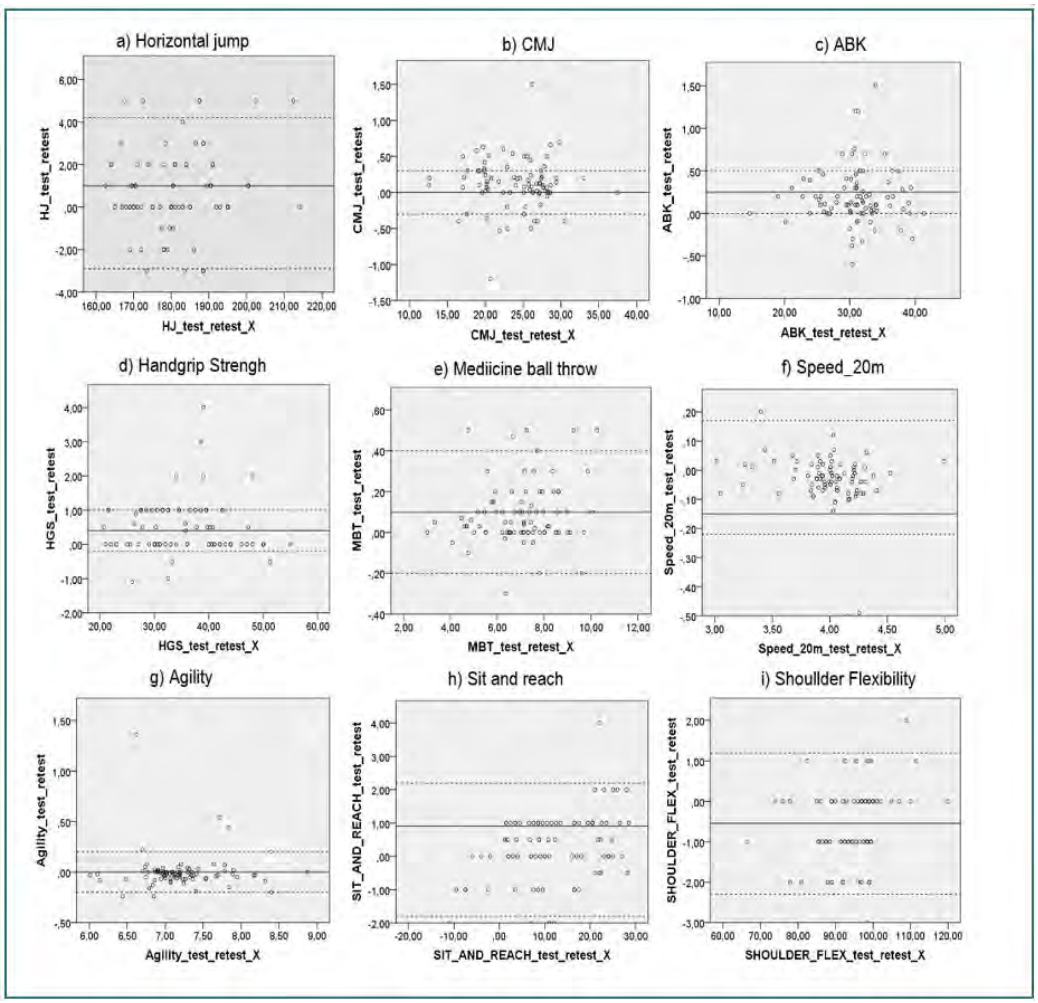
Table 3. Intra-day intra-rater reliability, relative and absolute evidence of physical tests

Variables	*ICC*			*CI* 95%						*SEM*			*MDC*	
				LL	*UL*	*LL*	*UL*	*LL*	*UL*					
	Total	Male	Female	Total		Male		Female		Total	Male	Female	Total	Male
HJ (cm)	.99	.99	.99	.99	1.00	.98	.99	.98	1.00	0.93	1.06	0.74	2.10	2.34
CMJ (cm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.14	0.20	0.12	0.33	0.43
ABK (cm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.15	0.19	0.11	0.36	0.43
HGS (kg)	1.00	1.00	1.00	1.00	1.00	.99	1.00	.99	1.00	0.37	0.41	0.29	0.85	0.95
MBT (m)	1.00	1.00	1.00	1.00	1.00	.99	1.00	1.00	1.00	0.07	0.09	0.03	0.16	0.20
Speed 20 m (s)	.99	.98	.97	.98	.99	.97	.99	.93	.98	0.46	0.64	0.05	1.08	1.49
Agility (s)	.80	.77	.99	.70	.87	.62	.87	.99	1.00	0.30	0.37	0.03	0.70	0.85
Sit and Reach (cm)	1.00	1.00	.99	1.00	1.00	.99	1.00	.99	1.00	0.55	0.55	0.41	1.23	1.22
Shoulder Flexibility	1.00	.99	1.00	1.00	1.00	.99	1.00	1.00	1.00	0.46	0.50	0.38	1.03	1.09

Note: *ICC* – Intraclass Correlation Coefficients; *CI* – Confidence Interval; *LL*- Lower limit; *UL* - Upper Limit; *SEM* – Standard Error of Measurements; *MDC*–Minimal Detectable Change; HJ – Horizontal jump; CMJ- Vertical Jump Countermovement; ABK –Abalakov Jump; HGS – Handgrip Strength; MBT – Medicine ball throw.

In Table 3, for the total sample, in all physical performance tests, excellent test-retest analyzes are reported on the same day, the *ICC* fluctuated between .80 to 1.00, the lowest value for relative reliability is in Agility (*ICC* = .80; *CI* 95% = .70 - .87), and the highest values are obtained in CMJ, ABK, HGS, MBT, Sit and Reach and Shoulder Flexibility (*ICC* = 1.00; *CI* 95% = 1.00 - 1.00). About the absolute reliability, the *SEM* presented small values. In detail, they fluctuated from 0.14 to 0.93 cm for the Jump Tests, for HGS it was 0.37 kg, for MBT it was 0.07 m, for the Flexibility test it ranged from 0.46 to 0.55 cm, for 20 m Speed and Agility it varied from 0.46 to 0.30 s respectively, while the *MDC* presents adequate values. In the jumping tests it was 0.33 to 2.10 cm, HGS 0.85 kg, MBT 0.16 m, on the flexibility tests varied from 1.02 to 1.23 cm, for the 20 m Speed 1.08 s and for Agility 0.70 s. Both *SEM* and *MDC*, are higher for males compared to females, in all tests. For the case of men, the lowest results were in Agility (*ICC* = .77; *CI* 95% = .62 - .87) and the highest was in CMJ and ABK (*ICC* = 1.00; *CI* 95% = 1.00 - 1.00); finally, the women showed lowest values in 20 m Speed (*ICC* = .97; *CI* 95% = .93-.98) and were best in CMJ, ABK, MBT and Shoulder Flexibility (*ICC* = 1.00; *CI* 95% = 1.00 - 1.00). Furthermore, the Bland-Altman graphs (Figure 1) showed that the test-retest measurements have an average difference close to zero in all tests.

Figure 1. Bland-Altman graphs that show the differences with the average values of the test-retest (n = 86)



Note: The central continuous line represents the average differences (systematic error). The dotted lines represent the upper and lower limits of 95%.

Discussion

The objective of this study was to evaluate intra-rater and intra-day test-retest reliability for physical performance tests in young Chilean tennis players. Results obtained, both in relative (*ICC*) and absolute (*SEM* and *MDC*) reliability, showed that the field tests to evaluate physical performance are highly reliable when carried out on the same day. The *ICC* of this study, in the total sample fluctuated between .80 and 1.00, a result very similar to other studies consulted with young athletes and tennis players (Vicente-Rodríguez et al., 2011), the above was achieved using low-cost elements such as manual digital chronometer, tape measure and jumping platforms.

The aforementioned was reinforced by the Bland-Altman analysis where all physical fitness tests showed an average difference of near zero, these findings are consistent with those found in similar studies on other sports groups (Stewart et al., 2014). This highlights that these tests can become a serious contribution to the planning of training, competition, and injury prevention, providing reliable ad valid data capable of identifying changes in physical performance.

In this way, these highly reliable results might be due, on the one hand, to the experience and theoretical/practical training of the evaluators, as well as to the fact that the subjects evaluated were tennis players accustomed to this kind of movement patterns due the development of their sport and training (Eriksson et al., 2015; Sekulic et al., 2017), another advantage observed from these results, can be used in future experimental studies, to consider changes, even minor ones, in the performance tests. These assumptions are relevant at practical level, knowing these values can identify effects of a training or injury prevention, especially for tennis player in the same age range similar to the present study.

The Horizontal Jump and Vertical Jumps (CMJ and ABK), showed excellent levels of absolute and relative reliability, these results are consistent with those reported by other studies (Fernández-Santos et al., 2015; Vanhelst et al., 2016), thus, these jumping test are a reliable measure for assessing the strength of young tennis players' lower limbs.

In the flexibility tests, Sit and Reach and Shoulder Flexibility, same as in another study (Henriques#Neto et al., 2020), which included athlete from different disciplines, reliability values were high, although higher in our study, confirming that this type of evaluations have a very good

reliability in different sports or physically active populations (Pion et al., 2015), which is very important for injury prevention, since the lack of flexibility is associated with decreased physical performance and increased pain and/or injury (Aben et al., 2018; Oosterhoff et al., 2019).

HGS and MBT Tests evidenced an excellent reliability. These results were similar to those found in other studies on teenage (Vanhelst et al., 2016) and college athletes (Kovacs et al., 2007). The use of this type of test is very important in determining the level of strength of upper limbs, which are not fundamental for sports performance, especially in tennis strikes, and to detect weaknesses, due to the high volume of use of the upper body segments in training and matches of this sporting discipline (Fernández-García et al., 2019; Fett et al., 2017; Kovalchik & Reid, 2017).

The 20 m Speed test delivered high reliability values, which is consistent with that reported in other studies (Sekulic et al., 2017; Vanhelst et al., 2016), this confirms that this test, which has been traditionally used in the sport, it is reliable and valid for evaluating speed in young athletes.

In regard to the agility test, this was the one that showed the lowest values of relative reliability in the total sample (*ICC* = .80; *CI* 95% = .70 - .87) and especially in men (*ICC* = .77; *CI* 95% = .62 - .87). These results were lower than those obtained in other studies: who applied the test to a population of young tennis players (Sekulic et al., 2017), or they evaluated young people who practiced sports other than tennis (Stewart et al., 2014) or used the same test on young soccer players (Sporis et al., 2010).

In these cases, the differences can be attributed to these subjects being older, so their level of experience could be wider on this type of test. besides, measuring instruments were not the same, thus contributing to a substantial difference in accuracy. These aspects have been described as elements that hinder standardizing a protocol and consequently, a uniform application across the population of young athletes (Henriques#Neto et al., 2020).

This study presents some limitations, such as, the non-probabilistic selection and quantity of sample tested, which limits the generalization of the results in other athletes. In addition, young players evaluated were quite homogeneous in age, sports background, and level of competition, which limited the scope of the study. Nevertheless, the main strength of the study is the novelty of the subject, which is rarely explored in South America. This study also sheds some light on procedures and tests, which are simple and quick to carry out, demanding minimal equipment and physical space and they can also be easily replicated.

Conclusions

In general, the physical performance tests evaluated and applied in this study reported high relative intra-day and intra-rater reliability, for all males and females, except for agility in men, showing a moderate relative reliability. The study, in turn, shows a very good absolute reliability with very low *SEM* values, in the total sample and by sex. Therefore, the physical performance tests evaluated in thus study and applied by trained personnel with previous experience proved to be reliable tests to monitor training, competition, and the risk of injury in young tennis players. For these reasons, results of this study might have implications for strengthening the process of sports training of young tennis players in the short, medium, and long-term training programs.

Acknowledgments

To all the adolescents and tennis clubs that participated in the study.

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CULTURA, CIENCIA Y DEPORTE

Hotspots and trends of flamenco dance research: A CiteSpace analysis

Focos de interés y tendencias sobre la investigación en el baile flamenco: Análisis CiteSpace

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Short title:
Analysis of flamenco dance

How to cite this article:
Zhang, N.Y., Gómez-Lozano, S., & Vargas-Macías, A. (2022). Hotspots and trends of flamenco dance research: A CiteSpace analysis. *Cultura, Ciencia y Deporte*, *17*(53), 99-108. https://doi.org/10.12800/ccd.v17i53.1861

Received: 14 january 2022 / Accepted: 03 may 2022

Abstract

Flamenco dance, which is increasingly internationalized and globalized, has a huge market demand all over the world and it has been popular and valued by researchers nowadays. Thus, hotspots and trends research is essential to provide information for industrial development and further development lines. Based on 130 articles published from 1982 to 2021 (database updated on 4 December 2021) about flamenco dance in Scopus and Web of Science Core Collection, this research by using CiteSpaceV software explored the research hotspots and trends of the flamenco dance from the time horizon, collaborate network incorporates authors, institutions, regions, and keywords. Result: The number of publications shows an upward trend with fluctuations Since 2008. 9 main research groups are formed. The University of Seville is the most prolific institution and the Saint Anthony Catholic University of Murcia ranks the highest centrality. Spain is the highest yield region. The hotspots included cultural aspects, which include identity and art in Andalusia, as well as biomechanical and physical aspects, including body, anthropometry, and physical activity focusing on dancers. The trend of this field will be physical and psychological aspects. Conclusion: future research may focus on the body and psychological aspects.

Keywords: flamenco dance, visualization analysis, CiteSpace, hotspots, trends.

Resumen

El baile flamenco se encuentra cada vez más internacionalizado y globalizado, teniendo una enorme demanda de mercado a nivel mundial. Actualmente es un campo de estudio para investigadores y profesionales del arte flamenco. Así, las zonas de referencia y tendencias en la investigación sobre el baile flamenco son esenciales para proporcionar información para el desarrollo industrial y futuras líneas de desarrollo.La muestra se basó en 130 artículos publicados desde 1982 hasta 2021 (base de datos actualizada el 4 de diciembre de 2021) sobre baile flamenco en las bases de datos de Scopus y Web of Science Core Collection. El análisis se realizó mediante el uso del software CiteSpaceV. Se exploraron los focos de interés y las tendencias de investigación en el baile flamenco desde el horizonte temporal. La red de colaboración incorpora autores, instituciones, regiones y palabras clave. Resultados: el número de publicaciones muestra una tendencia al alza con fluctuaciones desde 2008. Se forman 9 grupos de investigación principales. La Universidad de Sevilla es la institución más prolífica y la Universidad Católica San Antonio de Murcia ocupa el puesto de centralidad más alto. España es la región de mayor rendimiento. Los focos de interés incluyeron aspectos culturales, que incluyen la identidad y el arte en Andalucía, así como aspectos biomecánicos y físicos, incluidos el cuerpo, la antropometría y la actividad física centrada en los bailarines. La tendencia de este campo se basa en aspectos físicos y psicológicos. Conclusión: Investigaciones futuras pueden centrarse en aspectos corporales y psicológicos.

Palabras clave: baile flamenco, análisis de visualización, CiteSpace, focos de interés, tendencias.

Introduction

"Flamenco baile is a dance of passion, courtship, expressing a wide range of situations ranging from sadness to joy." (UNESCO, 2010). It has a history of more than 200 years and it is commonly considered that it is the result of the integration of multiple cultures which have developed in Andalusia (Machin-Autenrieth, 2015; Moon, 2015; Palma et al., 2017). It was listed as Intangible Heritage of Humanity in 2010 and has become the culture feature of Spain, which has been widely spread and recognized on the world stage and has attracted an increasing number of enthusiasts all over the world like United States, the United Kingdom, France (Cuellar-Moreno, 2016; De Santiago, 2018; Diamond, 2018). The impact of flamenco dance has been increasing by the international market demand (Aoyama, 2007), it has been proofed by universities' program between different countries, and activities or festivals and cultural tourism over continents (García et al., 2019; Palma, Palma, Rodríguez, Martín, & Cascajo, 2017). It also popular in Asia, like South Korea, the Philippines, Singapore, more and more practitioners are from China, and Japan has the largest number of amateurs and dancers of flamenco (Aoyama, 2007; Diamond, 2018).

Previous research studied the biomechanical aspect of flamenco dance generally related to footwork technique analysis with professional dancers as subjects described the average values of the vertical component of ground reaction force, analyzed the range of motion in lower limbs joints and pelvis (Forczek-Karkosz et al., 2021), demonstrated the smooth oscillations of the centre of mass in all three trajectory planes, which provide theoretical information to flamenco dancers and teachers (Forczek, Chicón, & Vargas-Macías, 2016). In terms of injury research, pains and injuries have been reported in professional flamenco dancers and students, and indicated knees, lumbar and cervical spine shows high incidence (Baena-Chicón et al., 2020). Already early studies such as those by Bejjani et al., 1988 suggested it may be caused by the huge vibrations accompanying the flamenco dance form. Considering physiological aspects, previous studies described the energy requirements of flamenco dancers by testing aerobic and anaerobic capacities, indicating flamenco dancers have those two both and have a substantial anaerobic power output, which is meaningful for developing training strategy (Pedersen, Wilmerding, Kuhn, & Enciñias-Sandoval, 2001). Meanwhile, the data on the average heart rate and maximal oxygen consumption of professional flamenco dancers have been described. It proved great physical workloads requirement in flamenco dance (González et al., 2011). However, there are still many limitations to applying flamenco in biomechanics or physiology, and fewer studies covered the holistic perspective of flamenco movement (Forczek et al., 2017). Some articles involved psychological analysis of flamenco participants. There is evidence that shows both students and professionals displayed higher levels of helplessness than those who were only students, and anxiety states which can be triggered by the artistic professional development on stage before spectators may relate to the levels of catastrophism (Baena-Chicón, Gómez-Lozano, Cano, & Vargas-Macías, 2021). Meanwhile, there is research that studied Brazilian female flamenco dancers and indicated 64.7% of participants were not satisfied with their bodies though they had high self-esteem (Nakamura, Juzwiak, de Almeida, & Montesano, 2012). Relating to the perspective of flamenco culture, tourists use the dance expression as a positive factor for self-esteem self-expression, and self-exploration, also, as a way to differentiate themselves from other groups (Matteucci, 2014). One empirical study focused on ethnography recorded from a martial arts club and a flamenco class, observing, recording filming and participating in the classes they found trans-situational practice, matching and combining situations and communications, can explain ethnography to some extent, for better understanding other social practices for sociological reasons, and being able to reconstruct it (Schindler, 2018). However, there is few studies have looked at review of flamenco's academic research field which could enable us to better understand the development and phenomenon of flamenco dance.

Through Citespace software, we can make a comprehensive review of the academic research status and hotspot of flamenco field and infer future research trends and what we can see more clearly than other types of review is that this software shows the hotspots and trend in visualized analysis. CiteSpace, commonly advanced by Dr Chen Chaomei, is an intellectual visualization software for analysing and visualizing co-citation networks (Chen, 2006). It was designed to behaviour the visualization electric network. The collaborate networks incorporate authors, institutions, and regions; the co-occurrence network includes terminology, keywords, and categories. The collaborate network is to manifest the community connection with author, organization, and district in a study field; the co-occurrence network is to uncover the development of study hotspots and trends (Chen et al. 2014; Chen, 2005).

Therefore, the objective of this study, with using of the CiteSpaceV software is to analyse and review the flamenco researches, which enables the development of flamenco dance research since 1982 to 2021 to be reported precisely and visually and provides reference information for the further research of flamenco dance in the future.

Materials and methods

The information was gathered from the Scopus and Web of Science Core Collection. This study strategy is used for the research without publishing time limitation: TOPIC: (flamenco) AND TOPIC: (danc* OR baile) AND LANGUAGE: (English OR Spanish) AND DOCUMENT TYPES: (Article OR Review). After the initial screening, 114 related documents were retrieved in WOS, 107 in the Scopus. After removing duplicates and screening records, there are 130 publications in total, database updated on 4 December 2021.

CiteSpace# were used to parse the literature in this research. It is an intellectual visualization software commonly advanced by Dr Chen Chaomei. It was made use for behaviour visualization electric network. The collaborate network incorporates authors, institutions, and regions; the co-occurrence network includes terminology, keywords, and categories. The collaborate network is to manifest the community connection with author, organization, district in a study field; the co-occurrence network is to uncover the development of study hotspots and trends (Chen et al. 2014). Co-citation is defined as the third article citing two references, it can be one case of co-occurrence, which can include co-occurrence words, as well as co-author, co-region. A reference may be cited for many purposes or for different reasons (Chen, 2013; White & McCain, 1998). However, the cited literature may be cited in a manner similar to the function of citing underlying concepts. Therefore, the visualized map from CiteSpace can identify the structure of patterns and trends and the dynamics of the underlying scientific literature (Braam, Moed, & Van Raan, 1991). The citation tree rings show the

citation history of an article. The ring's colour indicates the corresponding citation time. The thickness of the ring is proportional to the number of references in a given period (Chen, 2013).

The 130 documentations downloaded were inputted into the CiteSpace 5.5.R2 software for bibliographic analysis with the time spacing set from 1982 to 2021 (130 records), and content analysis with the time span set 2000 to 2021 (114 records), both with the time part of a place as one piece each year. The nodes of the author, organization, region, and keyword were selected. Selection criteria were g-index, k=15.

Results

Bibliographic analysis

1 Time distribution of published papers

The relationship between the number and time of published papers can reveal the research history and development speed in this field and predict its development trend. The time distribution of published papers in the field of flamenco dance research is shown in Figure 1.

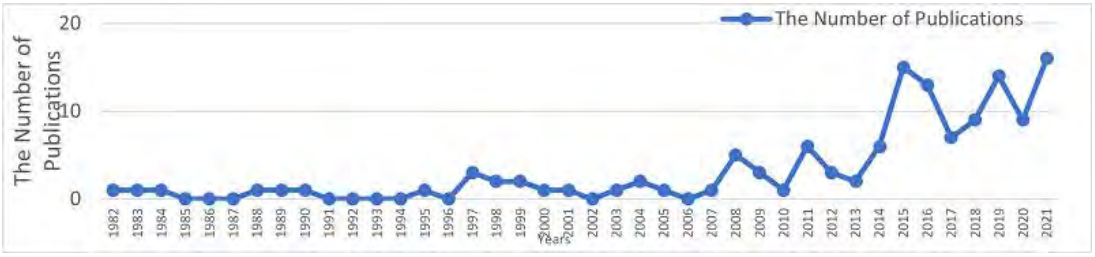

Figure1. The number of publications on flamenco dance per year from 1982 to 2021

It can be seen that the research papers on flamenco dance were first published in 1982. However, before 2008, researchers did not pay enough attention in this field, there are at most 3 articles published a year. Since 2008, it shows an upward trend with fluctuations even though the most was only 16 articles in 2021. While it also saw a surge in 2015 with 15 records and in 2019 with 14 records.

2 The co-occurrence network of scientific research authors

CiteSpace is only being equipped with use of counting the quantity of the first writers, so the writer is referred to underneath all first writers. Table 1 lists the authors with further than 2 articles. Alfonso Vargas-Macías, with 5 articles. Luis Gadea-Mateos, Alba Paris-Alemany and F.J. Bejjani with 3 articles, respectively.

Table 1. High-yield authors in the flamenco dance research

Author	Frequency
Alfonso Vargas-Macias	5
Luis Gadea-Mateos	3
Albea Paris-Alemany	3
F.J. Bejjani	3

As shown in Figure 2, 179 researchers (N = 179) participate in the related researches of flamenco dance, and they have 242 (N = 242) research cooperation of varying degrees, showing that 24 groups with at least 3 members are formed in the field, 9 of them have more than 2 publications and show relatively stable.

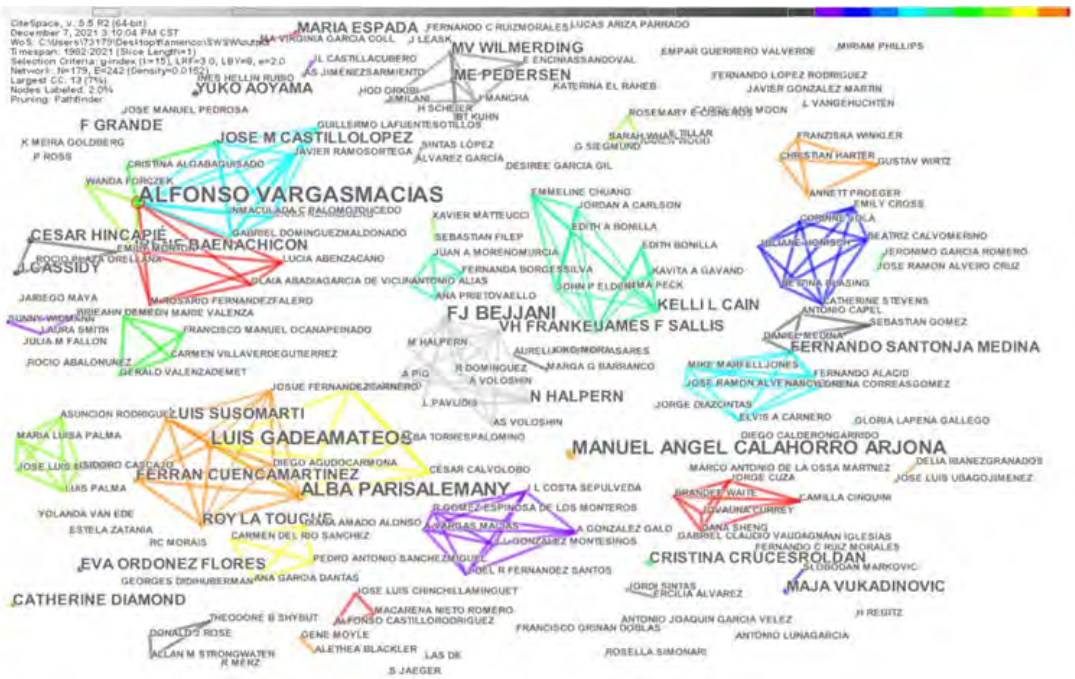

Figure 2. The co-occurrence network of authors in the flamenco dance research

It also can be seen from Figure 2, Alfonso Vargas-Macías, as a professor at the Telethusa Centre for Flamenco Research, has involved three teams and formed the largest research cooperation network in the field of flamenco dance. They focused on the aspects of biomechanics, podiatry, and injury of flamenco dance. One of the most cited articles is Metatarsal Pain and Plantar Hyperkeratosis in the Forefeet of Female Professional Flamenco Dancers (Castillo-López et al.,2014). The group of Fernando Santonja Medina did researches in the same area as well, such as Magnetic Resonance Study of Lumbar Disks in Female Dancers (Capel et al.,2009) and Comparison of two field methods for estimating body fat in different Spanish Dance disciplines (Alvero-Cruz et al., 2014). F.J. Bejjani with other members as a team also focused on the biomechanics aspects, publishing articles such as Musculoskeletal demands on flamenco dancers: a clinical and biomechanical study (Bejjani et al., 1988). Cain, K.L group studied on the physiological aspects, such as Physical activity in youth dance classes (Cain et al., 2015), as well as ME Pedersen group, which did research about energy requirement, plantar flexion and dorsiflexion strength in flamenco, such as Energy requirements of the American professional flamenco dancer (Pedersen et al., 2001) and Measures of plantar flexion and dorsiflexion strength in flamenco dancers (Pedersen et al., 1999). Alba Paris-Alemany with other researchers as a group focused on the motor image published, such as Visual-motor imagery predominance in professional Spanish dancers (Paris-Alemany et al., 2019). It can be seen that most of these groups focus on biomechanical and physical research.

3 The co-occurrence network of scientific research institutions

The authors' institutions which have more than 3 articles are listed in Table 2. The University of Seville with 8 articles are the most prolific institution, followed by the University of Granada with 7, Saint Anthony Catholic University has 6 publications as well as International University of La Rioja. And Telethusa Centre for Flamenco Research has 5, University of Malaga and Rey Juan Carlos University published 4 articles respectively. It shows the main research institutions are universities in different regions.

Table 2. High-yield institutions in the flamenco dance research

Institution	Frequency	Centrality
Univ Seville	8	0.05
Univ Granada	7	0
Univ Int La Rioja	6	0
Univ Catolica San Antonio Murcia	6	0.14
Ctr Invest Flamenco Telethusa	5	0.02
Univ Malaga	4	0.02
Univ Rey Juan Carlos	4	0.09

According to Figure 3, there are 82 (N=82) institutions involved in flamenco dance research, and these research institutions have 91 cooperations (E = 91). In the network, the density is 0.0274, which shows the cooperation network of scientific research institutions is relatively stable. However, as table 2 shows, in the largest groups, the centrality value of Saint Anthony Catholic University is 0.14, Rey Juan Carlos University with 0.09, The University of Seville with 0.05, University of Malaga and Telethusa Centre for Flamenco Research with 0.02, the rest all as 0.00

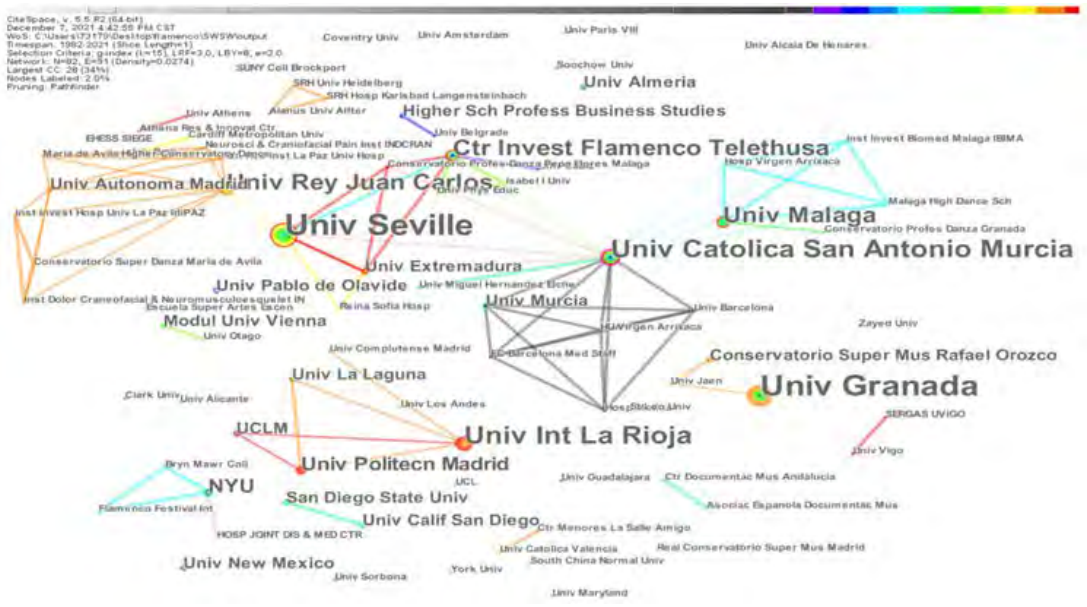

Figure 3. The co-occurrence network of institutions in the flamenco dance research

4 The co-occurrence network of scientific research region

As Table 3, Spain, as a place where flamenco developed, ranks the top with 60 publications. The second is the USA with 15. France and England with 3, respectively. Other regions which did not list on the table made little contribution. As Figure 4 shows, there is less cooperation research between regions.

Table 3. High-yield regions in the flamenco dance research

Region	Frequency
Spain	60
USA	15
France	3
England	3

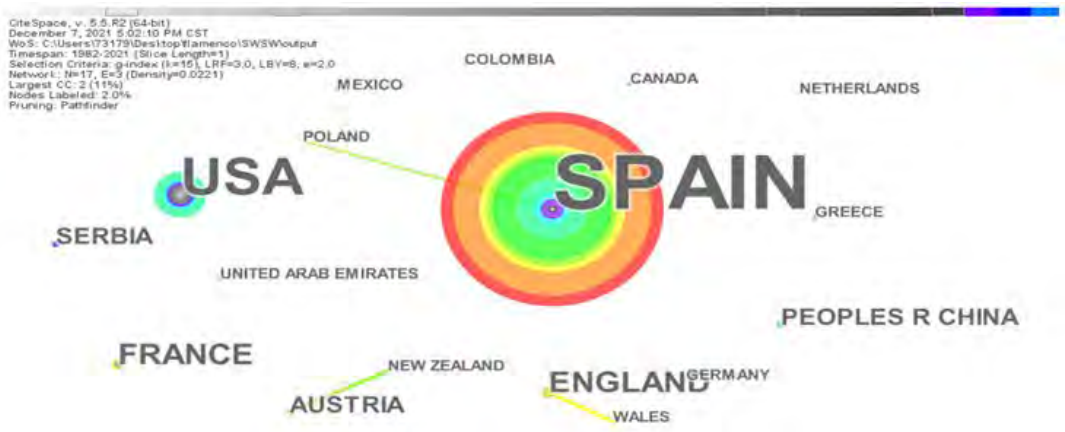

Figure 4. The co-occurrence network of regions in the flamenco dance research

Content analysis

1 Keywords co#occurrence analysis: thematic hotspots

As shown in Table 4 and Figure 5, "flamenco" has the largest nodes with 25 frequencies in the co-occurrence network, which is closely related to the keyword "dance", "flamenco dance". "Physical activity" is the 3rd on the list with 8 frequencies as well as "dancer". Followed with "body" with 7 frequencies. Other keywords whose frequency is more than 3 and less than 6 in the field are "culture" "identity" "pain" "Andalusia" "biomechanics" and "art".

The High-centrality keywords in the flamenco dance research. "Flamenco" (0.43) "dance" (0.42) and "dancer" (0.24) ranked the top 3 of the high-centrality keywords, while "art" (0.22) "body" (0.15) "anthropometry" (0.15) "physical activity" (0.12) are also the keywords whose centrality is more than 0.10. "injury" (0.09) "flamenco dance" (0.06) "Andalusia" (0.06) and "motor

imagery" (0.05) are also high-centrality keywords but less than 0.10 and more than 0.04. Combining with Tables 4 and Figure 5, it can be seen that there are two main hotspots in the last 21 years.

1) Biomechanical and physical aspects, as related keywords are "body", "anthropometry" "physical activity" "injury" "pain" and "biomechanics", focusing on "dancer", such as articles Physical Activity in Youth Dance Classes (Cain et al., 2015), Comparison of two field methods for estimating body fat in different Spanish Dance disciplines (Alvero-Cruz et al., 2014), Analysis of selection criteria in the access tests to official Dance Studies (Parent et al., 2016), Algias as a predisposing factor of injury in flamenco dance students (Baena-Chicón et al., 2020), Receptiveness of Spanish and Flamenco Professional Dancers in Their Training and Development (De las Heras-Fernández et al., 2020).

2) Cultural aspects, including related keywords "culture", "identity" "art" and related about "flamenco dance", especially in "Andalusia". Such as Domains of public activity in touristic flamenco shows (Wieczorek, 2017), Identity, Migration, and the Arts: Three Case Studies of Translocal Communities (Smith et al., 2011), Artists, Tourists, and the State: Cultural Tourism and the Flamenco Industry in Andalusia, Spain (Aoyama, 2009)

Table 4. High frequency and centrality keywords in the flamenco dance research

Frequency	Centrality	Keyword
25	0.43	flamenco
19	0.42	dance
8	0.12	physical activity
8	0.24	dancer
7	0.06	flamenco dance
7	0.15	body
5	0.01	culture
5	0.01	identity
5	0.01	pain
4	0.06	Andalusia
4	0.02	biomechanics
4	0.22	art

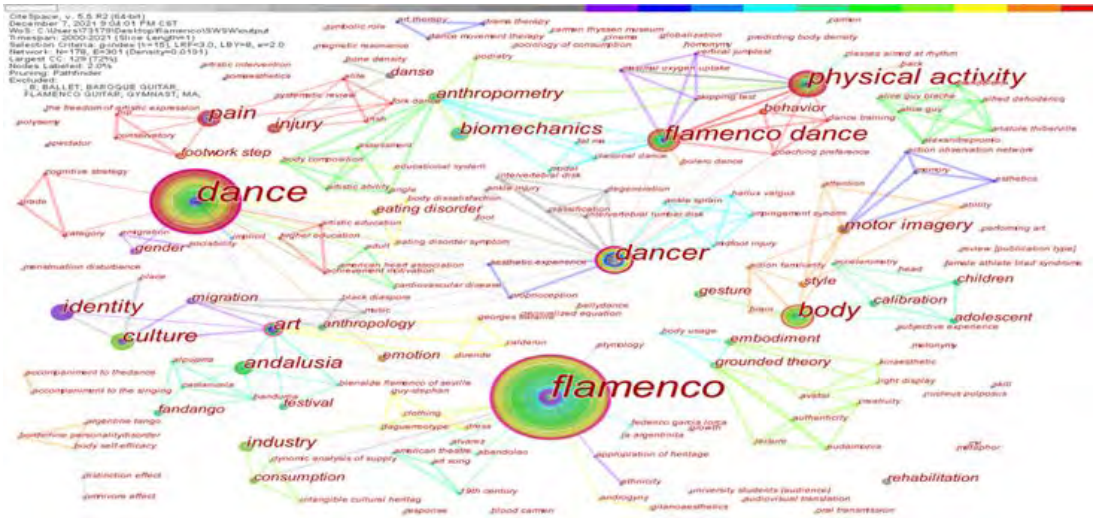

Figure 5. The co-occurrence network of keywords in the flamenco dance research

2 Strongest citation burst analysis: thematic trends

As Table 5 shows the strongest citation bursts of keywords in the field of flamenco dance, it can be seen that "body" shows the strongest burst from 2015 to 2021. "Physical activity", "motor imagery", "emotion" and "style", show a burst in the last three years. It indicated that the attentions of future studies on flamenco dance may pay to physical and psychological research.

Table 5. The keywords with the strongest citation bursts in the flamenco dance research

Keywords	Year	Strength	Begin	End	2000 - 2021
rehabilitation	2000	1.1761	2008	2010	
pain	2000	1.1672	2008	2011	
danse	2000	1.1761	2008	2010	
migration	2000	1.088	2009	2011	
identity	2000	2.76	2009	2011	
gender	2000	1.2439	2011	2011	
biomechanics	2000	1.1397	2014	2014	
Andalusia	2000	1.8822	2015	2016	
fandango	2000	1.1558	2015	2015	
body	2000	1.3214	2015	2021	
flamenco	2000	1.2649	2015	2016	
festival	2000	1.1558	2015	2015	
calibration	2000	1.1558	2015	2015	
adolescent	2000	1.1558	2015	2015	
children	2000	1.1558	2015	2015	
dance	2000	2.133	2016	2021	
gesture	2000	1.1761	2016	2016	
industry	2000	1.1001	2017	2017	
culture	2000	1.6147	2017	2017	
physical activity	2000	1.3459	2019	2021	
motor imagery	2000	1.1205	2019	2021	
emotion	2000	1.21	2019	2021	
style	2000	1.21	2019	2021	

Discussion

This study revealed that the hotspots and trends of flamenco dance research with a visualization analysis based on 130 articles published from 1982 to 2021 in Scopus and Web of Science Core Collection with Citespace# software, which included time distribution of published papers, Co-occurrence network of scientific research authors, institutions, regions, and keywords co-occurrence and strongest citation bursts analysis as well.

"Cultural", "physical" and "biomechanical" researches as hotspots and trend over the world in the flamenco field

It is not difficult to predict that "cultural" study is one of the hotspots. First of all, it is a multi-cultural background art product integrated and developed in the Andalucia region in Spain with various elements (Palma et al., 2017) and it was listed as Intangible Heritage of Humanity in 2010 and has become the culture feature of Spain. Secondly, even though flamenco was considered a marginal art for Spanish society and it is not until the 1980s that the form was professionalized (de la Torre, Lara, & Arjona-Fuentes, 2019), a number of scholars tried to improve the recognition of flamenco as heritage at a political level since 1990s, and it was chosen as a symbol of regional cultural development and a prominent symbol of Andalusian identity (Machin-Autenrieth, 2015). Therefore, the cultural aspects, including identity and art research related to flamenco dance, especially in Andalusia, is one of the hotspots in the last 21 years. Furthermore, Flamenco promotes tourism in Spain, as an important part of cultural tourism, it has attracted many people and creates a huge global market demand (de la Torre et al., 2019; García et al., 2019). So, to find the way to improve the experience to the tourists, bringing the emotion and also living it (García et al., 2019), some researches about "cultural" aspect was studied.

We can also notice that these researches are not only in Spain, there are also some from different regions. It is widely popular in the United States, the United Kingdom, France, and other Europe countries (Machin-Autenrieth, 2015; Palma et al., 2017). as well included regions like Mexico, Poland, Canada according to results of this research. Except for tourism, emigration could also be a reason of this popularization. Some of emigrants from Spain developed flamenco where they stayed. They devised training program, run restaurants, bars and related activities which is a medium to bonds between them (Ruiz-Morales, 2011). Activities are formed through individual groups, universities and communities related to flamenco dance, which not only expands social identity and strengthens regional identity, but also developed the flamenco culture world widely (Crespi#Vallbona & Richards, 2007; García et al., 2019). Eva Encinias Sandoval, who built the flamenco program at the the University of New Mexico, could be a great example. She wove flamenco into the cultural fabric of New Mexico and started Festival called "Flamenco de Alburquerque" which draws audiences and dancers. Additionally, in both the United States and Canada in the first half of the century also the intangible cultural heritage such as the art of flamenco has been moved (Briseno, 2021). Flamenco dance is popular in Asia as well, South Korea, the Philippines, Singapore, more and more practitioners are from China, and Japan has the largest number of amateurs and dancers of flamenco (Aoyama, 2007). This phenomenon may be caused by globalization. There were universities' program between different countries, and activities or festivals and cultural tourism over continents. On the contrary, unlike emigration or social identity, the main reason why it became popular in Japan is that it has a completely different culture from flamenco. The culture of Japan is opaque with its highly codified gestures in the observance of which propriety represses emotion to preserve a calm exterior of social harmony (Diamond, 2018). In the 21st century

in Japan, although many women have achieved economic independence, they still suffer from gender discrimination. Therefore, flamenco can express strong emotions and it does not necessary a partner, which is also a reason for its popularity in Japan (Diamond, 2018).

About "physical" and "biomechanical" aspect as hotspots, there are some main reasons. Flamenco dance has its unique characteristics with strong emotion and the footwork technique (Baena-Chicón, Gómez-Lozano, Cano, & Vargas-Macías, 2021), which requires dancers strike the floor to make a loud and rhythm voice (Vargas-Macías et al., 2021). Therefore, dancers were usually required to have a high level of physical conditions (Forczek, Baena-Chicon, & Vargas-Macias, 2017), there is research indicate that the require is similar to those of elite sports (Pedersen, Wilmerding, Kuhn, & Enciñias-Sandoval, 2001). Meanwhile, some research investigated as well the injury frequency of flamenco dancers and deduced that the pain and injuries on lower limbs and back may be caused by the model of footwork movement (Castillo-López et al., 2014; Pedersen, Wilmerding, & Science, 1998). Therefore, the biochemical and physical descriptions and relevant studies have been demanded to be researched, in order to prevent the injury or pain and improving dance performance. On the other hand, thanks for the advancement of research in the entire dance field, people are pursuing technical and aesthetic improvement in a more scientific way, and they have increased their awareness of physical health and injury protection. Also, compared with the previous family-style or mentor-apprentice-style methods (de la Torre et al., 2019; Palma et al., 2017), the official organizations and institute of development are more capable of academic research. The professional researchers who have been trained by institutionalization are more aware of scientific training methods. Meanwhile, flamenco has reached schools and universities, that could be also the reason that "psychological" aspect may be one of the trends for future studies. Therefore, biomechanical and physical aspects have become the hotspots in the field, including body, anthropometry, and physical activity research focusing on dancers, and it is going to act as an increasingly significant character in the future.

Comparing with related researches with Citespace software

There is limited research currently existing on research hotspots and trends in flamenco dance, but some articles have been reported to explore hotspots and trends related to other style dance fields. For instance, the article Quantitative Analysis on Research Trends of Dance Sport at Home and Abroad (Ma & Huang, 2019) studied on the hotspots and trends of DanceSport (Latin dance and Ballroom dance) research, including 61 records (1990-2018) with Citespace# as well, which has been found that the number of articles related to DanceSport published in Web of Science database, shows a skipping trend of rising since 2007, which is similar with flamenco dance time range in this article. Furthermore, another similar result is that in co-occurrence network of scientific research authors and institutions aspects, both of DanceSport and flamenco dance research show that although the number of research groups is less, there are some groups relatively stable, and the main research institutions are universities in different regions.

By contrast, the difference between DanceSport and flamenco dance researches is that the main research regions, Spain and the USA ranked the top of flamenco research, while the UK and the USA were the main regions in DanceSport research area. It may be due to the origin and level of development of those two styles of dance. Additionally, in terms of hotspots and trends, DanceSport researchers focused on the exercise, health, and disease interventions of adolescence and the elderly, while flamenco researchers draw more attention to the biomechanical and physical aspects as well as the psychological aspects of dancers.

Comparing with related researches with other statistical methods

Some bibliometric analysis about the dance field has been documented with other statistical methods: information was downloaded into spreadsheet software (Microsoft Office Excel), and additional coding was manually performed for all analysis. For example, Publications in dance field in Arts & Humanities Citation Index: a bibliometric analysis (Ho & Ho, 2015) and A bibliometric analysis of dance performance reviews in the dance category of the Web of Science (Wang & Ho, 2019), these two with this method analysis about dance research and dance reviews respectively, based on Arts & Humanities Citation Index database of the Clarivate Analytics' Web of Science Core Collection.

According to the results in the face of the authors, they all indicated that most of the authors are single-authors. Interestedly, comparing with this study of flamenco dance research that the number of relatively stable groups was few to 9. That might mean researchers in the dance area should strengthen cooperation in the future. Furthermore, Huei-Chen Ho has also found that "body" and "education" were new popular words in article titles. Similarly, "body" is also one of the high-frequency keywords with high-centrality in flamenco dance research. Simultaneously, a common result of those two above articles about dance research and review is that "Ballets" is the main area for current dance researches and reviews, which may partially indicate that other dance style research needs to be studied in the future. Even though those above two pieces of research included more records of the data, they had limited to the bibliometric analysis including aspects of publication language, output, authors, journals, and distribution of words in the article title. Rather, this article, researching flamenco dance with Citespace#, can more clearly show the bibliographic and visual analysis evolution, hotspots, trends in Co-occurrence network and keywords with the strongest citation bursts.

Conclusion

CiteSpace software applies to fix quantify analyse added apparently, intuitionistic, and objective. Precise algorithms can analyse the hotspots, trends, knowledge base, and high-quality literature. Although the data recorded in this study are only 130 publications, hotspots and trends in the field of flamenco dance could be detected, this research could manifest the start, bursts, high-centrality and frequency reveal the evolutionary trends of hotspots. Based on the above analyse, the following conclusions can be drawn:

From the bibliographic analysis, the number of announced works in this field shows a growing trend in 2008 and reaches its peak by 2021. From the scientific research authors, Alfonso Vargas-Macías is the highest yield author in flamenco dance research, followed by Luis Gadea-Mateos, Alba Paris-Alemany and F.J. Bejjani. 9 research cooperative groups which have more than 2 publications and at least 3 authors are formed in the field of flamenco dance research, and most of these groups focus on biomechanical and physical research. In terms of scientific research institutions, The University of Seville with 8 articles is the most prolific institution and Saint Anthony Catholic University ranks the highest centrality value. Main research institutions are universities in different regions.

The cooperation network of scientific research institutions is relatively stable. Spain and the United States are high yield regions.

From the content analysis, the cultural aspects, including identity and art research related to flamenco dance, especially in Andalusia, which is one of the hotspots in the last 21 years. Furthermore, biomechanical and physical aspects have become the hotspots in the field of flamenco dance, including body, anthropometry, and physical activity research in the last years focusing on the dancer, and it is going to act as an increasingly significant character in the future. Besides, as physical activity, motor imagery, emotion, and style as keywords showed a burst in the last three years, the attention of future studies on flamenco dance might change to psychological aspects as well.

Funding

This research received no external funding

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Academic performance, physical activity, sleep and gender in university students during the pandemic-2020

Rendimiento académico, actividad física, sueño y género en universitarios durante la pandemia-2020

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Short title:
Influence of the pandemic-2020 in university students

How to cite this article:
Bustamante-Ara, N., Russell J., Godoy-Cumillaf A., Merellano-Navarro E., & Uribe N. (2020). Academic performance, physical activity, sleep and gender in university students during the pandemic-2020. *Cultura, Ciencia y Deporte, 17*(53), 109-131. https://doi.org/10.12800/ccd.v17i53.1897

Received: 25 march 2022 / Accepted: 15 june 2022

Abstract

During the period of confinement, university education was delivered in a virtual modality, which could have an impact on the healthy lifestyles of students. The aim of this study was to evaluate the association between academic performance, physical activity, and sleep quality and determine the existing differences by gender in Physical Education Pedagogy students during the pandemic in 2020. This study was designed as a multicenter, cross-sectional study of 278 university students from Santiago, Talca, and Temuco, Chile. An online survey was applied from July to December, which included questions on physical activity (International Physical Activity Questionnaire, *IPAQ*), sleep quality (Pittsburgh Sleep Quality Index), and sociodemographic information. The results show that women presented better academic performance, worse quality of sleep, and similar physical activity-*MET* than men. The women (β = 0.26, 95% *CI* 0.10 to 0.43 points, p = .002) and those university students who presented a worse indicator in subjective quality of sleep (β = 0.11, 95% *CI* 0.02 at 0.20 points, p = .014) obtained better academic performance in the context of COVID-19. There was no association between academic performance and physical activity. It is essential to look for strategies that allow students to have adequate academic performance and promote healthy habits in this population.

Keywords: academic success, quality of sleep, physical activity, COVID-19.

Resumen

Durante el periodo de confinamiento, la educación universitaria fue impartida bajo modalidad virtual, pudiendo repercutir en los estilos de vida saludable de los estudiantes. El objetivo fue evaluar la asociación entre rendimiento académico, actividad física y calidad de sueño, y determinar las diferencias existentes según género en estudiantes de Pedagogía en Educación Física durante la pandemia en el año 2020. Se realizó un diseño transversal multicéntrico, en 278 universitarios pertenecientes a las ciudades de Santiago, Talca y Temuco; Chile. Se aplicó una encuesta online desde julio a diciembre, incluyendo preguntas sobre actividad física (Cuestionario Internacional de Actividad Física, *IPAQ*), calidad del sueño (Pittsburgh Sleep Quality Index) e información sociodemográfica. En los resultados, las mujeres presentaron mejor rendimiento académico, peor calidad del sueño, y similar actividad física-*METs* respecto a los hombres. Las mujeres (β = 0.26, *IC* 95% 0.10 a 0.43 puntos, p = .002), y aquellos universitarios que presentaron un peor indicador en la calidad subjetiva del sueño (β = 0.11, *IC* 95% 0.02 a 0.20 puntos; p = .014) obtuvieron mejor rendimiento académico en contexto por COVID-19. No existió asociación entre rendimiento académico y actividad Física. Es importante buscar estrategias que permitan un adecuado rendimiento académico, y también favorecer hábitos saludables en esta población.

Palabras clave: éxito académico, calidad de sueño, actividad física, COVID-19.

Introduction

In December 2019, in Wuhan, China, the first contagion by COVID-19 was detected, being declared a pandemic on March 11, 2020. Since then, in Latin America, the number of cases increased to 70 million, and 1.6 million deaths have been confirmed by the World Health Organization (WHO). Particularly in Chile, the number of infections amounts to 4,030,267 and the number of deaths to 58,617 as of the first week of July 2022 (PAHO, 2022). After the initial health alert, each country implemented various strategies, including the suspension of face-to-face classes in schools and universities and the suspension of cultural, sports, and social events.

As a result of health guidelines, virtual education through online platforms emerged as an alternative to continue the teaching-learning process, generating a process of historical transformation (UNESCO, 2020). University education in Chile began its academic year in a virtual mode in March 2020; this ended in December of the same year, providing more flexibility for face-to-face teaching depending on the specific area of the country and limited by the reduced capacity.

The academic performance of university students is an element of great importance and concern in higher education (Fenollar et al., 2007). In this regard, the evidence suggests that multiple factors are associated with academic success, including attitudinal, psychological, and contextual aspects (Fenollar et al., 2007; Pérez-López & Ibarrondo-Dávila, 2020; van Herpen et al., 2017). In parallel, other variables associated with healthy habits, such as sleep quality and physical activity, can influence the academic performance of students (Adelantado-Renau et al., 2019).

During the pandemic, problems associated with sleep have stood out, which have been described mainly in the population of students of healthcare careers; however, their implication in the context of university students of pedagogy is scarce (Lipert et al., 2021). This is relevant because good sleep quality and duration are associated with good health, especially mental well-being (Baglioni et al., 2016). Sleep recommendations indicate that adults (18 to 60 years old) should sleep between 7 to 9 hours a day (Watson et al., 2015). Cross-sectional studies carried out before and during the pandemic have shown that the prevalence of poor sleep quality in the university population is significantly higher in women (Dongol et al., 2022; Fatima et al., 2016).

Regarding the relationship between academic performance and adequate sleep quality in the university population, the evidence indicates that there is a positive association between the two (Ahrberg et al., 2012; Alotaibi et al., 2020; Fernández-Medina et al., 2020; Okano et al., 2019; Rathakrishnan et al., 2021; Satti et al., 2019; Suardiaz-Muro et al., 2020). Also, an association has been found between academic performance and physical condition in university students of pedagogy (Godoy et al., 2015). Although the minimum physical activity recommended by the WHO for this age range is 150 minutes of moderate physical activity per week (Bull et al., 2020), there are disparate results regarding its association with academic performance. A cross-sectional study found that engaging in two to three hours of weekly physical activity was significantly correlated with higher academic performance in students in their second year of college (Lipošek et al., 2019). On the other hand, a systematic review determined that there was no significant relationship between physical activity and academic performance when analyzing only four studies in a university population (Wunsch et al., 2021).

It has been shown that being physically active is beneficial for perceiving less stress, fewer sleep problems, and improving sleep quality, especially among those exposed to remote work (Lipert et al., 2021). On the other hand, the available evidence shows gender differences in the prevalence of physical activity (McCarthy & Warne, 2022) and sleep quality (Dongol et al., 2022; Fatima et al., 2016) in young and adult populations. Among university students, Physical Education Pedagogy students are physically active (Almagià et al., 2009; Godoy Cumillaf et al., 2021; Ruiz et al., 2012); therefore, they are a population of interest in analyzing these factors during the course of the academic year. The objective of the present study was to evaluate the association between academic performance, physical activity, and sleep quality and to determine the existing differences according to gender in Physical Education Pedagogy students during the pandemic period in 2020.

Methodology

Participants

Multicenter cross-sectional design study. The population was 603 university students from the Physical Education Pedagogy career of a university in Chile who had virtual classes and practices during the 2020 academic year. The study adopted non-probabilistic convenience sampling of students over 18 years of age enrolled in the three cities of the country where the career is taught (Santiago, Talca, and Temuco). The inclusion criterion was to be registered in the Autumn-Spring 2020 semester. Participants who presented subjects not completed at the end of the corresponding academic year were excluded. The final sample consisted of 278 Physical Education Pedagogy students.

The invitation to participate was made through infographics disseminated in the internal social networks and institutional emails of the university students, from which the online survey link (onedrive) could be accessed. The period of application of the instrument was between July and December 2020, a period in which Chile was in confinement.

All university participants had to give informed consent before starting the online survey and voluntarily provide access to their academic data under the 1964 Declaration of Helsinki and its subsequent updates. The project has the approval of the Institutional Scientific Ethics Committee of the Universidad Autónoma of Chile (CEC-2320).

Instruments

The collection considered the following data:

Sociodemographic data

Including information regarding sex, age, with whom they live, and geographic area of residence.

Self-report of chronic diseases

Physical symptoms in the last 14 days, and diagnosed positive for COVID-19.

Healthy habits

Regarding their practice of sport and exercise, type of physical activity, tobacco consumption, and alcohol consumption.

Physical activity

The International Physical Activity Questionnaire (*IPAQ*) was used to measure physical activity. The metabolic equivalent of total physical activity (*MET*) in minutes/week was calculated using the procedure established in the *IPAQ* web portal (www.ipaq.ki.es), and participants were classified into low or inactive, moderate, or high activity levels. For the Low level, the classification criterion was those that did not meet any of the criteria for either moderate or high levels of physical activity. For moderate, it was meeting any of the following criteria: three or more days of vigorous intensity activity for ≥ 20 minutes, five or more days of moderate intensity activity or walking for ≥ 30 minutes, five or more days of any combination of activities with at least ≥ 600 *MET*s min-week. For the High level, the criteria were to perform three or more days of vigorous activity or reach 1500 *MET*s min-week; or perform seven or more days of any combination of walking, moderate intensity, or vigorous intensity activities achieving a minimum total physical activity of at least 3000 *MET*s min-week (Bauman et al., 2011; Craig et al., 2003).

Sleep quality

It was assessed with the self-administered Sleep Quality Index (Pittsburgh Sleep Quality Index, *PSQI*) questionnaire (Buysse et al., 1989), which provides a sleep quality score based on the assessment of seven components: 1) subjective sleep quality; 2) sleep latency; 3) sleep duration; 4) sleep efficiency; 5) sleep disturbance; 6) use of sleep medication; and 7) daytime dysfunction. The sum of the seven components creates a scale from 0 to 21 points (*PSQI* score). A higher score indicates poorer sleep quality. A *PSQI* score of ≤ 5 was determined as good sleep quality.

Academic Performance

From the central database of the University, the final grades of the academic process of each student were requested considering all the subjects taken during the 2020 period (March to December). In Chile, the grading system ranges from 1.0 to 7.0 points (7.0 is the maximum qualification), with 4.0 points being the passing grade.

Statistical analysis

The characteristics of the sample were obtained through a descriptive analysis using means and standard deviation (*SD*) for continuous variables and proportions for categorical variables. The normality and homoscedasticity of the variables were examined through the Kolmogorov-Smirnov and Levene's tests, respectively. For the analyses differentiated by sex, the Chi. test and the variance test (ANOVA) were used according to the nature of the variables, applying the Welch test in the case of non-normality. Spearman's Rho correlations were performed to analyze the direction and strength of the association between academic performance and the general sleep quality score, each of their components, and physical activity *MET*s. To analyze academic performance with qualitative variables, analysis of variance (ANOVA) was used, applying the Welch test and Bonferroni post hoc tests if required. Subsequently, a multivariate linear regression analysis was carried out with academic performance as the dependent variable, including the associated variables and the geographical area adjustment variables. The level of significance was established at $p < .05$. Analyzes were performed using IBM SPSS® 28 and RStudio 4.0.3 software.

Results

The sample reached was 281 students, obtaining a response rate of 47%. Three students who did not present valid data in the physical activity questionnaire were excluded. Finally, 278 participants were analyzed.

The characteristics of the participants are shown in Table 1. The mean age was 21.3 ± 2.3 years, ranging between 18 and 29 years, and women represented 27.3% of the sample.

Regarding the sociodemographic characteristics, 15.8% indicated that they reside in a rural area, 50% currently live with both parents, and 35.3% only with their mother. According to the distribution of university students by geographical area, Santiago and Temuco had a higher proportion of male (43.6%) and female (40.8%) students compared to Talca, respectively ($p = .003$).

Table 1. Sociodemographic and health characterization of students

	Total	Men	Women	*p*-value
	N = 278	n = 202	n = 76	
Sex, %		72.7	27.3	
Age, years, mean (*SD*)	21.3 (2.3)	21.4 (2.3)	21.1 (2.2)	.160
Urban zone, % (n)	84.2 (234)	85.6 (173)	80.3 (61)	.273
Geographic area				.003
Santiago, % (n)	37.8 (105)	43.6 (88)	22.4 (17)	
Talca,% (n)	33.1 (92)	31.7 (64)	36.8 (28)	
Temuco,% (n)	29.1 (81)	24.8 (50)	40.8 (31)	
Academic year				.263
Fourth or more, % (n)	24,1 (67)	23.8 (48)	25.0(19)	
Third, % (n)	19.8 (55)	20.8(42)	17.1 (13)	
Second,% (n)	21.6 (60)	18.8 (38)	28.9 (22)	
First, % (n)	34.5 (96)	36.6 (74)	28.9(22)	
Residence home				.066
Lives with both parents, % (n)	50.0 (139)	53.0 (107)	42.1 (32)	
Lives only with mother,% (n)	35.3 (98)	35.1 (71)	35.5 (27)	
Live alone, with other family or friends,% (n)	14.7 (41)	11.9 (24)	22.4 (17)	
Has children, Yes,% (n)	5.0 (14)	4.0 (8)	7.9 (6)	.181
Works, Yes,% (n)	27.0 (75)	26.2 (53)	28.9 (22)	.650
Habits and health				
Have any disease, Yes,% (n)	8.3 (23)	5.4 (11)	15.8 (12)	.005
Diagnosis of COVID-19, Yes,% (n)	3.2 (9)	3.5 (7)	2.6 (2)	.726
Tobacco consumption, , Yes,% (n)	13.7 (38)	10.9 (22)	21.1 (16)	.028
Alcohol consumption, Yes,% (n)	63.7 (177)	63.4 (128)	64.5 (49)	.864
Environment				
Green areas near the home,% (n)	87.1 (242)	90.1 (182)	78.9 (60)	.014
Use of green areas prior to COVID-19,% (n)	64.7 (180)	75.3 (143)	56.1 (37)	.003

Note: *SD* = standard deviation.

Regarding the academic year, 56.1% of university students were in their first or second year of studies.

In health status, women reported almost three times more prevalence of some diseases than men ($p > .05$), and only 3.2% of the participants had been diagnosed with COVID-19 at the time of the survey.

The habit of alcohol consumption was the most prevalent, being over 60%, and with a similar response between both sexes. A difference was observed in tobacco consumption, where women had almost twice the prevalence as men (1.9 times more, $p = .028$).

Academic performance presented an annual average of 5.8 ± 0.6 points, with women performing 0.3 tenths of a point better than men ($p < .001$). At the end of the year, 98% of the university students obtained satisfactory academic approval (Table 2).

Table 2. Characterization of academic performance, physical activity and sleep quality of students

	Total N = 278	Men n = 202	Women n = 72	*p*-value
Academic Performance				
Annual average, mean (*SD*)	5.8 (0.6)	5.7 (0.6)	6.0 (0.6)	< .001
% Academic approval, mean (*SD*)	98.0 (8.5)	97.9 (8.1)	98.4 (9.3)	.337
Physical Activity				
Total METs week, mean(*SD*)	3584.4 (2687.7)	3697.6 (2771.1)	3282.8 (2444.0)	.226
Physical activity level, *IPAQ*				.020
High, % (n)	52.5 (146)	57.4 (116)	39.5 (30)	
Moderate, % (n)	37.4 (104)	32.7 (66)	50.0 (38)	
Low, % (n)	10.1(28)	9.9(20)	10.5 (8)	
Sleep quality				
PSQI score, mean (*SD*)	8.4 (3.3)	8.0 (3.2)	9.3 (3.4)	.003
Good sleep quality, % (n)	20.5 (57)	23.8 (48)	11.8 (9)	.028
≥ 7 hours of sleep, % (n)	64.0 (178)	64.9 (131)	61.8 (47)	.641

Note: *SD* = Standard deviation, *IPAQ* = International Physical Activity Questionnaire, *PSQI* = Pittsburgh Sleep Quality Index Good sleep quality: ≤ 5 *PSQI* points.

The university students of pedagogy in Physical Education presented a 52.5% high level of physical activity, and when compared by sex, men obtained a prevalence 18% higher than women (p = .002). Total physical activity was 3584.4 ± 2687.7 *METs*/week, with no differences between sex (Table 2).

Within the physical activities carried out by university students during the pandemic, specific activities such as strength, metabolism, flexibility, and general level exercises predominated.

The sleep quality of university students was 8.4 ± 3.3 points, which was 3 points above the criterion for a good quality of reference sleep. In this aspect, women scored higher than men (p = .004).

Only 20.5% of the university students presented an excellent quality of sleep, with the difference between the sexes persisting, as women obtained a 12% lower prevalence than men in this indicator (p = .028).

Pedagogy students had a sleep duration of 7.3 ± 2.0 hours, while 36% of university students did not meet the recommended minimum of 7 hours (Table 2).

When considering each of the components of sleep quality separately, the most remarkable alterations were in the sleep latency indicators, followed by subjective sleep quality and daytime dysfunction (presence of excessive sleepiness), which showed the highest values among students.

Differences between sexes were observed in the subjective quality of sleep (p = .030), sleep disturbances (p = .041), and daytime dysfunction (p = .007): these indicators were worse in women, Figure 1.

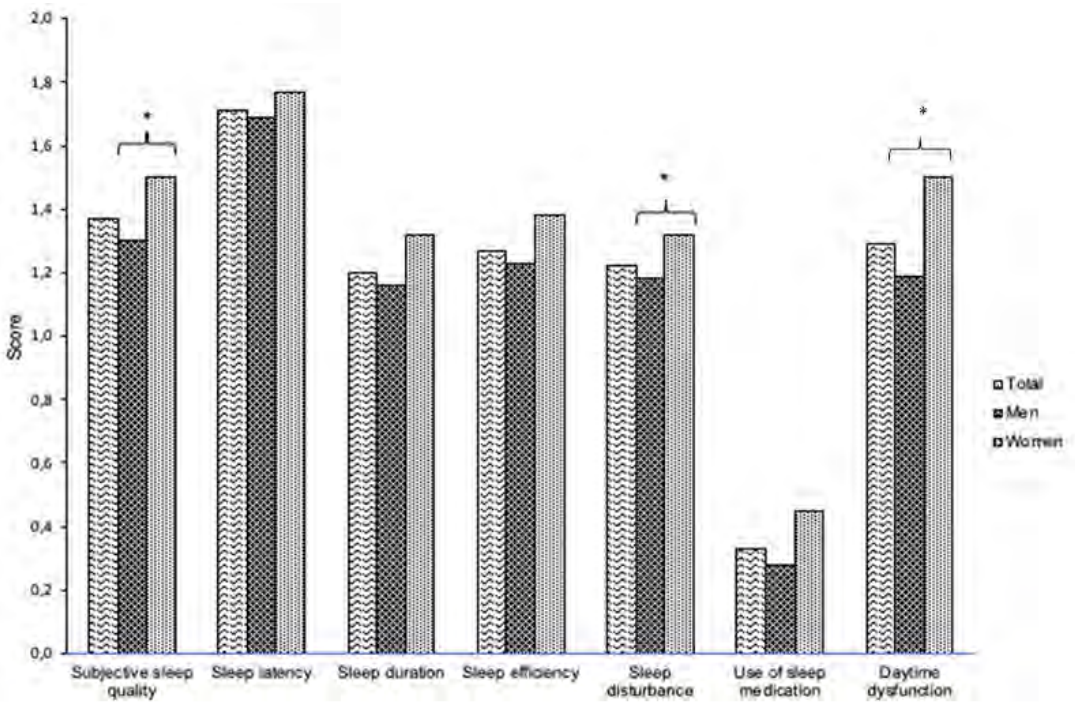

Figure 1. Analysis of the components of the sleep quality of students
*p < .05

When analyzing the association between academic performance and geographical area, there were significant differences. The annual average in Santiago was 5.7 ± 0.6 points, Talca 5.6 ± 0.5 points, and Temuco 5.9 ± 0.7 points (p = .034) specifically presenting a difference in performance between Talca and Temuco (p = .028).

When considering the habits of physical activity, alcohol consumption, and tobacco consumption, there was no association with academic performance; for all p > .05 (data not shown).

When analyzing the annual average and its association with the general sleep quality score, a weak positive correlation was found (r = .17; p = .005). When performing the analysis with each component, there was only a correlation between academic performance and subjective sleep quality (r = .15; p = .015) (Figure 2). In contrast, when analyzing academic performance and physical activity performed in *MET*s/week, there was no significant correlation (r = -.026, p = .663). The results showed no difference when analyzing the association between academic performance and level of physical activity (Low: 5.8 ± 0.6 points, Medium: 5.8 ± 0.6 points, High: 5.7 ± 0.7 points; p = .395).

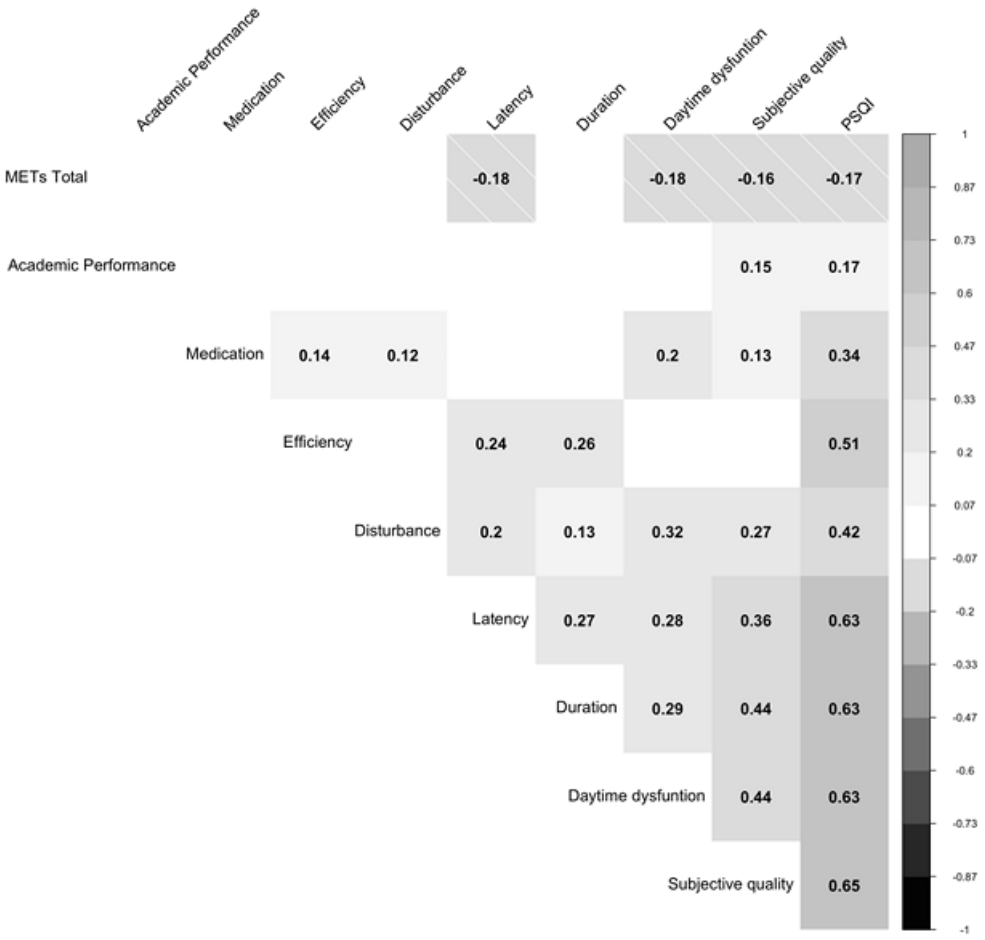

Figure 2. Correlation between academic performance, sleep quality and physical activity *METs*
Note: *PSQI*: Pittsburgh Sleep Quality Index. Significant results are shown with *p*-values < .05 from Spearman's correlation analysis.

When analyzing academic performance and the general sleep quality score, including gender and geographic adjustment, the association is lost (β = 0.014, 95% *CI* -0.008 to 0.036 points, p = .222). Finally, academic performance and the component of subjective sleep quality were analyzed—adjusted for geographic area and with gender as a co-variable. The results showed that women (β = 0.26, 95% *CI* 0.10 to 0.42 points, p = .002) and university students who presented a worse indicator in the subjective quality of sleep (β = 0.11, 95% *CI* 0.02 to 0.20 points; p = .014) presented a better annual academic performance considering the 2020 COVID-19 context. Only 7.5% of the academic average is explained by the variables described above.

Discussion

The objective of this study was to evaluate the association between academic performance, physical activity, and sleep quality and to determine the differences according to gender in Physical Education Pedagogy students during the pandemic period in 2020.

Worsening sleep quality was associated with better academic performance; in contrast, there was no correlation between academic performance and physical activity in university students of Physical Education Pedagogy during the COVID-19 pandemic. Our results show that the female gender, and specifically a worsening subjective sleep quality, was associated with higher academic performance during the pandemic.

Few studies analyze the association of these three variables. A pre-pandemic study of 219 Pakistani medical students found that physical activity (r = .61; p = .003) and better sleep quality (r = -.69; p < .001) were associated with academic performance (Satti et al., 2019). However, the pandemic context, the gender distribution (57% women), and the physical activity level profile (Level: 16.4% high, 40.2% low) may be the answer to the differences found in the present investigation.

Our study found that only 10.5% did not meet the physical activity recommendations (Low level), and 52.5% of university students declared a high level of physical activity during the pandemic, a high prevalence that is to be expected in the physical activity area student population (Farinola, 2011), and close to the 64% reported in Swiss students while in lockdown (Taeymans et al., 2021).

Our results also agree with the patterns of physical activity according to gender (Rodríguez-Larrad et al., 2021); a moderate level of physical activity predominated among women and a high level of physical activity among men. Although the absolute values of the *METs*/week performed by the students are within the recommendation for prevention and health benefits (Kyu et al., 2016), they are low values according to antecedents prior to the pandemic in Physical Education pedagogy students (≥ 6.000 *METs*/ week) (Farinola, 2011). Despite this, they were similar to

the *MET*s/week described in university students in Ireland (Du et al., 2021) and Switzerland during the pandemic (Taeymans et al., 2021). We found no gender differences in this aspect; women probably had to reduce their physical activity less than men as they were less dependent on outdoor activities (Rodríguez-Larrad et al., 2021). In this context, there was no association between physical activity and academic performance in physically active university students, possibly due to the homogeneity in these data among our participants. The review by Wunsch et al. (2021) is consistent with our findings and shows significant heterogeneity in their results from four analyzed studies (Wunsch et al., 2021).

On the other hand, the high level of physical activity in our university students during the pandemic may respond to a need of students to meet all the demands of the academic load, motivation, and self-determination to maintain this habit (Zubiaur et al., 2021), as well as a strategy to reduce their anxiety and stress during confinement by being aware of the benefit to their mental health (Martinez et al., 2020; Planchuelo-Gómez et al., 2020). Likewise, it can respond to the need to remain physically active, which is reflected in the activities they preferably developed during this time, adapting to the conditions and limitations of space in their homes. This situation goes hand in hand with what was exposed by Rodríguez-Larrad et al. (2021) regarding the modifications made by university students to stay active, i.e., preferring high-intensity and short-duration training (Rodríguez-Larrad et al., 2021).

In line with the evidence, the Sleep Quality Index (*PSQI* 8.4) and the prevalence of poor sleep quality (79.5%) were elevated during the COVID-19 pandemic in university students, reflecting poor sleep hygiene in Physical Education Pedagogy students. Previously, Chen Du et al. (2021), in their study of 2,254 university students from China, Ireland, Malaysia, South Korea, Taiwan, Netherlands, and the United States, with 66.6% of female participants, revealed unhealthy values in sleep quality, specifically among students from Ireland and the USA, both with a *PSQI* score of 7.4 ± 3.6 (Du et al., 2021).

Another study conducted during the pandemic in Spanish university students presented a *PSQI* score of 7.2 ± 3.9 and indicated that sleep quality worsened during the pandemic (Martínez-de-Quel et al., 2021). Parallel to this, university students from the United States and Europe reported worse health indicators (diet, alcohol consumption, sleep quality, and physical activity) compared to Asian countries during the pandemic (Du et al., 2021). It would be interesting to consider Latin American countries in the comparison, given the different socio-cultural contexts and the high prevalence of poor sleep quality in Chilean university students. Worse sleep quality reduces the time of alertness and memory, which is related to attention and difficulty in academic performance. Its negative effect on cognition and mental health can influence good academic performance in university students in the long term (Rathakrishnan et al., 2021).

Adequate sleep is essential for motivation, attention, and memory (Fernández-Medina et al., 2020). It has been described that those who report a poor quality of sleep have more daytime dysfunction problems related to fatigue, sleepiness, and worse cognition than those who sleep better (Okano et al., 2019). The study developed by Gelaye et al. (2014) in a heterogeneous sample of university students from different countries that included 880 students in a pre-pandemic context indicated an excessive daytime dysfunction present in students from Peru, Chile, and Thailand (Gelaye et al., 2014). Our results presented a more significant alteration in subjective quality of sleep and daytime dysfunction, which is in line with what has been reported in pre-pandemic studies in university students (Lemma et al., 2014; MacHado-Duque et al., 2015; Mirghani et al., 2015; Wong et al., 2013).

Accordingly, students from Italy presented a 73.3% prevalence of poor sleep quality (Marelli et al., 2021), emphasizing that the isolation period had a more significant impact on the sleep quality of women and students when compared to workers. In particular, our results show significant differences according to gender, associated with a greater impact on the quality of sleep during confinement in women. They presented a more remarkable alteration in the subjective quality of sleep, sleep disturbances, and daytime dysfunction. These data are consistent with previous studies in a university population (Cellini et al., 2021; de la Portilla Maya et al., 2019; Durán et al., 2017; Fawzy & Hamed, 2017) and with the evidence from different age groups, in which a lower quality of sleep associated with the female gender is reported, possibly due to differences in the architecture of sleep in the "non-REM" phase (Mallampalli & Carter, 2014) and the physiological responses generated from the menstruation cycle (Colten et al., 2006).

One of the possible causes of poor sleep quality in our general population is a longer exposure time to screens (Hjetland et al., 2021; Muhammad & Hussain, 2021) and their use close to bedtime (Guo et al., 2021; Islam et al., 2021). Increased time spent using electronic devices is associated with worsening sleep quality, higher sleep latency, and later wake-up time (Amra et al., 2017; Christensen et al., 2016; El Hangouche et al., 2018). In this regard, studies have reported a significant increase in the use of screens during the pandemic (Pišot et al., 2020). Specifically, Physical Education students attended classes and practices in a mainly "online" modality.

These antecedents suggest that students experienced increased use of electronic devices to follow their academic activities synchronously (connected in real-time) and asynchronously (independently to study their various subjects), which could affect their sleep quality in the context of a pandemic.

Another cause may be the sleep schedule of students during the pandemic. In our study, the sleep schedule of university students was from ~ 3:00 *am* to ~ 9:00 *am*. This is in line with the results of Csépe et al. (2021) on university students, which suggest that, during the confinement period, there was a delay in the time to go to sleep and greater flexibility in the time to get up, shifting the chronotype toward the evening (Csépe et al., 2021; Genta et al., 2021). Therefore, this new structure can cause drowsiness, changes in the biological rhythm, and a worsening of the subjective quality of sleep by reducing melatonin synthesis (Ahrberg et al., 2012; Marelli et al., 2021).

Finally, it has been suggested that a combination of anxiety and stress caused by the COVID-19 pandemic could be responsible for the negative results observed in sleep quality (Martínez-de-Quel et al., 2021).

Interestingly, the results showed a significant correlation between the *PSQI* score and academic performance, consistent with previous studies (Ahrberg et al., 2012; Alotaibi et al., 2020; El Hangouche et al., 2018; Fernández-Medina et al., 2020; Rathakrishnan et al., 2021; Satti et al., 2019; Suardiaz-Muro et al., 2020). In contrast, we found a weak positive correlation between overall sleep quality (r = .17; p > .05) and the subjective sleep quality component (r = .15; p = .015) with yearly grade point average.

A study conducted on sleep, well-being, and academic performance of Singapore university students stated that daytime dysfunction also had a low correlation with academic performance (r = -.240; p = .013) (Armand et al., 2021). However, the trend of the results prior to the COVID-19 pandemic shows a direction of the association that contrasts with the findings of our study.

Among the multiple factors associated with academic performance, self-efficacy and the establishment of study habits can be highlighted (Kocak et al., 2021). In the context of the pandemic, developing skills and achieving the performance required staying connected through various electronic devices.

The students with the highest academic performance likely were those who spent more time connected to electronic devices, perhaps preferably in the evening, which, in turn, affected their sleep quality.

The results of the association between academic performance with physical activity and sleep quality in a university population of Physical Education pedagogy students should be taken with caution; longitudinal studies are necessary to deepen the understanding of these factors.

Our work presents a cross-sectional design that does not allow us to evaluate the change in the academic performance of students as a consequence of the pandemic, nor the impact of sleep quality and physical activity on it. The low response rate of participants due to the difficulty of online application and saturation of different activities through virtual media during the pandemic, the gender imbalance, and not controlling the time of exposure to screens or technological devices make our results not generalizable to other populations.

The strengths of the study are its multicenter nature, carried out in a university population of Latin American Physical Education pedagogy students during the COVID-19 period, and with the application of validated and internationally used instruments.

The projections require studies with objective evaluations of sleep quality and physical activity to contrast the self-reported results, as well as including exposure time and screen use, such as longitudinal designs to deepen the understanding of the findings and risk indicators found in college students that may affect their cognitive and mental health in the long term.

Conclusion

Academic performance was associated with worse sleep quality among Physical Education pedagogy university students, specifically related to a worsening in the subjective quality of sleep component. In general, during the pandemic, women presented a worse quality of sleep and better academic performance than men. Physical activity was not associated with academic performance. 90% of the university students complied with the recommendations for physical activity during this period; men stood out in the high level and women in the moderate level of physical activity.

It is crucial to monitor the behavior of these variables for an academically demanding environment that favors healthy habits that impact the physical and mental well-being of university students throughout the process and post-pandemic.

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Rendimiento académico, actividad física, sueño y género en universitarios durante la pandemia-2020

Academic performance, physical activity, sleep and gender in university students during the pandemic-2020

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Título abreviado:
Influencia de la pandemia 2020 en estudiantes universitarios

Cómo citar el artículo:
Bustamante-Ara, N., Russell J., Godoy-Cumillaf A., Merellano-Navarro E., & Uribe N. (2020). Rendimiento académico, actividad física, sueño y género en universitarios durante la pandemia-2020. *Cultura, Ciencia y Deporte*, *17*(53), 109-131. https://doi.org/10.12800/ccd.v17i53.1897

Recibido: 25 marzo 2022 / Aceptado: 15 junio 2022

Resumen

Durante el periodo de confinamiento, la educación universitaria fue impartida bajo modalidad virtual, pudiendo repercutir en los estilos de vida saludable de los estudiantes. El objetivo fue evaluar la asociación entre rendimiento académico, actividad física y calidad de sueño, y determinar las diferencias existentes según género en estudiantes de Pedagogía en Educación Física durante la pandemia en el año 2020. Se realizó un diseño transversal multicéntrico, en 278 universitarios pertenecientes a las ciudades de Santiago, Talca y Temuco; Chile. Se aplicó una encuesta online desde julio a diciembre, incluyendo preguntas sobre actividad física (Cuestionario Internacional de Actividad Física, *IPAQ*), calidad del sueño (Pittsburgh Sleep Quality Index) e información sociodemográfica. En los resultados, las mujeres presentaron mejor rendimiento académico, peor calidad del sueño, y similar actividad física-*MET*s respecto a los hombres. Las mujeres (β = 0.26, *IC* 95% 0.10 a 0.43 puntos, p = .002), y aquellos universitarios que presentaron un peor indicador en la calidad subjetiva del sueño (β = 0.11, *IC* 95% 0.02 a 0.20 puntos; p = .014) obtuvieron mejor rendimiento académico en contexto por COVID-19. No existió asociación entre rendimiento académico y actividad Física. Es importante buscar estrategias que permitan un adecuado rendimiento académico, y también favorecer hábitos saludables en esta población.

Palabras clave: Éxito académico, Calidad de sueño, Actividad física, COVID-19.

Abstract

During the period of confinement, university education was delivered in a virtual modality, which could have an impact on the healthy lifestyles of students. The aim of this study was to evaluate the association between academic performance, physical activity, and sleep quality and determine the existing differences by gender in Physical Education Pedagogy students during the pandemic in 2020. This study was designed as a multicenter, cross-sectional study of 278 university students from Santiago, Talca, and Temuco, Chile. An online survey was applied from July to December, which included questions on physical activity (International Physical Activity Questionnaire, *IPAQ*), sleep quality (Pittsburgh Sleep Quality Index), and sociodemographic information. The results show that women presented better academic performance, worse quality of sleep, and similar physical activity-*MET* than men. The women (β = 0.26, 95% *CI* 0.10 to 0.43 points, p = .002) and those university students who presented a worse indicator in subjective quality of sleep (β = 0.11, 95% *CI* 0.02 at 0.20 points, p = .014) obtained better academic performance in the context of COVID-19. There was no association between academic performance and physical activity. It is essential to look for strategies that allow students to have adequate academic performance and promote healthy habits in this population.

Keywords: Academic success, Quality of sleep, Physical activity, COVID-19.

Introducción

En diciembre 2019, en Wuhan China, se detectó el primer contagio por COVID-19, siendo declarada pandemia el 11 de marzo del 2020. Desde entonces a la fecha, en Latinoamérica el registro de casos asciende a 70 millones y a 1.6 millones de muertes confirmadas por la Organización Mundial de la Salud (OMS). Particularmente en Chile, el contagio asciende a 4.030.267 personas, y 58.617 muertes hasta la primera semana de julio 2022 (PAHO, 2022). Tras la alerta sanitaria inicial, cada país implementó diversas estrategias incluyendo la suspensión de clases presenciales en colegios, universidades, como también la suspensión de eventos culturales, deportivos, y reuniones sociales.

Producto de las directrices sanitarias, la educación virtual a través de plataformas online surgió como una alternativa para continuar el proceso de enseñanza-aprendizaje generando un proceso de transformación histórico (UNESCO, 2020). La enseñanza universitaria en Chile inició su año académico en modalidad virtual en marzo 2020, finalizando en diciembre del mismo año, con más flexibilidad para la presencialidad, según diferentes zonas del país y limitado por aforos reducidos.

El rendimiento académico de los universitarios es un elemento de gran importancia y preocupación en el contexto de la educación superior (Fenollar et al., 2007). Al respecto, la evidencia sugiere que son múltiples los factores que se asocian con el éxito académico, los cuales incluyen aspectos actitudinales, psicológicos y contextuales (Fenollar et al., 2007; Pérez-López & Ibarrondo-Dávila, 2020; van Herpen et al., 2017). En paralelo, otras variables asociadas a los hábitos saludables, como la calidad del sueño y actividad física, pueden influir en el desempeño académico de los estudiantes (Adelantado-Renau et al., 2019).

Durante la pandemia, han resaltado problemáticas asociadas al sueño, las cuales han sido descritas especialmente en población del área de la salud, no obstante, su implicancia en un contexto de universitarios de Pedagogía es escasa (Lipert et al., 2021). Lo anterior es relevante, debido a que una buena calidad del sueño y duración, se asocian a buena salud, especialmente con el bienestar mental (Baglioni et al., 2016). Al respecto, las recomendaciones de sueño indican que las personas adultas (18 a 60 años) deberían dormir entre 7 a 9 horas diarias (Watson et al., 2015). Estudios de diseño transversal, efectuados antes y durante la pandemia, han mostrado que la prevalencia de mala calidad del sueño en población universitaria es significativamente mayor en las mujeres (Dongol et al., 2022; Fatima et al., 2016).

En lo que respecta a la relación entre rendimiento académico y adecuada calidad del sueño en población universitaria, la evidencia señala que entre ambas existe una asociación positiva (Ahrberg et al., 2012; Alotaibi et al., 2020; Fernández-Medina et al., 2020; Okano et al., 2019; Rathakrishnan et al., 2021; Satti et al., 2019; Suardiaz-Muro et al., 2020). También, se ha encontrado asociación entre rendimiento académico y condición física en universitarios de pedagogía (Godoy et al., 2015). Si bien la actividad física mínima recomendada por la OMS para este rango etario es de 150 minutos de actividad física moderada a la semana (Bull et al., 2020), existen resultados dispares respecto a su asociación con el rendimiento académico. Un estudio de diseño transversal encontró que realizar de dos hasta tres horas de actividad física semanal se correlacionó significativamente con un mayor desempeño académico en estudiantes en su segundo año de universidad (Lipošek et al., 2019). Por otra parte, una revisión sistemática determinó que no existió una relación significativa entre actividad física y rendimiento académico al analizar solo cuatro estudios en población universitaria (Wunsch et al., 2021).

Se ha evidenciado que ser físicamente activo es beneficioso para percibir menos estrés, menos problemas en el sueño y favorecer su calidad, especialmente entre aquellos que se han expuesto al trabajo remoto (Lipert et al., 2021). Por otra parte, la evidencia disponible, muestra diferencias según género en la prevalencia de actividad física (McCarthy & Warne, 2022) y calidad de sueño (Dongol et al., 2022; Fatima et al., 2016) en población joven y adulta. Entre los universitarios, los estudiantes de Pedagogía en Educación Física se caracterizan por ser físicamente activos (Almagià Flores et al., 2009; Godoy Cumillaf et al., 2021; Ruiz et al., 2012); por tanto, son una población de interés para analizar estos factores durante el transcurso académico. Considerando lo expuesto, el objetivo del presente estudio fue evaluar la asociación entre rendimiento académico, actividad física y calidad del sueño, y determinar las diferencias existentes según género en estudiantes de Pedagogía en Educación Física durante el periodo de pandemia en el año 2020.

Metodología

Participantes

Estudio con diseño transversal multicéntrico. La población fueron 603 universitarios pertenecientes a la carrera de Pedagogía en Educación Física de una Universidad en Chile que tuvieron clases y prácticas virtuales durante el año académico 2020. La muestra fue no probabilística, elegida de manera no aleatoria y por conveniencia, entre los estudiantes mayores de 18 años matriculados en las tres ciudades del país en las que se imparte la carrera (Santiago, Talca y Temuco). El criterio de inclusión fue presentar matricula vigente semestre Primavera 2020. Se excluyeron aquellos participantes que presentaron asignaturas no finalizadas al término del año académico correspondiente. La muestra final fue de 278 estudiantes de Pedagogía en Educación Física.

La invitación a participar se realizó a través infográficos difundidos en las redes sociales internas y correos electrónicos institucionales de los universitarios, desde el cual se accedía al link de la encuesta online (OneDrive). El periodo de aplicación del instrumento fue entre los meses de julio a diciembre del 2020, periodo en el que Chile estaba en confinamiento.

Todos los participantes universitarios debieron aceptar el consentimiento informado previo al inicio de la encuesta online, junto con dar acceso voluntario a sus datos académicos, acorde a la declaración de Helsinki del año 1964 y sus actualizaciones posteriores. El proyecto cuenta con la aprobación del Comité Ético Científico Institucional de la Universidad Autónoma de Chile (CEC-2320).

Instrumentos

La recolección consideró los siguientes datos:

Sociodemográficos

Se incluye información referente a sexo, edad, con quién vive, y zona geográfica de residencia.

Auto-reporte de enfermedades crónicas

Síntomas físicos en los últimos 14 días, diagnosticado positivo a COVID-19.

Hábitos saludables

Referente a su práctica de deporte y/o ejercicio, tipo de actividad física, consumo de tabaco y alcohol.

Actividad física

Se utilizó el Cuestionario Internacional de Actividad Física (*IPAQ*). El equivalente metabólico de la actividad física total (*MET*) en minutos / semana se calculó utilizando el procedimiento establecido en el portal web de *IPAQ* (www.ipaq.ki.es) y la clasificación de los participantes en nivel bajo o inactivos, moderado y alto. Para el nivel bajo el criterio de clasificación fue aquellos que no lograron las categorías moderada o alta. Para moderado, fue cumplir alguno de los siguientes criterios: realizar actividad vigorosa 3 o más días por ≥ 20 minutos, o realizar 5 o más días de actividad moderada o caminar por ≥ 30 minutos; o realizar 5 o más días una combinación de actividades con al menos ≥ 600 *MET* min-semana. Para el nivel Alto el criterio fue realizar 3 o más días de actividad vigorosa o alcanzar 1500 *MET* min-semana; o realizar 7 días una combinación de caminar, actividades moderadas o vigorosas logrando 3000 *MET* min-semana (Bauman et al., 2011; Craig et al., 2003).

Calidad de sueño

Evaluada con el cuestionario auto-aplicable Índice de Calidad de Sueño (Pittsburgh Sleep Quality Index, *PSQI*) (Buysse et al., 1989), el cual proporciona un puntaje de la calidad del sueño a partir de la evaluación de siete componentes: 1) calidad subjetiva de sueño; 2) latencia de sueño; 3) duración del dormir; 4) eficiencia de sueño habitual; 5) alteraciones del sueño; 6) uso de medicamentos para dormir y 7) disfunción diurna. La suma de los 7 componentes crea una escala de 0 a 21 puntos (puntaje *PSQI*). Un mayor puntaje indica peor calidad de sueño. Se determinó buena calidad de sueño obtener un puntaje *PSQI* ≤ 5.

Rendimiento Académico

Desde la base de datos central de la Universidad, fueron solicitados las calificaciones finales del proceso académico de cada estudiante considerando todas las asignaturas cursadas durante el periodo 2020 (marzo a diciembre). En Chile, la calificación considera una escala de 1.0 a 7.0 puntos (7.0 es la calificación máxima), se considera aprobado si se alcanza una nota mínima de 4.0 puntos.

Análisis estadístico

Las características de la muestra se obtuvieron a través de un análisis descriptivo utilizando medias y desviación estándar (*DE*) para las variables continuas, y proporciones para las variables categóricas. La normalidad y homocedasticidad de las variables fue examinada a través de la prueba de Kolmogórov-Smirnov y test de Levene, respectivamente. Para los análisis diferenciados por sexo se utilizaron test de Chi2, y de varianza (ANOVA) según la naturaleza de las variables, aplicando el test de Welch en caso de no normalidad. Para analizar la dirección y fuerza de la asociación entre el rendimiento académico con el puntaje general de calidad del sueño, cada uno de sus componentes y los *METs* de actividad física se realizaron correlaciones de Rho de Spearman. Para analizar el rendimiento académico con las variables cualitativas se utilizó análisis de varianza (ANOVA) aplicando el test de Welch, y las pruebas post hoc por Bonferroni en caso requerido. Posteriormente, se realizó un análisis de regresión lineal multivariante siendo el rendimiento académico la variable dependiente, incluyendo las variables asociadas y de ajuste zona geográfica. El nivel de significancia se estableció en $p < .05$. Los análisis se realizaron en el software IBM SPSS® 28 y Rstudio versión 4.0.3.

Resultados

La muestra alcanzada fue de 281 estudiantes, obteniendo una tasa de respuesta del 47%. Se excluyeron 3 estudiantes que no presentaron datos válidos en el cuestionario de actividad física, finalmente se analizaron a 278 participantes.

Las características de los participantes se muestran en la Tabla 1. La media de edad fue de 21.3 ± 2.3 años con un rango entre 18 a 29 años, y las mujeres representaron el 27.3% de la muestra. Entre las características sociodemográficas, un 15.8% señaló residir en zona rural, un 50% vive actualmente con ambos padres, y el 35.3% solo con la madre. Acorde a la distribución de universitarios por zona geográfica, Santiago y Temuco presentaron una mayor proporción de estudiantes hombres (43.6%) y mujeres (40.8%) comparado con Talca respectivamente ($p = .003$).

Tabla 1. Caracterización sociodemográfica y de salud de los estudiantes

	Total	Hombres	Mujeres	*p*-valor
	N = 278	n = 202	n = 76	
Sexo, %		72.7	27.3	
Edad, años, media (*DE*)	21.3 (2.3)	21.4 (2.3)	21.1 (2.2)	.160
Zona Urbana, % (n)	84.2 (234)	85.6 (173)	80.3 (61)	.273
Zona Geográfica				.003
Santiago, % (n)	37.8 (105)	43.6 (88)	22.4 (17)	
Talca, % (n)	33.1 (92)	31.7 (64)	36.8 (28)	
Temuco, % (n)	29.1 (81)	24.8 (50)	40.8 (31)	
Curso académico				.263
Cuarto o más, %(n)	24,1 (67)	23.8 (48)	25.0(19)	
Tercero, %(n)	19.8 (55)	20.8(42)	17.1 (13)	
Segundo, %(n)	21.6 (60)	18.8 (38)	28.9 (22)	
Primero, %(n)	34.5 (96)	36.6 (74)	28.9(22)	
Residencia hogar				.066
Vive con ambos padres, %(n)	50.0 (139)	53.0 (107)	42.1 (32)	
Vive con la madre, %(n)	35.3 (98)	35.1 (71)	35.5 (27)	
Vive solo, con otro familiar o amigos, %(n)	14.7 (41)	11.9 (24)	22.4 (17)	
Posee hijos, SI, %(n)	5.0 (14)	4.0 (8)	7.9 (6)	.181
Activo laboralmente, SI, %(n)	27.0 (75)	26.2 (53)	28.9 (22)	.650
Hábitos y Salud				
Posee alguna enfermedad, SI, %(n)	8.3 (23)	5.4 (11)	15.8 (12)	.005
Diagnóstico de COVID-19, SI, %(n)	3.2 (9)	3.5 (7)	2.6 (2)	.726
Consumo de Tabaco, SI, %(n)	13.7 (38)	10.9 (22)	21.1 (16)	.028
Consumo de Alcohol, SI, %(n)	63.7 (177)	63.4 (128)	64.5 (49)	.864
Entorno				
Áreas verdes cerca del hogar, %(n)	87.1 (242)	90.1 (182)	78.9 (60)	.014
Utilización áreas verdes previo COVID-19, %(n)	64.7 (180)	75.3 (143)	56.1 (37)	.003

Nota *DE*= Desviación estándar.

Referente al curso académico, el 56.1% de los universitarios estuvieron cursando su primer o segundo año de carrera. En el estado de salud, las mujeres reportaron casi 3 veces más prevalencia de alguna enfermedad frente a los hombres ($p > .05$), y solo un 3.2% de los participantes había sido diagnosticado con COVID-19 a la fecha de la encuesta.

El hábito de consumo de alcohol fue el más prevalente siendo sobre el 60%, y con una respuesta similar entre ambos sexos. La diferencia se presentó en el consumo de tabaco, donde las mujeres presentaron casi el doble de prevalencia que los hombres (1.9 veces más, $p = .028$).

El rendimiento académico presentó un promedio anual de 5.8 ± 0.6 puntos manifestando las mujeres un mejor rendimiento con 0.3 décimas más elevadas frente a los hombres ($p < .001$). Al término del año, el 98% de los universitarios obtuvo una aprobación académica satisfactoria (Tabla 2).

Los universitarios de pedagogía en Educación Física presentaron un 52.5% de alto nivel de actividad física, al comparar por sexo los hombres obtuvieron una prevalencia 18% mayor frente a las mujeres ($p = .002$). La actividad física total realizada fue de 3584.4 ± 2687.7 *MET*s/semana, sin diferencias entre ambos sexos en este criterio (Tabla 2).

Dentro de las actividades físicas que realizaron los universitarios durante el periodo de pandemia, predominaron las actividades específicas como ejercicios de fuerza, metabólicas, flexibilidad y/o de nivel general.

La calidad de sueño de los universitarios obtuvo 8.4 ± 3.3 puntos, el cual estuvo 3 puntos sobre el criterio para una buena calidad de sueño de referencia. En este aspecto, las mujeres reportaron un puntaje más elevado frente a los hombres ($p = .004$).

Solo un 20.5% de los universitarios presentó una buena calidad de sueño, persistiendo la diferencia entre sexos, las mujeres obtuvieron un 12% menos de prevalencia en comparación a los hombres en este indicador ($p = .028$).

Los estudiantes de Pedagogía tuvieron una duración del sueño de 7.3 ± 2.0 horas, paralelamente el 36% de los universitarios no cumplió con el mínimo de 7 horas de sueño recomendadas, (Tabla 2).

Tabla 2. Caracterización del rendimiento académico, actividad física y calidad del sueño de los estudiantes

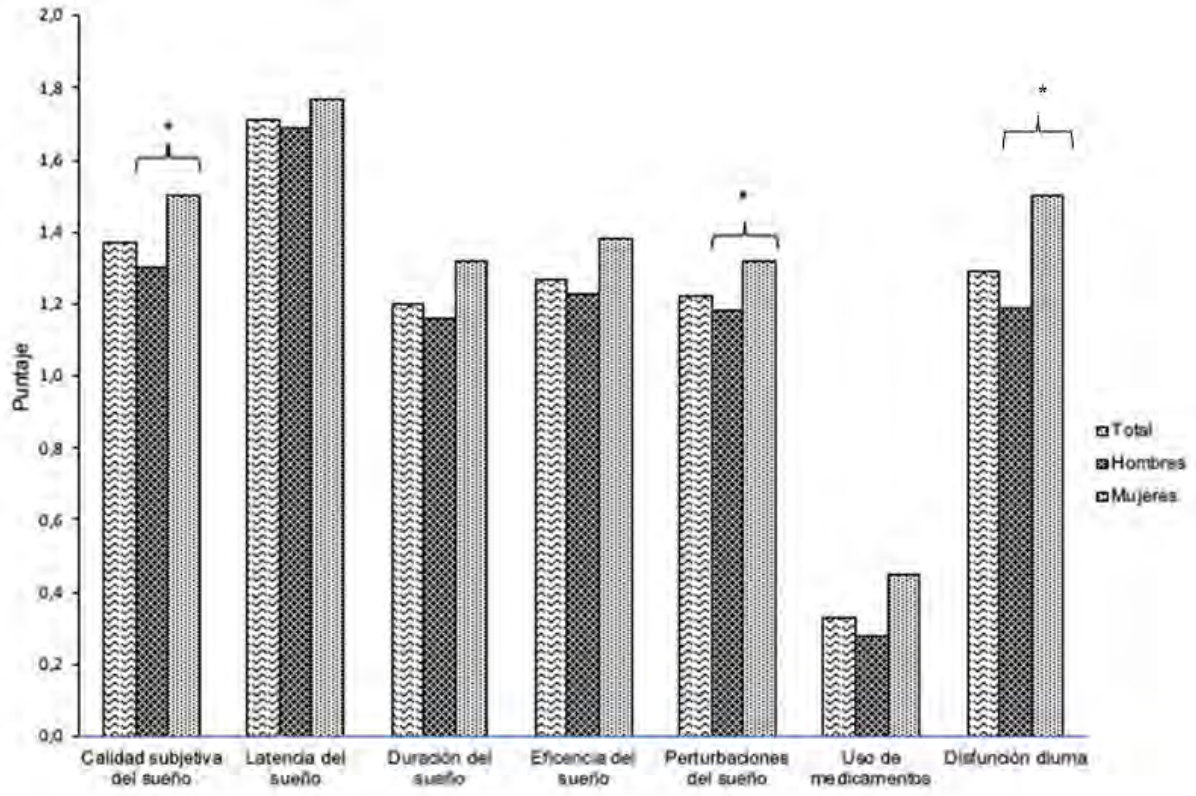
	Total N = 278	Hombres n = 202	Mujeres n = 72	p-valor
Rendimiento Académico				
Promedio Anual, media (*DE*)	5.8 (0.6)	5.7 (0.6)	6.0 (0.6)	< .001
% Aprobación asignaturas, media (*DE*)	98.0 (8.5)	97.9 (8.1)	98.4 (9.3)	.337
Actividad Física				
Total, *MET*s semana, media (*DE*)	3584.4 (2687.7)	3697.6 (2771.1)	3282.8 (2444.0)	.226
Nivel de Actividad Física, *IPAQ*				.020
Alto, %(n)	52.5 (146)	57.4 (116)	39.5 (30)	
Moderado, %(n)	37.4 (104)	32.7 (66)	50.0 (38)	
Bajo, %(n)	10.1(28)	9.9(20)	10.5 (8)	
Calidad del Sueño				
PSQI puntaje, media (*DE*)	8.4 (3.3)	8.0 (3.2)	9.3 (3.4)	.003
Buena calidad del sueño, % (n)	20.5 (57)	23.8 (48)	11.8 (9)	.028
≥ 7 horas de sueño, % (n)	64.0 (178)	64.9 (131)	61.8 (47)	.641

Nota *DE* = Desviación estándar, *IPAQ* = International Physical Activity Quiestionnaire, *PSQI* = Pittsburgh Sleep Quality Index (Índice de calidad del sueño). Buena calidad del sueño: ≤ 5 puntos *PSQI*.

Al considerar cada uno de los componentes de la calidad de sueño por separado, las mayores alteraciones estuvieron en los indicadores de latencia del sueño, seguido de la calidad subjetiva del sueño y disfunción diurna (presencia de somnolencia excesiva), los cuales manifestaron los valores más elevados entre los estudiantes.

Las diferencias entre sexo se presentaron en la calidad subjetiva de sueño (p = .030), perturbaciones del sueño (p = .041), y disfunción diurna (p = .007); concordantemente con peores indicadores para las mujeres, Figura 1.

Figura 1. Análisis de los componentes de la calidad del sueño de los estudiantes



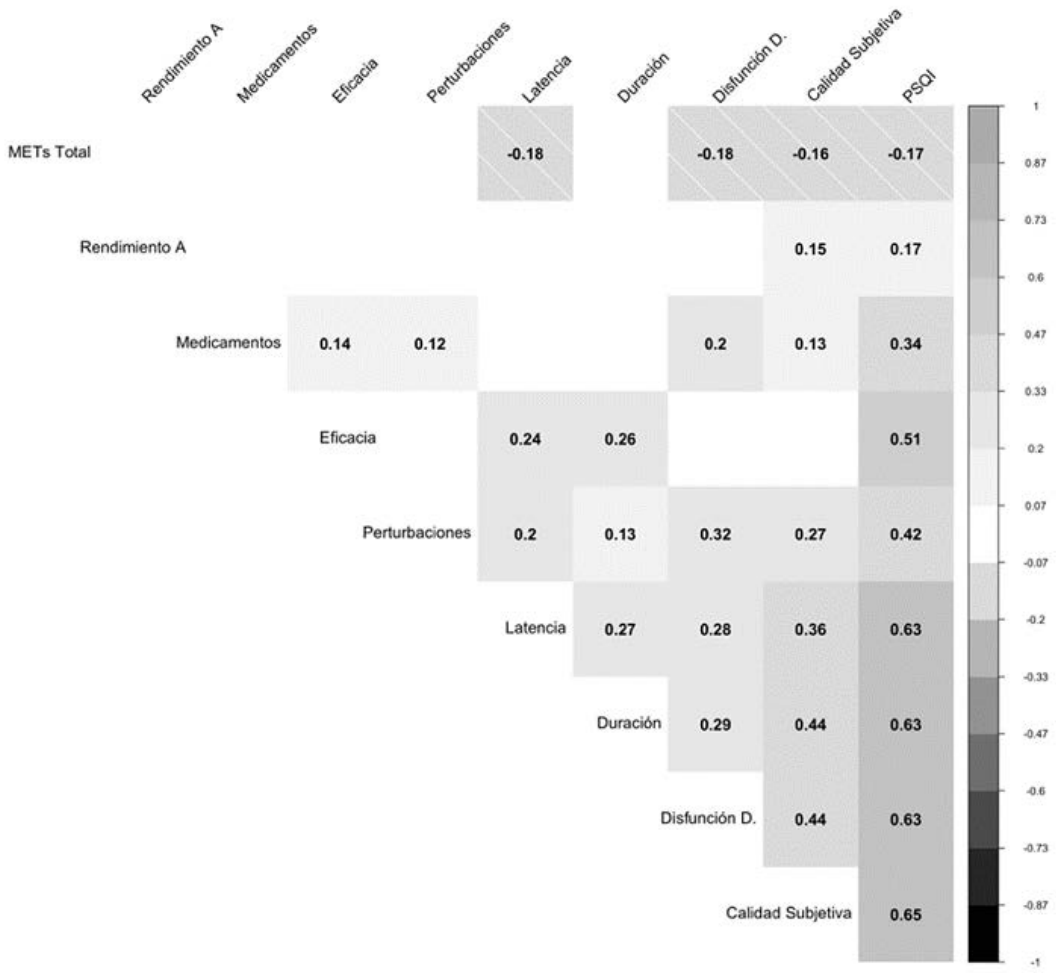
*p < .05

Al analizar la asociación entre el rendimiento académico y la zona geográfica, existieron diferencias significativas, en la cual el promedio anual en Santiago fue de 5.7 ± 0.6 puntos, Talca 5.6 ± 0.5 puntos y Temuco 5.9 ± 0.7 puntos (p = .034), específicamente presentando una diferencia en el rendimiento entre Talca y Temuco (p = .028).

Entre los hábitos de actividad física, consumo de alcohol y tabaco, no existió una asociación con el rendimiento académico, para todos p > .05 (datos no mostrados).

Al analizar el promedio anual y su asociación con el puntaje general de calidad de sueño se encontró una débil correlación positiva (r = .17; p = .005). Al realizar el análisis con cada uno de los componentes, existió solo correlación entre rendimiento académico y la calidad subjetiva del sueño (r = .15; p = .015) (Figura 2). En contraste, para el rendimiento académico y la actividad física realizada en *MET*s/semana, no existió una correlación significativa (r = -.026, p = .663). Los resultados se mantuvieron al analizar la asociación entre rendimiento académico y nivel de actividad física (Bajo: 5.8 ± 0.6 puntos, Medio: 5.8 ± 0.6 puntos, Alto: 5.7 ± 0.7 puntos; p = .395).

Figura 2. Correlación entre rendimiento académico, calidad de sueño y METs de actividad física



Nota *PSQI*: Pittsburgh Sleep Quality Index (Índice de Calidad de Sueño). Se muestran los resultados significativos con valores p < .05 del análisis de correlación de Spearman.

Al analizar el rendimiento académico junto al puntaje general de calidad de sueño, incluyendo el género y de ajuste la zona geográfica, la asociación se pierde (β = 0.014, *IC* 95% -0.008 a 0.036 puntos, p = .222). Finalmente, se analizó el rendimiento académico y el componente de la calidad subjetiva de sueño ajustado por zona geográfica, y co-variable el género. Los resultados manifestaron que las mujeres (β = 0.26, IC 95% 0.10 a 0.42 puntos, p = .002), y aquellos universitarios que presentaron un peor indicador en la calidad subjetiva del sueño (β = 0.11, IC 95% 0.02 a 0.20 puntos; p = .014) presentaron un mejor rendimiento académico anual considerando el contexto por COVID-19 en el año 2020. El promedio académico queda explicado solo en un 7.5% por las variables descritas.

Discusión

El objetivo del estudio fue evaluar la asociación entre rendimiento académico, actividad física y calidad del sueño, y determinar las diferencias según género en estudiantes de Pedagogía en Educación Física durante el periodo de pandemia en el año 2020.

Un empeoramiento en la calidad del sueño se asoció a un mejor rendimiento académico, en contraste, no existió una correlación entre rendimiento académico y actividad física en estudiantes universitarios de Pedagogía en Educación Física durante la pandemia por COVID-19. Nuestros resultados manifiestan que el género femenino, y específicamente un empeoramiento en la calidad subjetiva del sueño se asociaron a un rendimiento académico más elevado durante la pandemia.

Pocos estudios analizan la asociación de estas tres variables. Un estudio desarrollado antes de la pandemia en 219 estudiantes de medicina de Pakistán, encontró que la actividad física (r = .61; p =.003) y una mejor calidad del sueño (r = -.69; p < .001) se asociaron al rendimiento académico (Satti et al., 2019). No obstante, el contexto pandemia, la distribución de género (57% mujeres) y el perfil del nivel de actividad física (Nivel: 16.4% alto, 40.2% bajo) pueden ser la respuesta a las diferencias encontradas con la presente investigación.

Nuestro estudio reportó que solo el 10.5% no cumplió las recomendaciones de actividad física (Nivel bajo), y 52.5% de los universitarios declaró un nivel alto de actividad física durante la pandemia, prevalencia elevada acorde a la población de estudiantes en el área de la actividad física (Farinola, 2011), y cercana al 64% reportado en estudiantes de Suiza mientras estaban en confinamiento (Taeymans et al., 2021). Nuestros resultados también concuerdan con los patrones de actividad física acorde al género (Rodríguez-Larrad et al., 2021), en las mujeres predominó el nivel moderado y en los hombre en el nivel alto de actividad física. Si bien, los valores absolutos de los *MET*s/semana realizados por los estudiantes están dentro de la recomendación para la prevención y beneficios en salud (Kyu et al., 2016) son valores bajos según antecedentes previo a la pandemia en estudiantes de pedagogía en Educación Física (≥ 6.000 *MET*s/semana) (Farinola, 2011). Pese a ello, fueron similar a los *MET*s/semana descritos en estudiantes universitarios de Irlanda (Du et al., 2021), y Suiza durante la pandemia (Taeymans et al., 2021). No encontramos diferencias de género en este aspecto, probablemente las mujeres tuvieron que reducir menos su actividad física respecto a los hombres al ser menos dependientes de las actividades outdoor (Rodríguez-Larrad et al., 2021). Bajo este contexto, no existió asociación entre la actividad física y rendimiento académico en universitarios activos físicamente, posiblemente debido a la homogeneidad en estos datos entre nuestros participantes. La revisión de Wunsch et al. (2021), es consistente con nuestro hallazgo y manifiesta que existió gran heterogeneidad en sus resultados provenientes de cuatro estudios analizados (Wunsch et al., 2021).

Por otra parte, el alto nivel de actividad física durante la pandemia en nuestros universitarios, puede responder a una necesidad de los estudiantes de abarcar todas las exigencias propias de la carga académica, la motivación y auto-determinación para mantener este hábito (Zubiaur et al., 2021), como a su vez una estrategia para disminuir su ansiedad y estrés durante el confinamiento al ser conscientes del beneficio en su salud mental (Martinez et al., 2020; Planchuelo-Gómez et al., 2020). Así también, puede responder a la necesidad de mantenerse activos físicamente, lo cual se refleja en las actividades que de preferencia desarrollaron durante este tiempo, adecuándose a las condiciones y limitaciones de espacio en sus hogares. Situación que va de la mano por lo expuesto por Rodríguez-Larrad et al. (2021) frente a las modificaciones que realizaron los universitarios para mantenerse activos, fue preferir entrenamientos de alta intensidad y corta duración (Rodríguez-Larrad et al., 2021).

En línea con la evidencia, el Índice de calidad del sueño (8.4 *PSQI*), y prevalencia de mala calidad de sueño (79.5%) fueron elevados durante la pandemia por COVID-19 en los universitarios, reflejando una mala higiene del sueño en los estudiantes de Pedagogía en Educación Física. Previamente, Chen Du et al., (2021), en su estudio en 2254 universitarios pertenecientes a China, Irlanda, Malasia, South Corea, Taiwán, Netherlands y Estados Unidos, con 66.6% de participantes mujeres, señaló valores no saludables en la calidad de sueño específicamente entre los estudiantes de Irlanda y USA, ambos con un puntaje de 7.4±3.6 *PSQI* (Du et al., 2021). Otro estudio realizado durante la pandemia en universitarios Españoles, presentó un puntaje de 7.2 ± 3.9 *PSQI*, e indicó que la calidad del sueño empeoró durante la pandemia (Martínez-de-Quel et al., 2021). Paralelo a ello, estudiantes universitarios de Estados Unidos y Europa reportaron peores indicadores saludables (dieta, consumo de alcohol, calidad del sueño y actividad física) respecto a países de Asia durante la pandemia (Du et al., 2021). Sería interesante considerar en las comparaciones a países de Latinoamérica dado los diferentes contextos socioculturales, y tras las altas prevalencias encontradas en la mala calidad del sueño en universitarios chilenos. Una peor calidad del sueño reduce el tiempo de alerta y memoria, el cual esta relacionado con la atención y dificultad en el rendimiento académico. Su efecto negativo sobre la cognición, salud mental pueden influir en un buen desempeño académico en los universitarios a largo plazo (Rathakrishnan et al., 2021).

Un sueño satisfactorio es fundamental para la motivación, atención, y conceptos de memoria (Fernández-Medina et al., 2020). Se ha descrito que quienes reportan una mala calidad de sueño presentan más problemas de disfunción diurna referente a la fatiga, somnolencia, y peor cognición frente aquellos que duermen mejor (Okano et al., 2019). El estudio desarrollado por Gelaye et al. (2014) en una muestra heterogénea de universitarios de distintos países que incluye 880 estudiantes en un contexto pre-pandemia, indicó una excesiva disfunción diurna presente en estudiantes de Perú, Chile y Tailandia (Gelaye et al., 2014). Nuestros resultados presentaron una mayor alteración en la calidad subjetiva del sueño y en la disfunción diurna, lo cual está dentro de lo reportado en estudios pre-pandemia en universitarios (Lemma et al., 2014; MacHado-Duque et al., 2015; Mirghani et al., 2015; Wong et al., 2013).

Concordantemente, estudiantes de Italia presentaron una prevalencia del 73.3% de mala calidad del sueño (Marelli et al., 2021), enfatizando que el periodo de aislamiento impactó más en la calidad de sueño de las mujeres y estudiantes al comparar con trabajadores. Particularmente, en nuestros resultados se observan diferencias significativas según género, asociado a una mayor repercusión en la calidad del sueño durante el confinamiento en las mujeres. Ellas presentaron una mayor alteración en la calidad subjetiva del sueño, perturbaciones del sueño, y disfunción diurna. Estos datos son coherentes con estudios previos en población universitaria (Cellini et al., 2021; de la Portilla Maya et al., 2019; Durán et al., 2017; Fawzy & Hamed, 2017), y consistentes con la evidencias en distintos grupos etarios, en los cuales se reporta una menor calidad del sueño asociada al género femenino, posiblemente debido a diferencias en la arquitectura del sueño en la fase “no-REM” (Mallampalli & Carter, 2014) y a las respuestas fisiológicas generadas a partir del ciclo menstrual (Colten et al., 2006).

Una de las posibles causas de la mala calidad del sueño es un mayor tiempo de exposición a pantallas (Hjetland et al., 2021; Muhammad & Hussain, 2021) y su uso cercano a la hora de acostarse (Guo et al., 2021; Islam et al., 2021). Un mayor tiempo en el uso de dispositivos electrónicos se asocia a un empeoramiento en la calidad del sueño, una latencia del sueño elevada, y hora de levantarse más tarde (Amra et al., 2017; Christensen et al., 2016; El Hangouche et al., 2018). En este aspecto, estudios han reportado un aumento significativo en el uso de pantallas durante la pandemia (Pišot et al., 2020). Específicamente, los estudiantes de Educación Física realizaron sus clases y prácticas en una modalidad principalmente “online”. Estos antecedentes sugieren que los estudiantes experimentaron un aumento en el uso de

dispositivos electrónicos con el propósito de seguir sus actividades académicas sincrónicas (conectados en tiempo real) y asincrónicas (con independencia para estudiar sus diversas materias), lo cual pudo afectar su calidad de sueño en el contexto de pandemia.

Tal vez, otra de las causas puede ser el horario de sueño de los estudiantes durante la pandemia. En nuestro estudio, el horario de sueño de los universitarios fue entre las ~ 3:00 am hasta las ~ 9:00 am. Coherente con los resultados de Csépe et al. (2021) en universitarios, plantea que durante el periodo de confinamiento existió un retraso en el horario para ir a dormir, y mayor flexibilidad en el horario para levantarse, desplazando el cronotipo hacia el vespertino (Csépe et al., 2021; Genta et al., 2021). Por tanto, esta nueva estructura puede provocar, somnolencia, cambios en el ritmo biológico y un empeoramiento en la calidad subjetiva del sueño al reducir la síntesis de melatonina (Ahrberg et al., 2012; Marelli et al., 2021).

Por último, se ha planteado que puede existir una combinación de ansiedad y estrés motivado por la pandemia por COVID-19 que podría ser responsable de los resultados negativos observados en la calidad del sueño (Martínez-de-Quel et al., 2021).

Interesantemente, los resultados mostraron una correlación significativa entre el puntaje *PSQI* y el rendimiento académico, siendo coherente con estudios previos (Ahrberg et al., 2012; Alotaibi et al., 2020; El Hangouche et al., 2018; Fernández-Medina et al., 2020; Rathakrishnan et al., 2021; Satti et al., 2019; Suardiaz-Muro et al., 2020). En contraste, hallamos una débil correlación positiva entre la calidad general del sueño (r = .17; p > .05) y el componente de calidad subjetiva del sueño (r = .15; p = .015) con el promedio anual de calificaciones. Un estudio realizado en estudiantes universitarios de Singapur sobre el sueño, bienestar y rendimiento académico declaró que la disfunción diurna también tuvo una baja correlación con el rendimiento académico (r = -.240; p = .013) (Armand et al., 2021). Sin embargo, la tendencia de los resultados anteriores a la pandemia por COVID-19 muestran una dirección de la asociación que contrasta con los hallazgos de nuestro estudio.

Entre los múltiples factores que se asocian al rendimiento académico se pueden destacar la autoeficacia y la instauración de hábitos de estudio (Kocak et al., 2021). En el contexto de pandemia, la forma de desarrollar las competencias y lograr los desempeños requería permanecer conectado a través de diversos dispositivos electrónicos. Probablemente, los estudiantes con mayor rendimiento académico fueron aquellos que permanecieron más tiempo conectados a dispositivos electrónicos, tal vez, de preferencia en horario vespertino, y afectando en paralelo su calidad de sueño.

Los resultados de la asociación entre rendimiento académico con actividad física y calidad del sueño en población universitaria de pedagogía en Educación Física se deben tomar con precaución, siendo necesarios estudios longitudinales para profundizar en la comprensión de estos factores.

Nuestro trabajo presenta un diseño transversal que no nos permite evaluar el cambio en el rendimiento académico de los estudiantes a consecuencia de la pandemia, ni el impacto de la calidad del sueño y actividad física sobre éste. La baja tasa de respuesta debido a la dificultad de aplicación online y saturación durante la pandemia de los participantes en diferentes actividades a través de medios virtuales, el desbalance por género, y no controlar el tiempo de exposición a pantallas o dispositivos tecnológicos, hacen que nuestros resultados no sean generalizables a otra población.

Las fortalezas del estudio son su carácter multicéntrico, realizado en población universitaria de pedagogía en Educación Física, en población Latinoamericana durante el periodo de COVID-19, y con aplicación de instrumentos validados e internacionalmente utilizados.

Las proyecciones requieren estudios con evaluaciones objetivas de calidad del sueño y actividad física para contrastar los resultados de auto-reporte, inclusión del tiempo de exposición y uso de pantallas, como diseños longitudinales para profundizar en la comprensión de los hallazgos e indicadores de riesgo que presentaron los universitarios para una salud cognitiva, y mental a largo plazo.

Conclusión

El rendimiento académico fue asociado a una peor calidad del sueño entre los universitarios de pedagogía en Educación Física, específicamente relacionado a un empeoramiento en el componente de la calidad subjetiva del sueño. En general, durante la pandemia las mujeres presentaron una peor calidad del sueño y un mejor rendimiento académico respecto a los hombres. La actividad física no se asoció al rendimiento académico. El 90% de los universitarios cumplieron con las recomendaciones de actividad física durante este periodo, los hombres destacaron en el nivel alto y las mujeres en el nivel moderado de actividad física.

Es importante monitorear el comportamiento de estas variables para un entorno de exigencia académica que favorezca los hábitos saludables que repercuten en el bienestar físico y mental de los universitarios a lo largo del proceso, y post pandemia.

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Physical activity and academic performance in people with Trisomy 21. A narrative review

Actividad física y el rendimiento académico en personas con Trisomía 21. Una revisión narrativa

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Short title:
Trisomy 21: physical activity and academic performance

How to cite this article:
Vega-Díaz, M., & González-García, H. (2022). Physical activity and academic performance in people with Trisomy 21. A narrative review. *Cultura Ciencia y Deporte, 17*(53), 133-148. https://doi.org/10.12800/ccd.v17i53.1899

Received: 27 march 2022 / Accepted: 15 june 2022

Abstract

There is an increasing interest in the studies that relate academic performance and physical activity, although most of them do not examine the intellectual disability dimension. The objective of this review is to know the state of art in the literature in relation to down syndrome, physical activity and academic performance. A narrative review was carried out consulting articles located in the databases of Dialnet, Scopus, Google Scholar, Redalyc, ResearchGate and Scielo. The results show that the vital executive functions for high academic performance are altered in people with Trisomy 21 and that exercises where gross motor skills are put into practice manage to enhance them. As conclusions, physical activity decreases the degree of inattention given to irrelevant stimuli and develops memory in people with Down syndrome, but there is no solid evidence that demonstrates its specific and positive action on school grades.

Keywords: physical activity, Trisomy 21, disability, academic performance.

Resumen

Los estudios que relacionan el rendimiento académico y la actividad física están en auge, aunque la mayoría de ellos no abarcan la dimensión discapacidad intelectual. El objetivo de esta revisión es conocer qué suscita la literatura con relación al Síndrome de Down, la actividad física y el rendimiento académico. Se efectuó una revisión narrativa consultando artículos localizados en las bases de Dialnet, Google Scholar, Redalyc, ResearchGate y Scielo. Los resultados demuestran que las funciones ejecutivas vitales para un alto rendimiento académico están alteradas en las personas con Trisomía 21 y que los ejercicios en donde se ponen en práctica las habilidades motrices gruesas logran potenciarlas. Como conclusiones, la actividad física disminuye el grado de inatención prestada ante estímulos irrelevantes y desarrolla la memoria en personas con síndrome de Down, pero no existen evidencias sólidas que demuestren su acción específica y positiva sobre las calificaciones escolares

Palabras clave: actividad física, Trisomía 21, discapacidad, rendimiento académico.

Introduction

Academic performance has always been a topic of great research interest since it is essential to identify the variables that predict educational success (Fajardo et al., 2017). Academic performance is more susceptible to analysis if a reference is made to people with disabilities (Rodríguez, 2015). There is a tendency to conceptualize school performance as a construct, defined mainly by the level of knowledge that a person has, in a subject, and according to their chronological age (González et al., 2012). To objectively quantify school performance, systemic strategies such as evaluation must be used (Lamana-Selva & De-La-Peña, 2018). Likewise, evaluation reflects what the students have learned during their training process (Lamana-Selva & De-La-Peña, 2018).

Among the areas with the highest priority when carrying out an evaluation are linguistic competence (Cejudo et al., 2017) and mathematics (Mello & Hernández, 2019). The evaluation of language (oral and written) is vital, because it is one of the main ways for students to express the knowledge acquired (Ortiz et al., 2020). Therefore, at an educational level, the quantification of the degree to which students receive information (comprehension), expression (use of speech), written language (copying a dictation, legibility in calligraphy and spelling) should not be neglected (Cicres & Llach, 2019; Marcos, 2016). Regarding mathematical competence, academic performance should be evaluated as it is one of the areas where the worst school grades are seen (Mello & Hernández, 2019). In this case, this evaluation is carried out through numerical problems, operations and calculation (Cárdenas, 2018). Bearing this premise in mind, students should always be provided with activities in which to use these arithmetic operations, to develop their creativity (Llamana-Selva & De-La-Peña, 2018).

After having made reference to academic performance and the skills that have the highest priority of being evaluated, it is examined how intellectual disability can affect school success. The term intellectual disability is conceptualized as a significant limitation in cognitive functioning and adaptive behavior (which is expressed in adaptive, conceptual, social and practical skills), and that appears before the age of 18 years old (Cuesta et al., 2019). Directing the spotlight especially on Trisomy 21, commonly referred to as down syndrome, it is a cognitive disability caused by a chromosomal alteration (Díaz-Cuellar et al., 2016; Fernández, 2016).

Intellectual disability does not affect all people with Trisomy 21 in the same way (since there are different degrees of it). Following the DSM-5 criteria, mild, moderate, severe and profound intellectual disability are differentiated (Peredo, 2016). Below are the main characteristics of people with intellectual disabilities depending on their degree of involvement. As such, the criteria of Peredo (2016) are taken into consideration. Beginning with mild intellectual disability, people show some delay in perceptual and motor areas. However, they are quite autonomous when it comes to personal grooming. Also, it is described that this group usually develops sufficient social and communication skills to be able to adapt and integrate into the environment and the workplace. Continuing with moderate intellectual disability, people who present it tend to start speaking significantly late. In addition to this delay in language acquisition, they often show difficulties in expressing and understanding it. As far as autonomy is concerned, they can acquire a certain personal initiative in actions that involve moving around familiar places and routines such as cleaning. From an educational level, they usually have difficulties in subjects and activities that require the use of reading, writing and mathematics. Continuing with severe intellectual disability, this group of people shows a very poor degree of social and personal autonomy. Their psychomotor development and their expressive and comprehensive abilities are highly impaired. In this way, in order to communicate, they usually use an alternative communication system. Finally, people with profound intellectual disabilities are totally dependent when it comes to their routines and personal hygiene. In this sense, their mobility is practically non-existent and they require constant supervision.

Regarding down syndrome, there are individual differences depending on the degree of disability (Esquivel-Herrera, 2015). People with Trisomy 21 are usually found in mild or moderate degrees (Rojas et al., 2016). Regardless of the degree of involvement, there is unanimity that the most affected cognitive processes in this group are information processing, coding, interpretation, elaboration and emission of appropriate responses to environmental situations (Izquierdo, 2015). Furthermore, their limited attention span (by being distracted by irrelevant stimuli) cannot be excluded (Fernández-Olaria, 2018), and memory (difficulties in the tasks of memory consolidation, retrieval and evocation) (Milojevich & Lukowski, 2016).

Besides, some particularities are referred depending on the level of cognitive impairment in Trisomy 21. In line with that, people with mild disability have fewer difficulties in maintaining attention for long periods of time and ignoring irrelevant stimuli than people with moderate disability (Izquierdo, 2015). Despite this, in mild disability distractions are common in which people tend not to differentiate between old and new stimuli. The group with moderate disabilities will experience, in addition to the problems described, difficulties in continuing the activities previously started and carrying out new ones (provided that they require sequencing processes) (Izquierdo, 2015). On the other hand, the inefficiency in the coding processes, interpretation and elaboration of responses in mild disability supposes that these people fail to generalize their learning (Molero & Rivera, 2013). In addition, this group does not have a good capacity for abstraction. This situation is accentuated in people with Trisomy 21 with moderate disability. In addition, they have a limited planning capacity and a high probability of disorientation during the journeys and routes (Gago & Elgier, 2015). Concerning memory, people with mild disabilities have some difficulty processing sensory information and responding accordingly. Similarly, it is complex for them to store information in the short term and spontaneously imagine viable strategies to solve these "dysfunctionalities" (Molero & Rivera, 2013).

Having detailed the disturbances experienced by people with Trisomy 21, it is easy to imagine that they will manifest problems in school success. This happens because attention and memory are superior executive functions essential for high academic performance (López, 2013; Stevens & Bavelier, 2012). In several research projects, a positive relationship has been found between the practice of physical exercise in people with Down syndrome and the improvement of their attention (Maureira & Flores, 2017a; Schott & Holfelder, 2015). Similarly, there is evidence of the correlation between the satisfactory development of gross motor skills and cognitive functions (Schoot & Holfelder, 2015). As a novelty of this work, the action of physical activity on school grades and executive functions that favor school success are examined, specifically focusing on the disability Trisomy 21. Therefore, the objective of this review

is to know what the literature raises in relation to down syndrome, physical activity and academic performance.

Method

The present work consists of a narrative review of the scientific literature on academic performance in people with intellectual disabilities Trisomy 21 and the practice of physical activity. In the search, 58 articles in Spanish, 1 in Portuguese, 1 in Catalan and 20 in English were taken into account. The keywords that structure the conceptual essence of the text are "physical activity", "Trisomy 21", "disability", and "academic performance". Boolean operators "AND", "OR" and quotes have been used. Specifically, the following were used: "physical activity "AND" Trisomy 21", "academic performance "AND" physical activity", "Trisomy 21 "OR" disability" and "physical activity "AND" academic performance in Trisomy 21"

The articles are located in the bases of Dialnet, Google Scholar, Redalyc, ResearchGate and Scielo. An attempt has been made to assess exclusively current articles (publications in the last ten years, that is, since 2012). As exclusion criteria, articles that addressed the topic of practicing physical activity in other syndromes different than Trisomy 21 were eliminated. Also, it was discarded those research in which the study sample were over the age of 20 years old. In addition, the projects that addressed the inclusion of students with different special needs than down síndrome were erased. As inclusion criteria, it was added studies in which academic performance was analyzed in samples of school students with and without Trisomy 21. Finally, it was chosen those research in which the most affected cognitive areas in mild and moderate intellectual disability were examined. (since people with down syndrome are found mostly within these levels).

Trisomy 21: historical perspective and phenotypic aspects

Trisomy 21, commonly known as Down syndrome, is an intellectual disability described by John Langdon Down in 1866 (Fernández, 2016). In 1959, Lejeune, Gautier and Turpin found 47 chromosomes in a culture of fibroblasts in a sample of children with intellectual disabilities (compared to the relevant 46 within a human karyotype) (Díaz-Cuellar et al., 2016). At that time, it was when Trisomy 21 was classified as a chromosomal alteration. Although it mostly occurs due to a trisomy of the Hsa21 chromosome, it can also appear due to chromosomal mosaicism (a chromosome has "normal" cells and Hsa21 cells together; affecting 3% of people with Down syndrome), or due to an unbalanced chromosomal translocation (Díaz-Cuellar et al., 2016).

In the following phrases, will be detailed the main phenotypic features of people with Trisomy 21. Starting with the upper part of the trunk, it is detailed that, in the head, they present mild microcephaly with brachycephaly (Fernández, 2016). The face presents one of the most well-known features by the population, the "almond-shaped" eyes (Contreras et al., 2012). The nose and mouth are small in size, and there is a characteristic lingual protrusion (Vivar et al., 2019). Continuing with the ears, these are also small, have a very folded helix and do not usually have a lobe (Rodríguez et al., 2015). Moving towards the neck, it is usually shorter than the rest of the population (Restrepo et al., 2013). Continuing with the hands and feet, the first ones are small, they present brachydactyly (short metacarpals and phalanges), clinodactyly (crooked fingers) and little development of the middle phalanx of the 5th finger (Vidal et al., 2012). In the foot, there is a cleft between the first and second toes, with an increase in the distance between them (Alarcón & Salcedo, 2012).

Down syndrome and affected cognitive areas

As specified, people with Down syndrome have difficulties in cognitive processes such as processing, coding, interpretation, elaboration and emission of appropriate responses to environmental situations (Izquierdo, 2015). In addition, they experience problems when it comes to generalizing and transferring the learning incorporated (Rojas et al., 2016). Regarding intelligence, a term that is conceptualized as the bio-psychological potential to process information from the cultural environment, and that is useful for solving problems; the group with Trisomy 21 is represented by light or moderate levels (Rojas et al., 2016; Villamizar & Donoso, 2013). Following Gardner's model, there are eight different types of intelligence: musical, logical-mathematical, linguistic-verbal, bodily-kinesthetic, spatial, interpersonal, intrapersonal and naturalistic, and some are more developed than others (Gutiérrez, 2017). Directing the focus of attention to people with Down syndrome, interpersonal and musical intelligence are the most developed, with linguistic-verbal and logical-mathematical being at the opposite pole (Ruíz, 2016). Considering the premise described, it does not seem strange to verify that these people do not understand verbal messages (García, 2017), or are unable to solve calculation problems (Rahmah & Tengku, 2012).

Another area affected in this cognitive disability is attention. It is a neuropsychological function that allows the human being to orient their state of consciousness towards a certain stimulus of reality (Ramos-Galarza et al., 2016). Attention is not a single entity, but rather a multidimensional construct. Therefore, within it, there is focused, sustained, selective, alternating and divided attention (Ramos-Galarza et al., 2016). Focused attention refers to the ability to maintain stable concentration on a stimulus or task (Maureira & Flores, 2017a). This type of attention is practically non-existent in people with Down syndrome (Fernandez-Olaria, 2018). Sustained attention is similar to the previous one (but the attentional focus is maintained for a longer time), during which its levels fluctuate (Chiang et al., 2015; Rivera-Flores & Vera-Álvarez, 2019). Precisely because it is an extension of the focused one, if this was already weak, the sustained one will be even more deficient. Selective attention allows the person to process relevant information from the environment, while suppressing stimuli from another source more irrelevant (Ballesteros, 2014). The ability to inhibit unimportant stimuli is low in people with Down syndrome, so this type of attention will not be very effective (Izquierdo, 2015). Alternating attention implies the possibility of changing the focus of attention from one task to another quickly (Izquierdo, 2015). Divided attention comes into play when people attend to two tasks simultaneously (Maureira & Flores, 2017a). In this sense, divided attention is an extension of the alternant (it was already deficient). Therefore, the divided one will provide even more unsatisfactory results (Izquierdo, 2015).

Finally, memory is mentioned. It is the psychic ability to integrate information from the environment, keep it updated, store it and retrieve it when necessary (Bernabéu, 2017). Following the model of Estudillo (2012), when an external stimulus is perceived, it is retained in sensory memory for a few moments, then it passes to short-term memory and, finally, to long-term memory. Memory is not a unitary system, but there are several types. First, there is sensory memory, which intercepts stimuli from the environment through the senses (Muelas, 2014). Continuing with short-term memory, it stores the

information collected by sensory memory and makes use of learning that is applied in the present moment (Maureira et al., 2015). The ability to process information is practically null in people with down syndrome, so short-term memory will not be highly developed (Izquierdo, 2015). Finally, long-term memory is responsible for consolidating and storing the information learned to retrieve it and use it over time (López et al., 2013). People with Down syndrome have brain alterations that make memory consolidation, recovery and recall difficult (Milojevich & Lukowski, 2016). Within long-term memory, explicit and implicit are differentiated (Izquierdo, 2015). The explicit, in turn, encompasses the episodic and semantic. Episodic memory stores memories, autobiographical events, emotions and personal experiences in their space-time context (Strempler-Rubio et al., 2015). Semantics stores the knowledge of people in the form of words (Navarro et al., 2020). Finally, implicit memory stores knowledge related to motor skills that are acquired with practice, and are automated by repetition (Ramos et al., 2017). This last memory is the one that is better developed in people with Trisomy 21 (Izquierdo, 2015).

Physical activity in Down syndrome and its role on academic performance

The levels of physical activity practice of people with Trisomy 21 were analyzed by multiple research projects (Alghamdi et al., 2021; Barrios et al., 2021; Esposito et al., 2012; Izquierdo-Gómez et al., 2017; Ketcheson et al., 2017; Lama, 2018; Llewellyn, 2016; Matute-Llorente, 2013; Nocera et al., 2018; Oreskovic, 2020; Palma-Mochon, 2020; Pitetti et al., 2013; Shields & Blee, 2012). Several studies verified that there are low levels of physical activity practice among samples with down syndrome (Alghamdi et al., 2021; Esposito et al., 2012; Izquierdo-Gómez et al., 2017). In the study by Alghamdi et al. (2021) carried out with participants between the ages of 3 and 17 years old, it is exposed how families point out as main conditioning factors for the active lifestyles of their children with Trisomy 21 heart problems, obesity, osteoporosis and muscle weakness. This same study shows that another barrier to the practice of physical activity among the group with Down syndrome is the absence of specialists who know how to adapt the exercises to their needs. Also, it is alleged that people with Trisomy 21 often get bored when doing sports and dancing (Alghamdi et al., 2021). In the work of Esposito et al. (2012) carried out with a sample of people with Down syndrome aged between 11 and 20 years old, it was verified that the general tendency toward the practice of physical activity decreases as adolescents get older. In this way, the students with 14 or 15 years old were significantly more sedentary than their peer group with 12 and 13 years old. In addition to less practice of exercise, its intensity also decreases. In this way, the age group of 14 and 15 years old performed less moderate-vigorous physical activity than children aged 8-9 years old and 10 and 11. Finally, in the study by Izquierdo-Gómez et al. (2017) carried out with people between 11 and 20 years old, a significant difference was found in the intensity of physical activity based on gender. Thus, males performed a higher degree of vigorous physical activity compared to female samples.

People with down syndrome have anatomical, physiological, cognitive and psychosocial attributes that predispose them to experience limitations in their physical condition (Pitelli et al., 2013). The situation described leads this group, as specified, to practice low levels of physical activity (Alghamdi et al., 2021; Fernández, 2017; Ketcheson et al., 2017; Matute-Llorente et al., 2013; Shields & Blee, 2012). The adoption of mostly inactive lifestyles by those who manifest this disability means that they fail to benefit from the improvements that exercise provides, such as the reduction in the risk of obesity (Izquierdo-Gómez & Díaz-Cueto, 2017; Ketcheson et al., 2017) and the increase in cognitive functions (fundamental for academic success) (Nocera et al., 2018).

As specified, academic performance is a widely studied construct in the research literature (especially in regard to subjects such as mathematics and language) (González-Valenzuela & Martín-Ruíz, 2019; Mello & Hernández, 2019). However, there are not many studies that specifically address the relationship between cognitive functions and exercise practice in samples with Trisomy 21 (El-Hady et al., 2018; Schott & Holfelder, 2015). The few articles that have really addressed this issue have found that there is a slightly positive correlation between motor control and cognitive ability (Malak et al., 2013; Schott & Holfelder, 2015). Jurgen et al. (2022) determined that there was a positive relationship between the practice of physical activity and academic performance in a sample of children with Trisomy 21 whose ages were between 5 and 6 years old. Another conclusion of this study was that motor activities improved processing speed. A possible explanation for these findings is that physical activity enhances the functions of the cerebellum, an organ involved in motor control and executive functions (planning) (Jürgen et al., 2022). However, the insufficient sense of balance of these children was correlated with difficulties in mental flexibility. Finally, reference is made to the research by Schott and Holfelder (2015), whose authors found that children with Down syndrome who exercised were able to suppress responses to distracting stimuli to a greater extent.

In the following lines, it will be referenced other works in which the role of physical activity on school performance was examined, but in people without down syndrome (in order to establish a comparison between people with and without disabilities) (Carriedo & González, 2019; Faught et al., 2017; Oliveira et al., 2017). In some projects, positive results were obtained regarding the action of the exercise on said performance (Haapala et al., 2018; Oliveira et al., 2017). However, in other studies, no significant differences were found in school grades between sports practitioners and inactive people (Torbeyns et al., 2017). In a study by Oliveira et al. (2017), who worked with 640 students aged 10 to 18 years old during an academic year. The results showed that the most active sample was the one that obtained the best grades in the language subject (Oliveira et al., 2017). Apart from the subjects where linguistic competence is addressed, those that deal with mathematical operations do not usually predict high academic performance (Mello & Hernández, 2019). Haapala et al. (2018), evaluated the relationship between physical activity and the scores obtained in mathematics and language, in 158 students aged 6-8 years old during an academic year. The results showed a positive relationship between the practice of moderate-vigorous physical activity and reading fluency. However, no significant improvements were obtained in the mathematical domain (Haapala et al., 2018). Other researchers who studied the role of sport on arithmetic calculation (and languages), were Resaland et al. (2016). In this case, 1129 students aged 10 and 11 from 57 schools were selected and significant differences were found in the improvement of mathematical operations (Resaland et al., 2016). Despite this, there are also studies where no differences were found between the levels of physical exercise practice and academic performance. In the work of Torbeyns et al. (2017), who worked with a sample of 44 students of 3rd and 4th grade (between 8 and 10 years old, respectively) for 5 months, concluded that no improvement was obtained in any academic discipline in physical activity practitioners.

Finally, it is described that, in cases where academic progress is observed, perhaps it can be explained because exercise improves cognitive functions and increases brain activity (Maureira & Flores, 2017a). More specifically, physical activity favors the ability to maintain selective and divided attention (Maureira & Flores, 2017b). In addition, it also enhances short-term memory (Hawkes et al., 2014; Maureira et al., 2015).

Importance of the students inclusión in the ordinary classroom and in the subject of Physical Education

Some variables negatively influence the inclusion of students with down syndrome in ordinary centers (Ortiz & Reinosa, 2021). Among them, there are the insufficient awareness of families with children without disabilities, the scarce existence of specialized personnel in the centers of this modality (Fernández, 2017) and the bullying of the peer group (Ortiz & Reinosa, 2021). The mothers and fathers of children with Trisomy 21 must assume a socially and politically active role, in which they claim the right of their children to share schooling with those who do not have disabilities (in an inclusive manner and all subjects) (Fernández, 2017). The previous premise is supported by Ortiz and Reinosa (2021), who found that children with down syndrome aged between 2 and 5 years old schooled under an ordinary inclusive regime, experienced improvements in cognition. Specifically, in the aforementioned sample with disabilities, reasoning ability, logical thinking, and creative thinking were enhanced (they were able to learn to discern between what is real and what was imaginary), and short-term memory was improved (they were able to remember names, people, details, facts and places) and attention. This situation was maximized because both, the sample with intellectual disability and the children without it, developed homogeneous school tasks (Ortiz & Reinosa, 2021). In addition, when teachers proposed playful dynamics within the ordinary classroom, students with Down syndrome improved their ability to adapt to the rules of the games (Ortiz & Reinosa, 2021). In works such as those by Pereira-Silva et al. (2018) an improvement in the ability to concentrate and in the behavioral pattern of children with Down syndrome schooled under an ordinary regimen was observed. Other studies emphasize that, under this modality, students manage to improve their skills for active social participation and autonomously (Dessen & Poland, 2014).

With special emphasis on the subject of Physical Education, the literature reveals that the participation of students with Trisomy 21 in this subject provides social benefits, improves their integration and favors the development of moral values (Fernández, 2016; Tanure & Duarte, 2012). In the study by Tanure and Duarte (2012) it is stated that students with Down syndrome did not show interest in interacting with their peers in free time (recess). In this playful time interval, the children with this disability limited themselves to observing how their classmates played. However, the approach of cooperative activities in school physical education facilitated the interrelation and their social integration in the group-class (Tanure & Duarte, 2012). In other works, it was found that educational sport helped the classmates of children with this type of disability to acquire values of tolerance and respect towards them (Fernández, 2016). In addition, physical education promotes the ability to solve problems through motor skills (Fernández, 2016; Pelegrín et al., 2020).

Conclusions

After reviewing the literature, the following conclusions can be drawn. On the one hand, the existence of unanimity of criteria that show alterations in some superior executive functions in the population with Down syndrome (attention and memory). These limitations favor poor school performance. On the other hand, it can be concluded that attention and cognitive functions can improve with the practice of exercise. However, at the school level, no evidence was found that affirms that active lifestyles necessarily provide improvements in school grades in samples with Trisomy 21 disability.

Regarding the significance of the study, this work is useful to publicize the importance of practicing exercise in the group with Down syndrome. This happens because, if there is evidence that, at least, physical activity increases the attention span of these people and stimulates their cognitive processes. Due to this, it could be recommended that, in the matter of school physical education, betting on the implementation of exercises where people with Down Syndrome can make use of their gross motor skills (running, dragging, dancing or climbing). This simple practice could help people with Trisomy 21 automate repeated sequences of actions (improving procedural memory) and also increase their ability to concentrate. Similarly, cognitive flexibility will allow them to quickly shift their focus of attention from one activity to another (improving shifting attention). Finally, inhibitory self-control will help them ignore irrelevant stimuli by curbing their high degree of impulsivity (increasing focused and sustained attention).

Continuing with the limitations of the present study, the difficulty in finding research works focused exclusively on people with Down syndrome, where the studied variables are examined together, should be mentioned. Therefore, it is suggested that other investigations continue working on this line of research. As future lines of research, it could be examined if the exercise produces advantages on the executive functions of planning, cognitive flexibility and inhibitory self-control. Planning supposes the possibility of mentally anticipating the correct way to execute a task or achieve a certain goal. Cognitive flexibility refers to the brain's ability to adapt behavior to changing situations. Lastly, inhibitory self-control is the human ability to inhibit impulsive behaviors. If physical activity exerts a positive action on these higher functions, people with Trisomy 21 will be able to plan the steps to follow during the completion of a calculation problem with greater success (increasing academic performance in mathematical competence). Similarly, cognitive flexibility will allow them to quickly shift their focus of attention from one activity to another (improving shifting attention). Finally, inhibitory self-control will help them ignore irrelevant stimuli by curbing their high degree of impulsivity (increasing focused and sustained attention).

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Actividad física y el rendimiento académico en personas con Trisomía 21. Una revisión narrativa

Physical activity and academic performance in people with Trisomy 21. A narrative review

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Título abreviado:
Trisomía 21: actividad física y rendimiento académico

Cómo citar el artículo::
Vega-Díaz, M., & González-García, H. (2022). Actividad física y el rendimiento académico en personas con Trisomía 21. Una revisión narrativa. *Cultura Ciencia y Deporte, 17*(53), 133-148. https://doi.org/10.12800/ccd.v17i53.1899

Recibido: 27 marzo 2022 / Aceptado: 15 junio 2022

Resumen

Los estudios que relacionan el rendimiento académico y la actividad física están en auge, aunque la mayoría de ellos no abarcan la dimensión discapacidad intelectual. El objetivo de esta revisión es conocer qué suscita la literatura con relación al Síndrome de Down, la actividad física y el rendimiento académico. Se efectuó una revisión narrativa consultando artículos localizados en las bases de Dialnet, Google Scholar, Redalyc, ResearchGate y Scielo. Los resultados demuestran que las funciones ejecutivas vitales para un alto rendimiento académico están alteradas en las personas con Trisomía 21 y que los ejercicios en donde se ponen en práctica las habilidades motrices gruesas logran potenciarlas. Como conclusiones, la actividad física disminuye el grado de inatención prestada ante estímulos irrelevantes y desarrolla la memoria en personas con síndrome de Down, pero no existen evidencias sólidas que demuestren su acción específica y positiva sobre las calificaciones escolares.

Palabras clave: actividad física, Trisomía 21, discapacidad, rendimiento académico.

Abstract

There is an increasing interest in the studies that relate academic performance and physical activity, although most of them do not examine the intellectual disability dimension. The objective of this review is to know the state of art in the literature in relation to down syndrome, physical activity and academic performance. A narrative review was carried out consulting articles located in the databases of Dialnet, Scopus, Google Scholar, Redalyc, ResearchGate and Scielo. The results show that the vital executive functions for high academic performance are altered in people with Trisomy 21 and that exercises where gross motor skills are put into practice manage to enhance them. As conclusions, physical activity decreases the degree of inattention given to irrelevant stimuli and develops memory in people with Down syndrome, but there is no solid evidence that demonstrates its specific and positive action on school grades.

Keywords: activity, Trisomy 21, disability, academic performance.

Introducción

El rendimiento académico siempre ha sido un tema de gran interés en investigación, ya que es imprescindible identificar las variables que predicen el éxito educativo (Fajardo et al., 2017). Dicho rendimiento, todavía es más susceptible de análisis, si se hace referencia a personas con discapacidad (Rodríguez, 2015). Existe una tendencia a conceptualizar el rendimiento escolar como un constructo, definido principalmente por el nivel de conocimientos que tiene una persona, en una materia, y acorde a su edad cronológica (González et al., 2012). Para cuantificar objetivamente dicho rendimiento escolar, se debe hacer uso de estrategias sistémicas como la evaluación (Lamana-Selva & De-La-Peña, 2018). Esta última, refleja lo que ha aprendido el alumnado durante su proceso formativo (Lamana-Selva & De-La-Peña, 2018).

Entre las áreas con mayor prioridad a la hora de efectuar una evaluación se encuentran la competencia lingüística (Cejudo et al., 2017) y la matemática (Mello & Hernández, 2019). La evaluación del lenguaje (oral y escrito) es vital, porque es una de las vías principales del alumnado para expresar los conocimientos adquiridos (Ortiz et al., 2020). Por lo tanto, a nivel educativo, no debe descuidarse la cuantificación del grado de recepción de información de los estudiantes (comprensión), expresión (uso del habla), el lenguaje escrito (copia de un dictado, legibilidad en caligrafía y ortografía) (Cicres & Llach, 2019; Marcos, 2016). En lo que respecta a la competencia matemática, el rendimiento académico debe evaluarse por ser de las áreas en donde se aprecian peores calificaciones escolares (Mello & Hernández, 2019). En este caso, dicha evaluación, se efectúa a través de problemas numéricos, operaciones y cálculo (Cárdenas, 2018). Teniendo esta premisa presente, siempre se le deben facilitar a los estudiantes actividades en donde utilizar dichas operaciones aritméticas, para desarrollar su creatividad (Llamana-Selva & De-La-Peña, 2018).

Tras haber hecho referencia al rendimiento académico y las competencias que tienen mayor prioridad a la hora ser evaluadas, se examina cómo puede afectar la discapacidad intelectual al éxito escolar. El término discapacidad intelectual se conceptualiza como una limitación significativa en el funcionamiento cognitivo y en la conducta adaptativa (que se expresa en las habilidades adaptativas, conceptuales, sociales y prácticas), y que aparece antes de los 18 años (Cuesta et al., 2019). Dirigiendo el foco de atención especialmente a la Trisomía 21, comúnmente denominada Síndrome de Down, esta se trata de una discapacidad cognitiva originada por una alteración cromosómica (Díaz-Cuellar et al., 2016; Fernández, 2016).

La discapacidad intelectual no afecta de la misma manera a todas las personas con Trisomía 21 (dado que existen diferentes grados de la misma). Siguiendo los criterios del DSM-5, se diferencian la discapacidad intelectual leve, la moderada, la severa y la profunda (Peredo, 2016). A continuación, se exponen las características principales de las personas con discapacidad intelectual dependiendo de su grado de afectación. Para ello, se tienen en consideración los criterios de Peredo (2016). Comenzando con la discapacidad intelectual ligera, las personas que la presentan manifiestan cierto retraso en las áreas perceptivas y motoras. Sin embargo, son bastante autónomas en lo que respecta al aseo personal. Además, se describe que este colectivo suele desarrollar habilidades sociales y comunicativas suficientes para lograr adaptarse e integrarse en el entorno y el ámbito laboral. Siguiendo con discapacidad intelectual moderada, quienes la presentan tienden a empezar a hablar de manera significativamente tardía. Además de este retraso en la adquisición del lenguaje, suelen mostrar dificultades en la expresión y comprensión del mismo. En lo que respecta a la autonomía, pueden adquirir cierta iniciativa personal en acciones que suponen desplazarse por lugares conocidos y rutinas como el aseo. A nivel educativo, suelen tener dificultades en materias y actividades que requieren el uso de la lectura, la escritura y las matemáticas. Continuando con la discapacidad intelectual severa, este colectivo de personas manifiesta un grado de autonomía social y personal muy pobre. Su desarrollo psicomotor y sus habilidades expresivas y comprensivas están altamente deterioradas. De este modo, para poder comunicarse, suelen emplear un sistema alternativo de comunicación. Finalmente, las personas con discapacidad intelectual profunda son totalmente dependientes en lo que concierne a sus rutinas y aseo personal. En este sentido, su movilidad es prácticamente inexistente y requieren de supervisión constante.

En lo que respecta al síndrome de Down, tal y como se precisó, existen diferencias individuales en función del grado de discapacidad (Esquivel-Herrera, 2015). Las personas con Trisomía 21 suelen encontrarse dentro de los grados leve o moderado (Rojas et al., 2016). Independientemente del grado de afectación, existe unanimidad en que los procesos cognitivos más afectados en este colectivo son el procesamiento de la información, la codificación, interpretación, elaboración y emisión de respuestas adecuadas a las situaciones del entorno (Izquierdo, 2015). Además, tampoco se puede excluir su limitada capacidad de atención (al distraerse con estímulos irrelevantes) (Fernández-Olaria, 2018), y memoria (dificultades en las tareas de consolidación, recuperación y evocación memorística) (Milojevich & Lukowski, 2016). Seguidamente, se hace alusión a algunas particularidades en función del nivel de afectación cognitivo en Trisomía 21. Las personas con discapacidad leve presentan menores dificultades para mantener la atención durante largos períodos de tiempo e ignorar los estímulos irrelevantes que las muestras con discapacidad moderada (Izquierdo, 2015). A pesar de ello, en la discapacidad leve son frecuentes las distracciones y dichas personas tienden a no diferenciar entre estímulos antiguos y nuevos. El colectivo con discapacidad moderada experimentará, además de las problemáticas descritas, dificultades para continuar las actividades previamente iniciadas y realizar otras nuevas (siempre que requieran procesos de secuenciación) (Izquierdo, 2015). Por otro lado, la ineficacia en los procesos de codificación, interpretación y elaboración de respuestas en la discapacidad leve supone que estas personas no logran generalizar sus aprendizajes (Molero & Rivera, 2013). Además, dicho colectivo tampoco cuenta con una buena capacidad de abstracción. Esta situación se acentúa en las personas con Trisomía 21 con discapacidad moderada. En este último caso, a mayores, se aprecia una limitada capacidad de planificación y una alta probabilidad de desorientación durante los trayectos y recorridos (Gago & Elgier, 2015). En lo que respecta a la memoria, las personas con discapacidad leve tienen cierta dificultad para procesar la información sensorial y responder acorde a la misma. De igual modo, les es complejo almacenar información a corto plazo e imaginar espontáneamente estrategias viables para solventar estas "disfuncionalidades" (Molero & Rivera, 2013). En el grado moderado, dichas problemáticas aumentan en intensidad, por lo que es especialmente relevante poner en práctica actividades en donde se haga uso de la memoria visual y auditiva (Izquierdo, 2015).

Tras haber detallado las alteraciones que experimentan las personas con Trisomía 21, resulta sencillo imaginar que manifestarán problemas en el éxito escolar. Esto sucede porque la atención y la memoria son funciones ejecutivas superiores esenciales para el alto rendimiento académico (López, 2013; Stevens & Bavelier, 2012). En varios proyectos de investigación se ha encontrado una relación positiva entre la práctica de ejercicio físico en personas con Síndrome de Down y la mejora de su atención (Maureira & Flores, 2017a; Schott & Holfelder, 2015). Del mismo modo, existen evidencias de la correlación entre el satisfactorio desarrollo de las habilidades motrices gruesas y las funciones cognitivas (Schoot & Holfelder, 2015). Como novedad de este trabajo, se examina la acción de la actividad física sobre las calificaciones escolares y las funciones ejecutivas que favorecen el éxito escolar, incidiendo específicamente en la discapacidad Trisomía 21. Por ello, el objetivo de esta revisión es conocer qué suscita la literatura con relación al Síndrome de Down, la actividad física y el rendimiento académico.

Método

El presente trabajo consiste en una revisión narrativa de la literatura científica sobre el rendimiento académico en personas con discapacidad intelectual Trisomía 21 y la práctica de actividad física. En la búsqueda, se han tenido en cuenta 58 artículos en castellano, 1 en portugués, 1 en catalán y 20 en inglés. Las palabras clave que vertebran la esencia conceptual del texto son "actividad física", "Trisomía 21", "discapacidad", y "rendimiento académico". Se han usado operadores boleanos "AND", "OR" y comillas. Concretamente, se usaron: ""physical activity "AND" Trisomy 21", "academic performance "AND" physical activity", "Trisomy 21 "OR" disability" y "physical activity "AND" academic performance in Trisomy 21"

Los artículos se encuentran localizados en las bases de Dialnet, Google Scholar, Redalyc, ResearchGate y Scielo. Se han tratado de valorar exclusivamente artículos de actualidad (publicaciones en los últimos diez años, es decir, desde 2012). Como criterios de exclusión, se eliminaron los artículos que abordaban el tópico de la práctica de actividad física en síndromes distintos al de la Trisomía 21. También se han descartado las investigaciones en donde la muestra de estudio realizada con el colectivo de síndrome de Down se puso en práctica con personas de edades superiores a los 20 años. Además, se ha prescindido de los proyectos en donde se abordaba la inclusión del alumnado con necesidades especiales diferentes a dicha discapacidad. Como criterios de inclusión, se han añadido los trabajos en donde se analizó el rendimiento académico en muestras en edad escolar con y sin Trisomía 21. Finalmente, se han escogido investigaciones en donde se examinaron las áreas cognitivas más afectadas en la discapacidad intelectual leve y moderada (al encontrarse las personas con Síndrome de Down mayoritariamente dentro de estos niveles).

La Trisomía 21: perspectiva histórica y aspectos fenotípicos

La Trisomía 21, comúnmente conocida como síndrome de Down, es una discapacidad intelectual descrita por John Langdon Down en 1866 (Fernández, 2016). En 1959, Lejeune, Gautier y Turpin, hallaron 47 cromosomas en un cultivo de fibroblastos en una muestra de infantes con discapacidad intelectual (frente a los 46 pertinentes dentro de un cariotipo humano) (Díaz-Cuellar et al., 2016). En ese momento, fue cuando se clasificó la Trisomía 21 como una alteración cromosómica. Aunque mayoritariamente ocurre por una trisomía del cromosoma Hsa21, también puede aparecer por mosaicismo cromosómico (un cromosoma presenta conjuntamente células "normales" y células Hsa21; afectando al 3% de las personas con Síndrome de Down), o por una translocación desequilibrada cromosómica (Díaz-Cuellar et al., 2016).

Seguidamente, se describen los principales rasgos fenotípicos de las personas con Trisomía 21. Comenzando por la parte superior del tronco, se detalla que, en la cabeza, presentan microcefalia leve con braquicefalia (Fernández, 2016). La cara alberga uno de los rasgos más conocidos por la población, los ojos "almendrados" (Contreras et al., 2012). La nariz y la boca son de un tamaño pequeño, y existe una protusión lingual característica (Vivar et al., 2019). Continuando con las orejas, estas también son pequeñas, tienen el hélix muy plegado y no suelen presentar lóbulo (Rodríguez et al., 2015). Avanzando hacia el cuello, suele ser más corto que el de la población sin dicha discapacidad (Restrepo et al., 2013). Continuando con las manos y los pies, las primeras son pequeñas, presentan braquidactilia (metacarpianos y falanges cortas), clinodactilia (dedos torcidos) y poco desarrollo de la falange media del 5º dedo (Vidal et al., 2012). En el pie, existe una hendidura entre el primer y segundo dedo, con un aumento de la distancia entre los mismos (Alarcón & Salcedo, 2012).

El síndrome de Down y áreas cognitivas afectadas

Tal y como se precisó, las personas con Síndrome de Down presentan dificultades en los procesos cognitivos tales como el procesamiento, codificación, interpretación, elaboración y emisión de respuestas adecuadas a las situaciones del entorno (Izquierdo, 2015). Además, experimentan problemas a la hora de generalizar y transferir los aprendizajes incorporados (Rojas et al., 2016). En lo que respecta a la inteligencia, término que se conceptualiza como el potencial bio-psicológico para procesar información del ambiente cultural, y que resulta de utilidad para resolver problemas; el colectivo con Trisomía 21 está representado por los niveles ligero o moderado (Rojas et al., 2016; Villamizar & Donoso, 2013). Siguiendo el modelo de Gardner, existen ocho tipos diferentes de inteligencia: musical, lógico-matemática, lingüístico-verbal, corporal-kinestésica, espacial, interpersonal, intrapersonal y naturalista, y unas, están más desarrolladas que otras (Gutiérrez, 2017). Dirigiendo el foco de atención a personas con Síndrome de Down, la inteligencia interpersonal y la musical son las más desarrolladas, encontrándose en el polo opuesto la lingüístico-verbal y la lógico-matemática (Ruíz, 2016). Teniendo en consideración la premisa descrita, no parece extraño comprobar que estas personas no comprendan los mensajes verbales (García, 2017), o no logren resolver los problemas de cálculo (Rahmah & Tengku, 2012).

Otra área afectada en esta discapacidad cognitiva es la atención. Se trata de una función neuropsicológica que permite al ser humano orientar su estado de conciencia hacia un determinado estímulo de la realidad (Ramos-Galarza et al., 2016). La atención no es una entidad única, sino un constructo multidimensional. Por ello, dentro de la misma, existen la atención focalizada, sostenida, selectiva, alternante y dividida (Ramos-Galarza et al., 2016). La atención focalizada se refiere a la capacidad de mantener la concentración estable sobre un estímulo o tarea (Maureira & Flores, 2017a). Este tipo de atención es prácticamente inexistente en personas con Síndrome de Down (Fernández-Olaria, 2018). La atención sostenida es similar a la previa (pero se mantiene el foco atencional durante más tiempo), durante el cual sus niveles fluctúan (Chiang et al., 2015; Rivera-Flores & Vera-Álvarez, 2019). Precisamente, por ser una prolongación de la focalizada, si esta, ya era débil, la sostenida aún será más deficitaria. La atención selectiva permite que la persona

procese la información relevante del entorno, mientras suprime los estímulos de otra fuente más irrelevante (Ballesteros, 2014). La capacidad de inhibir estímulos poco importantes es baja en las personas con Síndrome de Down, por lo que este tipo de atención no será demasiado efectiva (Izquierdo, 2015). La atención alternante, implica la posibilidad de cambiar el foco de atención de una tarea a otra de manera rápida (Izquierdo, 2015). La atención dividida se pone en juego cuando las personas atienden simultáneamente a dos tareas (Maureira & Flores, 2017a). Esta última, es una extensión de la alternante (ya era deficitaria). Por lo tanto, la dividida, proporcionará resultados aún más insatisfactorios (Izquierdo, 2015).

Por último, se hace mención a la memoria. Se trata de la capacidad psíquica de integrar información del entorno, mantenerla actualizada, almacenarla y recuperarla cuando es preciso (Bernabéu, 2017). Siguiendo el modelo de Estudillo (2012), al percibir un estímulo externo, este es retenido en la memoria sensorial durante unos instantes, luego pasa a la memoria a corto plazo y, finalmente, a la memoria a largo plazo. La memoria no es un sistema unitario, sino que existen varios tipos. En primer lugar, se encuentra la memoria sensorial, que intercepta los estímulos del entorno a través de los sentidos (Muelas, 2014). Continuando con la memoria a corto plazo, esta almacena la información recogida por la memoria sensorial y hace uso de los aprendizajes que se aplican en el momento presente (Maureira et al., 2015). La capacidad de procesar información es prácticamente nula en las personas con síndrome de Down, así que la memoria a corto plazo no estará muy desarrollada (Izquierdo, 2015). Finalmente, la memoria a largo plazo se encarga de consolidar y almacenar la información aprendida para recuperarla y usarla con el transcurso del tiempo (López et al., 2013). Las personas con Síndrome de Down presentan alteraciones cerebrales que dificultan la consolidación, recuperación y evocación memorística (Milojevich & Lukowski, 2016). Dentro de la memoria a largo plazo, se diferencian la explícita y la implícita (Izquierdo, 2015). La explícita, a su vez, engloba a la episódica y semántica. La memoria episódica almacena los recuerdos, los acontecimientos autobiográficos, las emociones y las experiencias personales en su contexto espacio-temporal (Strempler-Rubio et al., 2015). La semántica, almacena el conocimiento de las personas en forma de palabras (Navarro et al., 2020). Por último, la memoria implícita, almacena el conocimiento relacionado con las habilidades motoras que se adquieren con la práctica, y se van automatizando por repetición (Ramos et al., 2017). Esta última memoria, es la que está mejor desarrollada en personas con Trisomía 21 (Izquierdo, 2015).

La actividad física en Síndrome de Down y su papel sobre el rendimiento académico

Los niveles de práctica de actividad física de las personas con Trisomía 21 fueron analizados por múltiples proyectos de investigación (Alghamdi et al., 2021; Barrios et al., 2021; Esposito et al., 2012; Izquierdo-Gómez et al., 2017; Ketcheson et al., 2017; Lama, 2018; Llewellyn, 2016; Matute-Llorente, 2013; Nocera et al., 2018; Oreskovic, 2020; Palma-Mochón, 2020; Pitetti et al., 2013; Shields & Blee, 2012). En varios estudios se verificó que existen bajos niveles de práctica de actividad física entre las muestras con síndrome de Down (Alghamdi et al., 2021; Esposito et al., 2012; Izquierdo-Gómez et al., 2017). En el estudio de Alghamdi et al. (2021) realizado con participantes con edades entre los 3 y 17 años se expone como las familias señalan como principales condicionantes para los estilos de vida activos de sus hijos/as con Trisomía 21 las problemáticas cardíacas, la obesidad, osteoporosis y debilidad muscular. En este mismo estudio se manifiesta que otra barrera para la práctica de actividad física entre el colectivo con síndrome de Down es la ausencia de especialistas que conozcan cómo adaptar los ejercicios a sus necesidades. Además, se alega que las personas con Trisomía 21 suelen aburrirse al hacer deporte y bailar (Alghamdi et al., 2021). En el trabajo de Esposito et al. (2012) realizado con una muestra de personas con Síndrome de Down con edades comprendidas entre los 11 y 20 años, se verificó que la tendencia general hacia la práctica de actividad física disminuye a medida que los adolescentes aumentan en edad. De esta manera, los estudiantes con 14 o 15 años eran significativamente más sedentarios que su grupo de compañeros/as con 12 y 13 años. Además de la menor práctica de ejercicio, la intensidad del mismo también desciende. De este modo, el grupo de edad de 14 y 15 años realizaba menos actividad física moderada-vigorosa que los niños/as con 8-9 años y 10 y 11. Por último, en la investigación de Izquierdo-Gómez et al. (2017) realizada con personas entre 11 y 20 años se halló una diferencia significativa en la intensidad de práctica de actividad física en función del género. De este modo, los varones realizaban un mayor grado de actividad física vigorosa frente a las muestras femeninas.

Las personas con síndrome de Down poseen unos atributos anatómicos, fisiológicos, cognitivos y psicosociales que les predisponen a experimentar limitaciones en su condición física (Pitelli et al., 2013). La situación descrita conduce a este colectivo, tal y como se especificó, a la práctica de bajos niveles de actividad física (Alghamdi et al., 2021; Fernández, 2017; Ketcheson et al., 2017; Matute-Llorente et al., 2013; Shields & Blee, 2012). La adopción de estilos de vida mayoritariamente inactivos por quienes manifiestan esta discapacidad supone que no logren beneficiarse de las mejoras que proporciona el ejercicio, como la disminución del riesgo de obesidad (Ketcheson et al., 2017) y el aumento de las funciones cognitivas (fundamentales para el éxito académico) (Nocera et al., 2018).

Tal y como se precisó, el rendimiento académico se trata de un constructo ampliamente estudiado en la literatura de la investigación (sobre todo en lo referido a asignaturas como las matemáticas y lengua) (González-Valenzuela & Martín-Ruíz, 2019; Mello & Hernández, 2019). Sin embargo, no existen demasiados estudios que traten de manera específica la relación entre las funciones cognitivas y la práctica de ejercicio en muestras con Trisomía 21 (El-Hady et al., 2018; Schott & Holfelder, 2015). Las escasas investigaciones que realmente abordaron dicha temática han encontrado que existe una correlación ligeramente positiva entre el control motriz y la capacidad cognitiva (Malak et al., 2013; Schott & Holfelder, 2015). Jürgen et al. (2022) determinaron que existía una relación positiva entre la práctica de actividad física y el rendimiento académico en una muestra de niños con Trisomía 21 cuyas edades estaban comprendidas entre los 5 y 6 años. Otra conclusión de dicho estudio fue que las actividades motrices mejoraban la velocidad de procesamiento. Una posible explicación para estos hallazgos es que la actividad física potencia las funciones del cerebelo, un órgano implicado en el control motor y en las funciones ejecutivas (planificación) (Jürgen et al., 2022). Sin embargo, el insuficiente sentido del equilibrio de estos niños/as se correlacionaba con dificultades en la flexibilización mental. Por último, se hace alusión a la investigación de Schott y Holfelder (2015), cuyos autores encontraron que los niños con síndrome de Down que realizaban ejercicio lograban suprimir en mayor medida las respuestas a estímulos distractores.

Seguidamente, se hace referencia a otros trabajos en donde se examinó el rol de la actividad física sobre

el rendimiento escolar, pero en personas sin dicha discapacidad (con motivo de establecer una comparativa entre personas con discapacidad y sin la misma) (Carriedo & González, 2019; Faught et al., 2017; Oliveira et al., 2017). En algunos proyectos, se obtuvieron resultados positivos en lo que respecta a la acción del ejercicio sobre dicho rendimiento (Haapala et al., 2018; Oliveira et al., 2017). Sin embargo, en otros, no se hallaron diferencias significativas en las calificaciones escolares entre las personas practicantes de deporte y las inactivas (Torbeyns et al., 2017). El primer estudio es el de Oliveira et al. (2017), quienes trabajaron con 640 estudiantes con edades de 10 a 18 años durante un curso académico. Los resultados mostraron que la muestra más activa era la que obtenía mejores calificaciones en la asignatura de lengua (Oliveira et al., 2017). Aparte de las asignaturas en donde se aborda la competencia lingüística, las que tratan operaciones matemáticas tampoco suelen predecir rendimientos académicos altos (Mello & Hernández, 2019). Haapala et al. (2018), evaluaron la relación entre la actividad física y las puntuaciones obtenidas en matemáticas y lenguaje, en 158 estudiantes de 6-8 años durante un año académico. Los resultados mostraron una relación positiva entre la práctica de actividad física moderada-vigorosa y la fluidez lectora. Sin embargo, no se obtuvieron mejoras significativas en el ámbito matemático (Haapala et al., 2018). Otros investigadores que estudiaron el papel del deporte sobre el cálculo aritmético (y los idiomas), fueron Resaland et al. (2016). En este caso, se seleccionaron 1129 alumnos de 10 y 11 años de 57 escuelas y se hallaron diferencias significativas en la mejora de las operaciones matemáticas (Resaland et al., 2016). A pesar de ello, también hay investigaciones en donde no se encontraron diferencias entre los niveles de práctica de ejercicio físico y el rendimiento académico. En el trabajo de Torbeyns et al. (2017), quienes trabajaron con una muestra de 44 alumnos de 3º y 4º de primaria (entre 8 y 10 años respectivamente) durante 5 meses, llegaron a la conclusión de que no se obtenía mejoría en ninguna disciplina académica en los practicantes de actividad física.

Finalmente, se describe que, en los casos en donde se aprecia un progreso académico, tal vez pueda explicarse porque el ejercicio mejora las funciones cognitivas e incrementa la actividad cerebral (Maureira & Flores, 2017a). De manera más concreta, la actividad física favorece la capacidad de mantener la atención selectiva y dividida (Maureira & Flores, 2017b). Además, también potencia la memoria a corto plazo (Hawkes et al., 2014; Maureira et al., 2015).

Importancia de la inclusión del alumnado en el aula ordinaria y en la materia de Educación Física

Existen variables que influyen negativamente sobre la inclusión del alumnado con síndrome de Down en los centros ordinarios (Ortiz & Reinosa, 2021). Entre las mismas, se encuentran la insuficiente concienciación de las familias con hijos/as sin discapacidad, la escasa existencia de personal especializado en los centros de dicha modalidad (Fernández, 2017) y el bullying del grupo de pares (Ortiz & Reinosa, 2021). Es fundamental que las madres y padres de los niños/as con Trisomía 21 asuman un papel social y políticamente activo, en el que revindiquen el derecho de sus hijos/as a compartir la escolaridad con quienes no presentan discapacidad (de manera inclusiva y en todas las materias) (Fernández, 2017). La anterior premisa está apoyada por investigaciones como las de Ortiz y Reinosa (2021), quienes encontraron que los niños/as con Síndrome de Down con edades comprendidas entre los 2 y 5 años escolarizados bajo un régimen inclusivo ordinario, experimentaban mejoras en la cognición. Concretamente, en dicha muestra con discapacidad se potenció la capacidad de razonamiento, el pensamiento lógico, el creativo (lograban aprender a discernir entre lo real y lo imaginario), mejoraba la memoria a corto plazo (conseguían recordar nombres, personas, detalles, hechos y lugares) y la atención. Esta situación se maximizaba porque, tanto la muestra con discapacidad intelectual como los niños/as sin la misma, desarrollaban tareas escolares homogéneas (Ortiz & Reinosa, 2021). Además, cuando los docentes planteaban dinámicas lúdicas dentro del aula ordinaria, los estudiantes con síndrome de Down mejoraban su capacidad de adaptación a las reglas de los juegos (Ortiz & Reinosa, 2021). En trabajos como los de Pereira-Silva et al. (2018) se apreció una mejora en la capacidad de concentración y en el patrón conductual de los niños/as con síndrome de Down escolarizados bajo un régimen ordinario. Otros estudios hacen hincapié en que, bajo dicha modalidad, los estudiantes logran mejorar sus competencias para la participación social activa y de manera autónoma (Dessen & Polonia, 2014).

Haciendo especial hincapié en la materia de Educación Física, la literatura revela que la participación del alumnado con Trisomía 21 en dicha materia proporciona beneficios a nivel social, mejora su integración y favorece el desarrollo de valores morales (Fernández, 2016; Tanure & Duarte, 2012). En el estudio de Tanure y Duarte (2012) se expone que los estudiantes con Síndrome de Down no manifestaban interés en interaccionar con sus coetáneos en los momentos libres (recreo). En ese intervalo de tiempo lúdico, los niños/as con dicha discapacidad se limitaban a observar cómo jugaban sus compañeros/as. Sin embargo, el planteamiento de actividades cooperativas en la educación física escolar facilitaba la interrelación y su integración social en el grupo-clase (Tanure & Duarte, 2012). En otros trabajos se encontró que el deporte educativo ayudaba a que los compañeros/as de niños/as con este tipo de discapacidad adquirieran valores de tolerancia y respeto hacia los mismos/as (Fernández, 2016). Además, la educación física promueve la capacidad de resolver problemas a través de la motricidad (Fernández, 2016; Pelegrín et al., 2020).

Conclusiones

Tras la revisión de la literatura, se pueden extraer las siguientes conclusiones. Por un lado, la existencia de unanimidad de criterios que demuestran alteraciones en algunas funciones ejecutivas superiores en la población con Síndrome de Down (atención y memoria). Estas limitaciones, favorecen un bajo rendimiento escolar. Por otra parte, se puede concluir que la atención y las funciones cognitivas pueden mejorar con la práctica de ejercicio. Sin embargo, a nivel escolar, no se lograron encontrar evidencias que afirmen que los estilos de vida activos proporcionen necesariamente mejoras en las calificaciones escolares en muestras con discapacidad Trisomía 21.

En lo que respecta a la significación del estudio, este trabajo es útil para dar a conocer la importancia de la práctica de ejercicio en el colectivo con Síndrome de Down. Esto sucede porque, si existe evidencia de que, cuanto menos, la actividad física aumenta la capacidad de atención de estas personas y estimula sus procesos cognitivos. Debido a ello, podría ser recomendable que, en la materia de educación física escolar, se apueste por la puesta en práctica de ejercicios en donde las personas con Síndrome de Down puedan hacer uso de sus habilidades motrices gruesas (carrera, arrastre, danza o escalada). Con esta sencilla práctica se podría ayudar a que las personas con Trisomía 21 automaticen secuencias repetidas de acciones (mejorando la memoria

procedimental) y, además, incrementen su capacidad de concentración.

Continuando con las limitaciones del presente estudio, se debe citar la dificultad para encontrar trabajos de investigación focalizados exclusivamente sobre personas con Síndrome de Down, en donde se examinen conjuntamente las variables estudiadas. Por lo tanto, se sugiere que otras investigaciones continúen trabajando sobre esta línea de investigación. Como futuras líneas de investigación, se podría examinar si el ejercicio produce ventajas sobre las funciones ejecutivas de planificación, flexibilidad cognitiva y autocontrol inhibitorio. La planificación supone la posibilidad de anticipar mentalmente la manera correcta de ejecutar una tarea o alcanzar un determinado fin. La flexibilidad cognitiva hace referencia a la capacidad cerebral de adaptar la conducta a situaciones cambiantes. Por último, el autocontrol inhibitorio es la capacidad humana para inhibir comportamientos impulsivos. Si la actividad física ejerce una acción positiva sobre estas funciones superiores, las personas con Trisomía 21 podrán planificar con mayor éxito los pasos a seguir durante la realización de un problema de cálculo (incrementándose el rendimiento académico en la competencia matemática). Del mismo modo, la flexibilidad cognitiva les permitirá cambiar rápidamente el foco de atención de una actividad a otra (mejorando la atención alternante). Por último, el autocontrol inhibitorio les ayudará a ignorar estímulos irrelevantes al frenar su alto grado de impulsividad (incrementándose la atención focalizada y sostenida).

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Perspective on health and backcare in adolescents practicing rhythmic gymnastics and classical dance: a qualitative investigation of multiple cases

Perspectiva sobre la salud y los cuidados de la espalda en adolescentes practicantes de gimnasia rítmica y danza clásica: una investigación cualitativa de casos múltiples

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Short title:
Back health in rhythmic gymnastics and classical dance

How to cite this article:
Ríos-Morales, E., Miñana-Signes, V., & Monfort-Pañego, M. (2021). Perspective on health and backcare in adolescents practicing rhythmic gymnastics and classical dance: a qualitative investigation of multiple cases. *Cultura, Ciencia y Deporte*, 17(53), 149-171. https://doi.org/10.12800/ccd.v17i53.1841

Received: 02 december 2021 / Accepted: 13 may 2022

Abstract

The main objective of this work was to explore the perceptions of high school students and teachers involved in the performing arts (rhythmic gymnastics and classical dance) concerning the health and care of the back. Three adolescents and a high school teacher participated, responding openly to questions through a semi-structured interview. The results showed that the four participants had some episodes of back pain, and three of them experienced LBP throughout their lives, and their perception of this is predominantly negative. They explained that the activity practiced required the development of exercises with continuous trunk extensions and rotations, as well as extreme movements, and awkward and disharmonious postures. The workouts require a high level of demand and the hours of training are very long. In conclusion, participants in performance arts, such as competitive rhythmic gymnastics and professional classical dance, perceive that they require high levels of dedication, which in turn requires extreme mobilization of the spine that could have repercussions on back problems. And for these reasons, they believe that a professional person, specialized in sports or dance, is required to direct this type of activity to avoid back health problems.

Keywords: physical education, back health, perception, survey, qualitative.

Resumen

El objetivo principal de este trabajo fue explorar las percepciones de estudiantes de secundaria y profesoras practicantes de actividades escénicas (gimnasia rítmica y danza clásica) sobre la salud y el cuidado de la espalda. Participaron tres adolescentes y una profesora de secundaria, las cuales respondieron de forma abierta a preguntas a través de una entrevista semiestructurada. Los resultados mostraron que las cuatro participantes tuvieron algún episodio de dolor de espalda y tres de ellas DLI a lo largo de sus vidas y su percepción sobre este es predominantemente negativo. Explicaron que la actividad practicada requería el desarrollo de ejercicios con continuas extensiones y rotaciones de tronco, así como buscar movimientos extremos, posturas viciosas y disarmónicas. Los entrenamientos requieren un alto nivel de exigencia y las horas de entrenamientos son muy elevadas. En conclusión, las participantes en actividades escénicas como la gimnasia rítmica competitiva y la danza clásica profesional perciben que requieren una alta dedicación, que dichas actividades a su vez requieren una extrema movilización de la columna vertebral que podría repercutir en problemas de la espalda. Y que por esas razones creen que se requiere a una persona profesional de la especialidad deportiva o danza para dirigir este tipo de actividades para evitar problemas de salud de la espalda.

Palabras clave: educación física, salud de la espalda, percepción, encuesta, cualitativa.

Introduction

Back pain affects all ages, all peoples, in all geographical areas (James et al., 2018). This study, despite the fact that information was collected on back pain (pain in the lower back, dorsal and cervical areas), focuses on the most common back pain, that is, non-specific low back pain (LBP) whose causes remain uncertain and probably unspecific (Buchbinder et al., 2020).

Etymologically, the term low back pain derives from the Latin "lumbus", "loin, lumbar area", and the Greek "algia", "pain", meaning "pain (myalgia or neuralgia) in the loins or in the lumbar region" (Gabaudan, 2011). Nonspecific low back pain is defined as pain located between the lower limit of the ribs and the lower limit of the buttocks, and its intensity depends on posture and physical activity. It is also usually accompanied by painful limitations of movement and may be associated with referred or radiating pain (Kovacs et al., 2006). In the past, LBP was attributed to underlying diseases (Cardon & Balague, 2004), as well as alterations in the statics or dynamics of the spine, such as spondylosis, spondylolisthesis or scoliosis, or disc or facet lesions, such as disc or facet degeneration. However, these things are observed just as frequently among healthy people as among subjects with pain (Latorre et al., 2008). For this reason, LBP is currently specified as all pain located in the reference area, and it is implied that it is not attributable to known specific pathologies, such as infections, tumours, osteoporosis, fractures, structural deformations, inflammatory disorders, etc. et al., 2012).

This type of symptom is also observed in adolescents due to different modifiable factors such as sedentary activities, the level of physical activity, the loads carried daily and psychosocial factors, among others (Calvo-Muñoz et al., 2018; Trevelyan & Legg, 2006). All these risk indicators mean that the prevalence in this group of the population is very high (Minghelli, 2020) ranging between 7 and 72% according to some authors (Jeffries et al., 2007).

As mentioned, the level of physical activity is considered one of the many risk factors for back pain (Franz et al., 2017) and specifically, the practice of competitive sports, such as rhythmic gymnastics (Kruse & Lemmen, 2009) or activities such as classical dance (McMeeken et al., 2002).

The Royal Spanish Federation of Gymnastics describes seven specialties: artistic, rhythmic, trampoline, aerobic, acrobatic, gymnastics for all and parkour. Three of these (artistic, rhythmic and trampoline) are Olympic sports. Rhythmic gymnastics includes ballet and modern dance set to music while performing complex techniques with hoops, balls, clubs, ribbons or ropes. Scores for each exercise involve a series of motor skills and physical capabilities based on a combination of jumps, balances, turns and flexibility (d'Hemecourt & Luke, 2012). For its part, ballet, or classical dance, is a form of physical activity in which repetitive and extreme movements are performed that apply force especially to the lower limbs and spine. It is characterized by complete control of the body and each of its parts (Vidal-Rubio & da Cuña-Carrera, 2016). These two activities constitute the group of physical-sport activities which are those most practiced by adolescents and women in Spain (Martin et al., 2009).

Gymnastics routines are complex, with repetitive directional movements that put pressure on the spine (d'Hemecourt & Luke, 2012). Gymnastics requires extreme flexion and extension of the spine, as well as jumping and lifting loads that increase back pain (Sweeney et al., 2019). Specifically, repeated hyperextension and rotational forces predispose gymnasts to spondylolysis or spondylolisthesis (Kruse & Lemmen, 2009). For these reasons, gymnasts may be at increased risk of low back injuries due to the excessive forces applied to the spine during some of the movements in the sport (Purcell & Micheli, 2009).

Classical dance requires repetitive mechanical stress on physiological structures, such as stretching exercises that promote extreme ranges of motion. Very complicated coordinated movements are also practiced which, carried out at high speed, could affect parts of the body that are sensitive to the aging process of young people, altering the morphology of ligaments and vertebrae during growth. These repetitive stresses can also affect the systems controlling the development of spinal curvatures (Moller & Masharawi, 2011). Among the most relevant positions that can influence the appearance of back pain, we highlight those in which lumbar extensions appears arabesques and cambres combined with dehors. Dancers can also suffer from other ailments, such as neck pain (including headaches) and back pain (Lozano et al., 2008).

As Andújar and Santonja (1996) explain, there are differences between correct posture and poor posture.

> Correct posture is anyone that does not overload the spine or any other element of the musculoskeletal system» and poor posture «that posture which overloads the bones, tendons, muscular, vascular structures, etc., permanently wearing down the body, in one or more of its elements, especially affecting the spine.

Based on these arguments, the following research questions were raised: how have the participants bodies reacted vis-a-vis the practice of rhythmic gymnastics and classical dance? What role has back pain played in their lives as athletes, and in their lives as high school students? How have they managed LBP if they have experienced it? And what role has Physical Education, as a school subject, played in their way of seeing sport and its relationship their bodies?

Taking this problem into account, it is interesting to be able to use a qualitative study methodology in which information can be collected and delved into to get a better understanding of the perspective that adolescents, who practice sports activities at a competitive level, have on health and back care. Their perception and experience can be used to prevent future undesirable situations in the practice of these activities. For the design and elaboration of more specific educational interventions on health and back care in the school context, it will be of great help to have personal testimonies from athletes. For these reasons, the main objective of this study was to explore the perceptions that secondary school students, who participate in the performing arts (rhythmic gymnastics and classical dance), have regarding health and back care.

Methodology

Paradigm

The work carried out corresponds to a type of interpretive paradigm, based mainly on qualitative research, understood as "any type of research that produces results that have not been reached by statistical procedures or other types of quantification" (Paz, 2003).

We understand that for the objective presented here, the qualitative perspective is the most appropriate because subjective and intersubjective reality can be approached as legitimate objects of scientific knowledge, although it has already been stated that there is no single way, position

or orientation when carrying out qualitative research (Flick, 2015).

Type of study design

For the development of this work, a cross-sectional, multiple case study design was applied. According to Crowe et al. (2011) the multiple case study approach allows for in-depth, multifaceted explorations of complex problems in their real-life setting.

This type of design was selected because it is appropriate when existing knowledge about the phenomenon is limited (Yin, 2009).

On the other hand, multiple cases are conceived as a more robust and reliable methodological strategy in terms of research than the use of only one case (Mohajan, 2018), because this allows the gathering of empirical evidence and allows the researcher to analyse each case individually, as well as several cases (Gustafson, 2017). This strategy is used to study the differences and similarities between the cases, to predict similar results or predict opposing results (Yin, 2009). For these reasons, we have opted for more than one case and multiple units of analysis (students and teachers).

Multiple case studies can be intrinsic or instrumental. The intrinsic ones refer to learning about a particular case, while the instrumental ones are those in which you have a research question and you need to obtain a general understanding, or you want to have an idea of a problem (Buchanan & Jones, 2010). This study aims to gain a general understanding of back health and care in adolescent rhythmic gymnasts and classical dancers through the use of a series of instrumental case studies.

Participants

The sample (n = 4) was made up of 3 students from a Secondary Education Institute (IES) and an English teacher from the same institute, with the aim of obtaining several points of view. The 3 students were the same age (16 years old). meaning they were in their 1st year of high school, and the participation of the teacher was included because her interview was focused on experiences, perceptions and feelings generated during her adolescence; the teacher was 30 years old at the time of the interview.

The participants in the research were selected by the Physical Education teacher from the IES through a non-probabilistic convenience sampling process to allow a homogeneous sample.

All the participants came from the same geographical area (the city of Valencia). In addition, they had all been involved in rhythmic gymnastics or classical dance since childhood (beginning between the ages of 4 and 8) and had experienced some episodes of back pain and LBP throughout their sports career. Two had done rhythmic gymnastics and the other two participants were classical dancers.

It should be noted that, in order to maintain the anonymity of the 4 people interviewed in this study a code was assigned to each of them, based on the order in which the interviews were conducted: E1 (Interviewee number 1, classical dance), E2 (Interviewee number 2, artistic gymnastics), E3 (Interviewee number 3, classical dance) and E4 (Interviewee number 4, rhythmic gymnastics).

Ethical statement

All the people interviewed participated voluntarily in the study. The centres, the class tutors and the parents were informed in writing about the study and gave their consent. The study was also accepted by the Experimental Research Ethics Committee of the University of Valencia, registration number H1509086047576.

Data Collection

The data was collected electronically through semi-structured interviews during February and March 2021: 2 students on February 15, 1 student on February 16 and the teacher on March 3rd. Each meeting lasted approximately 60 minutes and was subsequently transcribed in order to carry out the pertinent qualitative analysis in a reliable and objective manner. At the beginning of the collection of testimonies, the objectives of the investigation and the commitment concerning confidentiality of the data collected were explained to the interviewees, and permission was requested to record the interviews in order to analyse their content a posteriori.

In relation to back pain or back problems, and especially concerning LBP, these were defined as prevalence throughout life (pain reported from the beginning of their lives until the day of the interview). Although it was proposed to talk about back problems for any region of the spine (lower back, dorsal area or cervical area), the objective of the researchers was to focus on LBP. As explained in the introduction, LBP is the most common and prevalent symptom in the adolescent population.

The value of qualitative data does not depend on the number of people interviewed, but rather on the ability of the researcher to understand a small number of people with particular characteristics (Fontana & James, 2005). In this study, three researchers participated in carrying out the interview: two professors and researchers with more than 10 years' experience who are specialists in the subject, and a postgraduate student with training in research methodology.

Interviews are the most common technique in qualitative research (Silverman, 2019). In these interviews, the aim is to understand the perspectives of the participants, based on their experience, allowing the interviewee to speak freely, without directing their points of view, thus adjusting to the objectives of exploratory and inductive research (Seidman, 2006).

Interviews can be classified as structured, semi-structured or unstructured (Stucky, 2013). Each type of interview has a different purpose. Structured interviews are related to more quantitative studies, since it is intended that the interviewee responds only to closed questions. Unstructured ones allow more in-depth studies and are especially directed towards fundamental research. Semi-structured interviews are the ones most used in qualitative research, and especially in the use of case studies, in order to take advantages of the two previous types. Thus, it is possible to follow a general structure and at the same time allow the possibility of being able to improvise and get away from the script to investigate and help the interviewee to provide better answers (Myers, 2019). This type of interview tries to gather as much information as possible from the participants, but following guidelines that focus on a specific investigation.

The fact of having a structure is due to the need to provide an answer to the research questions formulated. The creation of the script to carry out a semi-structured interview allows the researcher, on the one hand, to guide the interview itself, focusing on the essentials of the study and, on the other hand, it gives the respondents the freedom to respond more broadly to the questions.

The application of qualitative research techniques has been considered opportune because, in general terms,

they provide satisfactory results when studying complex phenomena (Fernandez & Quintero, 2013).

In this way, the semi-structured interviews with the four participants followed the categories and guiding questions shown in Table 1.

With this interview guide, the intention was to maintain an order that could vary depending on the evolution of the conversation. Some concrete and specific questions were formulated to promote a dynamic and fluid meeting. On the other hand, it was considered convenient to formulate an extensive and complementary number of items per category to offer the researchers options to choose the most appropriate items in case some questions did not manage to extract sufficient information from the participants. Thus, when disinterest, ignorance or simply no arguments were detected, new questions were formulated to recover motivation. During the course of the interview, the expert and moderator made sure they showed interest in the answers given and actively listened to the interviewees in order to create a comfortable, friendly atmosphere.

Analysis

As this is a qualitative study based on in-depth interviews, the analysis has been carried out based on the recommendations of García, Gil and Rodríguez (1994). The analysis process was as follows:

1. Separation of units with their own meaning by means of grammatical criteria (for example, a sentence).
2. Data reduction
    a) Categorization: categories and subcategories were established for all those units of meaning that had their own characteristics
    b) Coding: each category was assigned a code in order to make it more visual.
    c) Synthesis and grouping: all meaning units were grouped into the corresponding categories/ subcategories.
3. Development of a conceptual scheme where the meta-categories, categories, subcategories are grouped.
4. Obtaining results: since the data is textual and not numerical, comparison and contextualization have been carried out to obtain results.
5. Process to obtain conclusions.

Table 1. Semistructured interview guide

Categories	Guiding questions
Greeting and explanation of the reason for the study	Report on voluntary participation and record informed consent. Do not start directly with the questions, but first try to create a good relaxed atmosphere.
Introduction	1. What sports do you participate in or did you participate in (artistic gymnastics / rhythmic gymnastics / Dance /etc.)? 2. How many years have you been involved in this discipline, or how many years did you participate in it? 3. Can you briefly tell us about the routine of a person who participates in your discipline?
Lifestyle	1. How is your school day and workload throughout the day? 2. Do you spend many hours sitting at work/in class? And at home? 3. Do you do any type of sport/physical activity in your free time? 4. How many hours do you spend doing sport/physical activity a week? 5. What is your diet throughout the week? 6. How many hours a day do you watch television (TV)/use the computer/mobile?
Back pain: LBP	1. Have you ever suffered from back pain and especially LBP? 2. Since when did you notice LBP? 3. Could you explain what that pain is like? 4. During all the time you have been in pain, has its intensity varied? 5. At what time of day does it hurt the most? 6. What kinds of daily activities bother you the most? 7. Does the sport you practice or practiced cause you or do you think it influenced the LBP?
Feelings generated towards pain	1. How do you feel when you experience LBP? 2. How does this pain affect your academic performance? 3. Do you feel unable to perform daily-life tasks for this reason? 4. Have you started any kind of therapy? (OTHERWISE)→Why do you think it has/has not worked? (Therapies you have done) 5. Do you think there may be other solutions? 6. Do you see yourself in the future/long term with the same limitations caused by pain? Why? 7. How do you think your back problem affects your well-being and the quality of your life today?
Knowledge about back health	1. What degree of back health do you consider you have and why? (Question related to the perception of pain)→What is your perception of your health in general? What about your back specifically? 2. Where did you learn to take care of yourself? Through what methods / therapies? 3. Do you think that well-focused physical activity can be a tool to reduce pain? 4. Has your perception of sport changed due to low back pain? How did you see AF before? And now? (before DLI) 5. Have you worried about "health" before your problems? 6. Do you think you now know more about how to take care of your back? How do you take care of your back today and how has the treatment you evolved?
Sports practice and free time	1. What extracurricular activity/sport do you practice/did you practice in your free time? 2. How do you think this pain affects your sports/music practice? 3. Has it helped you get to know yourself better?
Future perspectives	1. Do you think that your current situation has conditioned and will condition your current and future life? How and why? 2. Have your back problems changed your view of the health potential of activity and physical exercise?

Source: Own elaboration

Results

After analysing all the information provided through the interviews, the following categories were established:

1. Types of workouts.
2. Contributions of sports practice.
3. Daily routines or habits.
4. First episodes of LBP.
5. Causes of LBP.
6. Knowledge about health and back care.
7. Perceptions and feelings when experiencing LBP.
8. Possible solutions to LBP.
9. General health perception.
10. Future perspectives related to LBP.
11. Recommendations to better manage LPB.

Category 1: Types of training.

This category was based on general aspects, related to the day-to-day training of athletes. It subcategorizes, on the one hand, initiating training and, on the other hand, training routines.

Regarding initiating training in their specialty, all the answers indicated that initiation began in stages prior to adolescence: "I started when I was 8-9 years old" (E2); "I started ballet at the age of 4 and continued until I was 21" (E4); "I started at 4 and a half years old, but professionally at 9" (E3).

In the subcategory related to training routines, we found comments in which they described their day-to-day training "The training sessions were almost always the same, beginning with a warm-up, then working on flexibility and finishing with dance" (E2), while others comments analyse the time spent on the modality "he spent more than 15 hours a week" (E4).

Category 2: Contributions of sports practice

In relation to everything that sport or expressive activity has given them, various comments were given. These have

been subcategorized into: contributions at the physical, emotional, values and time levels.

The contributions on a physical level were given by 3 of the 4 students, in comments such as "On a physical level I feel muscular and toned for other things" (E1) or "On a physical level, I guess, being in shape, being active".

The emotional variable appeared in the comments of 2 of the 4 students: "When you don't get something, frustration." (E1); "On an emotional level, when it comes to dancing, I am another person and I express my feelings in any way" (E3).

The subcategory related to values and effort appeared in some comments such as "Above all values as a person, companionship, responsibility, maturity, management of emotions (nerves, frustration, etc.)" (E2); "I usually get what I want. If you work at it, in the end you get it" (E1).

Only one person interviewed considered that time is one of the contributions of ballet: "I always have time for everything. It was one of the things that classical dance gave me" (E4).

Category 3: Daily routines or habits

The category of routines was related to everything that they consider important in their day-to-day life, regardless or not of gymnastics/dance. Therefore, it has been subcategorized into lifestyle and food.

Regarding lifestyle, all the comments, except one, mentioned the lack of time, overwork or lack of sleep: "It takes a lot of effort (the school day). I am used to it because I have been doing it since I was 8 years old" (E1); "I am very busy: I get up, go to class, eat, rest or do homework, go training (all afternoon) and I continue studying" (E2); "I only have (hours of sleep), unfortunately" (E3). Only one student responded from a positive point of view "No (it does not burden me much), because it is something that I like. For me it is not an obligation. It is a way to clear my mind" (E3).

Food is another point where somewhat similar comments were observed. Three of the people interviewed admitted that they had a balanced diet and even a follow-up by an expert in nutrition: "I don't control it as such (food), I don't pay attention to calories because at home I eat a balanced diet" (E1); "Some seasons restricted us a bit (not eating chocolate and things like that). Even so, at home we eat quite a balanced diet" (E2); "Currently, I go to a nutritionist to control my diet and to know the amounts of macronutrients, fruit, vegetables that I should eat" (E3). The teacher interviewed admits that "At that time I didn't eat very well, I ate sweet things. Mothers didn't see this to be as important as they do now" (E4).

Category 4: First episodes of LBP

This category was related, on the one hand, to the lifetime prevalence of LBP. Of the four participants, three (E2, E3 and E4) stated that they had suffered from LBP. For his part, E1 stated that he had only experienced discomfort in the cervical area.

In relation to the date (understood as age) when the pain began, with the initial symptoms, the three female students (E2, E3 and E4) coincided with the onset of pain, more specifically in early adolescence: "Around 1st/2nd ESO" (E1), "It all started at 12 years old" (E2), "5 years ago (that is, at 11 years old)" (E3).

Of the four people interviewed, only one stated that LBP has persisted to the present day and that he/she continues to suffer from it: "Not at the same level as before, but yes. When I sleep badly, or make some effort, I do notice it" (E3). The rest of the participants (E1, E2 and E4) stated that they do not currently have symptoms of back pain, or LBP, and even expressed these perceptions in the past.

The symptoms (duration, intensity, etc.) were explained by the three participants with LBP: "At first, I thought it was soreness, I didn't know what it was. It was something that lasted a couple of days and then it went away" (E2); "I learned to live with low back pain, which I suffered from continuously, although sometimes I noticed it more than others, depending on the intensity of the training sessions" (E3); "The first time I stopped dancing it started to get more serious. But the headaches and neck pain started a little earlier, especially when I reduced the hours of training" (E4).

Category 5: Causes of LBP

The four people interviewed highlighted 5 key aspects that they considered could be related to the LBP: lack of strength, the activity performed, the execution of the movement, stress, or the teacher/coach.

The cause related to the lack of strength was described by a student and the teacher: "As I was exerting myself and my muscles were not "worked" it happened more" (E1), "When I stopped doing ballet (before not because my muscles were strong) my body began to change, causing a pinched nerve and I had a disk problem" (E4).

Two students considered that rhythmic gymnastics/dance (in general) was the trigger for these discomforts: "(I put it down) Sometimes because of dance" (E1), "Obviously I think that it could be the cause (Gymnastics). Rhythmic gymnastics is a sport that seeks extremes, awkward postures and pushing yourself to the limit" (E2).

The execution of some specific movement within the internal logic of dance/gymnastics was another of the key points at the beginning of LBP: "By curving the back (cambré), lumbar extension. Or, if not, the same, but moving the pelvis forward" (E1), "When raising my leg, I needed to rotate it from the hip and not from the knee. When I did this, my knee was inwards (valgus) and my lower back hurt" (E3).

Only one student blames it on stress: "I am also a person who, when stressed a lot, notices that all the discomfort goes to my back, because of my body posture" (I2).

Finally, the influence of the teacher, or coach, is important; according to the teacher interviewed, to prevent LBP: "If you don't have a good teacher, since it is a discipline that handles the body a lot, and if you don't know anatomy, you can end up with many injuries" (E4).

Category 6: Knowledge about health and back care

This category was related to the knowledge that the 4 people interviewed have acquired from the beginning of back pain to the present. Among the knowledge acquired we find muscles, emotions, physical abilities and technique.

The first subcategory was related to the musculature involved. Three of the four people interviewed considered that the muscles are very important to prevent injuries, and how excessive training can have a negative impact on back health: "At least I try to prepare my muscles. I do my back exercises to keep myself straight" (E3), "in rhythmic gymnastics the muscles that stabilize are more extended, they lose that stiffness" (E2).

One of the students commented that she learned to relate the level of pain with her emotions: "I have learned why that pain comes to me: if I am stressed, because of my posture, etc." (E2).

As for the subcategory related to physical abilities, flexibility was one of the aspects which they highlighted, and from which they learned in their career as athletes: "Because with stretching the pain goes away" (E1), "But I also have that flexibility that I think is important" (E3).

Lastly, E4 gave great importance to the technique and execution of the movement and in the interview, she mentioned the knowledge she acquired regarding exercises that can be counterproductive for the back: "there are certain movements that are dangerous. The basic stance can become very forced. It asks you to retrovert your hips and lift your neck, eliminating the two natural curves of the spine".

Category 7: Perceptions and feelings when experiencing LBP

In this category, all the interventions by the interviewees in which they showed their feelings and perceptions towards LBP were grouped. Three of them (E2, E3 and E4) demonstrated predominantly negative and pessimistic feelings.

The first subcategory was related to disability, understood as the situation in which some activities are limited due to physical impediment: "It really is something (Low back pain) that prevents you from doing many things. The fact of sitting for a long time is really annoying. It's harder for you to concentrate" (E2), "It really hasn't been something that has limited me to a normal life, but I did have to give up paddle" (E2), "When I started the competitions, even knowing how to deal with those problems, I spent many hours studying, and there were days that I couldn't study because of headaches" (E4).

The second subcategory was related to the feeling of guilt: "I just thought I had done it wrong, because if I hurt myself, it is because I did that step, that movement wrong" (E1), "At first I never thought about it and I blamed ballet. I had simply done it wrong and had reached a point of no return" (E4).

Another of the subcategories that was analysed in the interviews was that related to frustration as a consequence of LBP: "Frustration was always there, since I could not give 100% of myself" (E4), "Any type of pain reduces your moral. As it caused a headache, it also changed my character: you don't want anyone to look at you, yell at you or talk to you" (E4).

Lastly, acceptance of pain was another subcategory that was seen in some interventions by the students and the teacher: "In the end, the body is very wise and ends up adapting to pain. As right now it is not something that prevents me from following my daily life activities" (E2), "Now it is something I have learned to live with: I need to stretch every day, postural hygiene. I go to the physio from time to time" (E4).

Category 8: Possible Solutions to LBP

This category was linked to all those comments in which possible solutions to back pain were provided: physiotherapist, stretching and mobility, technique, physical exercise and others.

All of them contributed proposals, although each one from a different approach. Two students considered that physiotherapy worked for them in the short term, more specifically manual therapy: "I have gone to physiotherapist very regularly. In itself, I noticed that massage was what worked best for me" (E2), "I had that problem, and I went to the physiotherapist and he solved it for me" (E3).

Stretching and mobility are another important subcategory that the students considered to play a part in the injury: "Because with stretching the pain goes away" (E1), "Stretching and exercises: little egg, Cat-camel, maintaining postures, etc. Especially mobility" (E2), "I think stretching is essential" (E4).

The correct technique for the exercises and even their modification was another key factor that some of the students commented on to solve pain: "I was looking for a solution, I asked how it is done or I adapted it to my body" (E1), "The teacher corrected my technique and the pain has gone." (E3).

Physical exercise was also considered fundamental for back health: "Yes, the physio recommended swimming" (E2), "I think that PE is essential. A professional told me to start going to the gym" (E4), "For me, gaining strength at the upper body level was a discovery" (E4).

Finally, two comments highlighted that the solution could lie in other therapies: "Yes, osteopathy has given me a lot of quality of life" (E4), "As it has been for so long. Apply heat, creams, stretching, sleeping postures" (E2).

Category 9: General health perception

Another category analysed in our study was the perception of general health that the interviewees had. Two students had a positive perception of their health: "I consider myself healthy" (E1), "Globally, I consider myself a healthy person. It is not something that limits my life" (E2). Only E4 considered that during her adolescence she had poor back health: "Terrible (Back health), I studied a lot" (E4).

Category 10: Future perspectives concerning LBP

Future perspectives were subcategorized into optimistic and pessimistic. A student approached her future from a positive point of view "If she had an injury, she would continue dancing" (E3). Another of the students, more specifically the one who suffered from low back pain for a longer period of time (E2), was somewhat more pessimistic: "I think it is going to be something that I am going to have, to a greater or lesser extent, depending on the time. It will be something that is there, but it is not going to limit me".

Category 11: Recommendations to better manage LBP

The final category was related to the advice that the interviewees would give to other colleagues to prevent or improve back-care health. This category was subdivided into external focus and internal focus.

There were two comments addressed to external focus: "Apart from looking for that solution, giving them advice, massaging them, stretching them" (E2), "Pay a lot of attention to people who know, exercises that they tell you" (E1). Comments aimed at the internal focus were mentioned by 2 of the people interviewed, but these were more extensive and detailed: "I would start listening to myself a little earlier. Also, that, when I felt pain not to force myself, he knew when it's time to stop" (E2), "1) Forcing does not mean stressing. 2) Moments of high performance must always be accompanied by knowing how to relax. 3) Take care of your body as if it were a temple" (E4).

Discussion

The aim of the present study was to gain a general understanding of back health and care in adolescent rhythmic gymnasts and classical dancers through the use of a series of instrumental case studies. Within back problems, this was specified in the lumbar region as this is most common and frequent among the population studied.

Prevalence of low back pain in adolescence

Although our study was not an epidemiological study, it should be noted that, of the four people interviewed, three of them suffered some episodes of non-specific low back pain, and one of them explained that he only suffered back pain, but at the cervical level. In addition, it should be noted that the onset of symptoms was around 11-12 years old, with the onset of adolescence, as described in the literature (Leboeuf-Yde & Kyvik, 1998). Therefore, most of the adolescents surveyed experienced back problems, coinciding with the data reflected in the literature regarding the prevalence of LBP among young people (Bento et al., 2020; James et al., 2018; Jeffries et al., 2007).

In relation to the duration of the pain, two of the three participants who reported experiencing LBP indicated that it was recurrent and intermittent. Conventionally, LBP is categorized, from the point of view of its duration, as acute (lasting less than 4 weeks), subacute (lasting between 4 and 12 weeks) and chronic (lasting more than 12 weeks) (Spitzer, Leblanc, & Dupuis, 1987).

Different epidemiological studies established a range of 7-27% of recurrent LBP in the school population (Burton et al., 1996; Harreby et al., 1999; Jones & Macfarlane, 2009; Jones et al., 2004; Vikat et al., 2000). These young people reported a lower quality of life, visited the doctor more frequently and took painkillers (Harreby et al., 1999), as did two of the participants in this study who currently still need a health professional to relieve pain in the lower back (E3 and E4). Furthermore, recurrent LBP during adolescence could be a precursor to chronic LBP in adulthood (Harreby et al., 1995; Salminen et al., 1999).

Back health and sports practice

In our study, four participants were selected who were currently involved in, or had been involved in, rhythmic gymnastics or performance arts, such as classical dance. One of the categories that we considered relevant in our study was the so-called “Causes of LBP”. During the course of the interviews, the participants confirmed that the level of demand and the hours of training were very high: E1 trained 4 days a week, E2 dedicated 12 hours of weekly training spread over 4 days, E3 currently dedicates 3 or 4 hours a day, and E4 trained more than 15 hours a week during adolescence. According to authors such as Kujala et al. (1992) and McMeeken et al. (2002), the fact of practicing an institutionalized sport and dedicating a high training load (understood as hours of practice) can be a risk factor that triggers episodes of low back pain.

Other risk factors that can be seen in our results, and which are in line with the contributions of other authors (Bento et al., 2020; Lynch, Kashikar-Zuck, Goldschneider, & Jones, 2006), are stress or hours a day in a sitting position. None of the people interviewed gave great importance to these factors; however, all of them spent many hours sitting down due to attending school. In addition, they admitted that they led a very busy lifestyle, with a heavy load of weekly activities and responsibilities due to their studies and hard training.

The perception that the four people interviewed had about the causes of low back pain was another of the categories analysed and was closely related to that of other authors. Among them we highlight, firstly, the continuous extensions and rotations of the trunk: all of them confirm, both in rhythmic gymnastics and in dance (although the latter to a lesser extent), that extreme and disharmonious postures are sought, which can have negative repercussions on back health (Cugusi et al., 2020; Hart et al., 2018; Henn et al., 2020; Paxinos et al., 2019; Solomon et al., 2017 ; Sweeney et al., 2019). However, one of the substantial differences between the two disciplines is jumps. Aldazabal (2010) affirms in his study that jumps with previous displacement, very common in rhythmic gymnastics, show a very high impact peak, which can increase the risk of injury for gymnasts. On the contrary, in classical dance the movements are more controlled and there are fewer jumps. In addition, the extensive experience and academic training of dance conservatory teachers provide the students, who must be examined in concepts related to biomechanics, anatomy, physiology, etc., with greater knowledge.

The lack of strength is another intrinsic factor which athletes highlighted as a cause of injuries and back problems, since this physical ability, according to them, is essential to avoid imbalances and hyperlaxity due to the excessive development of flexibility. Flexibility is developed differently in the federative and educational spheres. In the latter, there are fewer sessions, and forced and extreme exercises are not necessary (Ruiz & Minarro, 2020). On the other hand, they considered the role of the coach, or teacher, to avoid injury as crucial, since they are the people in charge of controlling the training loads and techniques. This was reflected in our work and is observed in other qualitative studies (Fawcett et al., 2020). Our results evidenced different perceptions regarding this subcategory: some athletes managed to get over their injury thanks to the instructions of the coach, while others confirmed that this same person had been the main cause of the symptoms.

One of the risk factors in the appearance of low back pain according to Fawcett et al. (2020) is sports equipment; the footwear or the type of flooring used during sporting activities . However, in our results this was not a factor mentioned by the people interviewed.

Future prospects and advice to other colleagues

Regarding the categories related to the perception of back health and future prospects, the students were very optimistic and considered that they were in good health in general. This can be very positive, since the fact of acquiring disruptive or negative behaviours, lack of confidence, worry or lack of control over pain is related to the appearance of low back pain (Lynch et al., 2006).

However, the students, throughout the interviews, stated that they would continue practicing their modality (dance or gymnastics) despite the fact that the injuries or back problems caused by their practice were maintained over time. The reasons they mentioned were: that they really liked the activity they practiced; that they had to live with the pain, or that said injury or symptom was not going to limit them. These contributions coincide with those of authors such as Cogusi et al. (2020), which affirm that the fact of continuing to practice a sport despite an injury or problem can increase its risk and magnitude.

The category related to "advice to other colleagues" are contributions made by the students and that answered the following question: What advice would you give to a training partner to prevent the pain that you are suffering right now? The students mentioned different strategies that were related to the contributions of different authors: the importance of having a good physical activity professional to lead the training sessions/classes (Fawcett et al., 2020) or control of emotions (Bento et al., 2020; Lynch et al., 2006).

Knowledge about back health and its care

Our results showed how knowledge about back health in the four people interviewed was probably somewhat higher than the general adolescent population, who show low levels in reference to these concepts (Monfort-Pañego et

al., 2016, Minana-Signes & Monfort-Panego, 2015; Miñana-Signes et al., 2019). This may be due to both the positive and negative experiences that the students have had regarding their back health throughout their sporting careers. The role of intervention programs in the educational field on back health can be fundamental, especially in the area of physical education, where, in addition to teaching theoretical knowledge, students must be able to put this into practice in their daily lives (Miñana-Signes et al., 2021). However, the results show how, at least in our work, the students and the teacher had not acquired this knowledge from their school, but rather had had to resort to advice from different health professionals to solve the problems. (Physiotherapists, doctors, osteopaths, etc.).

Main limitations

The main limitations have been linked to the search for qualitative scientific literature, since there is little research of this type, especially on back health and education. For this reason, the discussion section has had to resort to other types of studies, especially quantitative ones.

On the other hand, another limitation has been the absence of a control group (which does not show symptoms of back pain or LBP), since this would have allowed us to compare both groups in reference to lifestyles, knowledge about back health, perceptions or feelings.

The sample size was optimal for carrying out a study of multiple cases, but we consider that a greater number of samples could provide much more enriching data and thus draw a greater number of conclusions.

In relation to the questions about the feelings generated towards back pain, it should be noted that there was some complexity in that the participants could describe an adequate analysis of the causes of their back pain without the help of the interviewer. Due to this situation, the researchers thought it convenient not to delve into this variable and limit themselves to finding out if they had experienced any episodes of back pain and especially LBP.

Conclusion

As a main conclusion, it can be said that adolescents participating in performance arts, such as competitive rhythmic gymnastics and professional classical dance, perceive that they require a high level of dedication which can lead to excessive physical exercise. They experienced that these activities in turn require movements and high demands on the spine that could cause problems in this area. For this reason, they consider that the professional person in charge of directing these activities is a key agent to avoid future back health problems. In general, it is recognized that their level of knowledge about health and back care is high due to experience in pain management and consultations with health professionals during their careers as athletes.

As more specific conclusions we can say that:

1. The four participants experienced some episodes of back pain and three of them suffered LBP throughout their lives, caused, according to them, by participation in sporting activities (rhythmic gymnastics and dance).
2. The perception and feelings as a result of LBP were predominantly negative, among which we highlight frustration, incapacitation, guilt and acceptance.
3. They explained that the activity they are / were involved in required the development of exercises with continuous trunk extensions and rotations, as well as extreme movements and awkward postures.
4. In relation to the duration of the training, the participants stated that the level of demand and the hours of training were very high.
5. The experiences they have had throughout their lives in sports and their injuries have allowed them to learn concepts about health and back care independently, or with the help of different health professionals.
6. Linked to the previous conclusion, the interviews do not reflect that the students gained any knowledge about back health through the educational field. This fact must be taken into account by teachers, since all those students who are not involved in sports in their extracurricular day will not receive strategies and methods for the prevention of this common injury.

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Perspectiva sobre la salud y los cuidados de la espalda en adolescentes practicantes de gimnasia rítmica y danza clásica: una investigación cualitativa de casos múltiples

Perspective on health and backcare in adolescents practicing rhythmic gymnastics and classical dance: a qualitative investigation of multiple cases

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Título abreviado:
La salud de la espalda en la gimnasia rítmica y danza clásica

Cómo citar el artículo:
Ríos-Morales, E., Miñana-Signes, V., & Monfort-Pañego, M. (2021). Perspectiva sobre la salud y los cuidados de la espalda en adolescentes practicantes de gimnasia rítmica y danza clásica: una investigación cualitativa de casos múltiples. *Cultura, Ciencia y Deporte, 17*(53), 149-171. https://doi.org/10.12800/ccd.v17i53.1841

Recibido: 02 diciembre 2021 / Aceptado: 13 mayo 2022

Resumen

El objetivo principal de este trabajo fue explorar las percepciones de estudiantes de secundaria y profesoras practicantes de actividades escénicas (gimnasia rítmica y danza clásica) sobre la salud y el cuidado de la espalda. Participaron tres adolescentes y una profesora de secundaria, las cuales respondieron de forma abierta a preguntas a través de una entrevista semiestructurada. Los resultados mostraron que las cuatro participantes tuvieron algún episodio de dolor de espalda y tres de ellas DLI a lo largo de sus vidas y su percepción sobre este es predominantemente negativo. Explicaron que la actividad practicada requería el desarrollo de ejercicios con continuas extensiones y rotaciones de tronco, así como buscar movimientos extremos, posturas viciosas y disarmónicas. Los entrenamientos requieren un alto nivel de exigencia y las horas de entrenamientos son muy elevadas. En conclusión, las participantes en actividades escénicas como la gimnasia rítmica competitiva y la danza clásica profesional perciben que requieren una alta dedicación, que dichas actividades a su vez requieren una extrema movilización de la columna vertebral que podría repercutir en problemas de la espalda. Y que por esas razones creen que se requiere a una persona profesional de la especialidad deportiva o danza para dirigir este tipo de actividades para evitar problemas de salud de la espalda.

Palabras clave: educación física, salud de la espalda, percepción, encuesta, cualitativa.

Abstract

The main objective of this work was to explore the perceptions of high school students and teachers practicing performing activities (rhythmic gymnastics and classical dance) on the health and care of the back. Three adolescents and a high school teacher participated, who responded openly to questions through a semi-structured interview. The results showed that the four participants had some episode of back pain and three of them DLI throughout their lives and their perception of it is predominantly negative. They explained that the activity practiced required the development of exercises with continuous trunk extensions and rotations, as well as seeking extreme movements, vicious and disharmonious postures. The workouts require a high level of demand and the hours of training are very high. In conclusion, participants in stage activities such as competitive rhythmic gymnastics and professional classical dance perceive that they require high dedication, which in turn requires extreme mobilization of the spine that could have repercussions on back problems. And for these reasons they believe that a professional person specialized in sports or dance is required to direct this type of activity to avoid health problems in the back.

Keywords: physical education, back health, perception, survey, qualitative.

Introducción

El dolor de espalda afecta a todas las edades, a todos los pueblos, en todas las áreas geográficas (James et al., 2018). En este estudio, pese a que se recogió información sobre el dolor de espalda (dolores en la zona lumbar, dorsal y cervical), y especialmente se centró en dolores de espalda más comunes, es decir, el dolor lumbar inespecífico (DLI) cuyas causas siguen siendo inciertas y probablemente inespecíficas (Buchbinder et al., 2020).

Etimológicamente, el término lumbalgia deriva del latín "lumbus", "lomo, zona lumbar", y del griego "algia", "dolor", dando como significado "dolor (mialgia o neuralgia) en los lomos o en la zona lumbar" (Gabaudán, 2011). La lumbalgia inespecífica o dolor lumbar inespecífico (DLI) se define como el dolor localizado entre el límite inferior de las costillas y el límite inferior de las nalgas, cuya intensidad varía en función de las posturas y la actividad física, suele acompañarse de limitación dolorosa del movimiento y puede asociarse a dolor referido o irradiado (Kovacs et al., 2006). Antiguamente, el DLI se atribuía a enfermedades subyacentes (Cardon & Balague, 2004), así como a alteraciones de la estática o dinámica de la columna vertebral, como la espondilosis, la espondilolistesis o la escoliosis, o a lesiones discales o facetarías, como la degeneración discal o facetaría. Sin embargo, esas imágenes se observan tan frecuentemente entre los sanos como entre los sujetos con dolor (Latorre, et al., 2008). Por eso, actualmente se especifica que el DLI es todo aquel dolor localizado en la zona de referencia e implica que no sea atribuible a patologías específicas conocidas como infecciones, tumores, osteoporosis, fracturas, deformaciones estructurales, trastorno inflamatorio, etc. (Balague et al., 2012).

Este tipo de síntoma también se observa en adolescentes, debido a diferentes factores modificables como las actividades sedentarias, el nivel de actividad física, las cargas transportadas diariamente y los factores psicosociales entre otros (Calvo-Muñoz et al., 2018; Trevelyan & Legg, 2006). Todos estos indicadores de riesgo hacen que la prevalencia en este grupo poblacional sea muy alta (Minghelli, 2020) oscilando entre un 7 y un 72% según algunos autores (Jeffries et al., 2007).

Como bien se ha comentado, el nivel de actividad física está considerado uno de los múltiples factores de riesgo del dolor de espalda (Franz et al., 2017) y concretamente, la práctica de deportes competitivos tales como la gimnasia rítmica (Kruse & Lemmen, 2009) o actividades como la danza clásica (McMeeken et al., 2002).

La Real Federación Española de Gimnasia describe siete especialidades: artística, rítmica, trampolín, aeróbica, acrobática, para todos y parkour, de las cuales las tres primeras son olímpicas. La gimnasia rítmica incluye ballet y pasos de baile moderno al ritmo de la música mientras se realizan maniobras complejas con aros, pelotas, mazas, cintas y cuerdas. Para la puntuación de cada ejercicio se deben combinar una serie de habilidades motrices y capacidades física basadas en los saltos, equilibrios, giros y flexibilidad (d'Hemecourt & Luke, 2012). Por su parte, El ballet, o danza clásica, es una forma de actividad física en la que se realizan movimientos repetitivos y extremos que aplican fuerza sobre todo a los miembros inferiores y la columna. Se caracteriza por el control completo del cuerpo y de cada una de sus partes (Vidal-Rubio & da Cuña-Carrera, 2016). Estas dos actividades constituyen el grupo de actividades físico-deportivas más practicadas por las adolescentes y mujeres en España (Martin et al., 2009).

Las rutinas de gimnasia son complejas, con movimientos repetitivos direccionales que ejercen presión sobre la columna vertebral (d'Hemecourt & Luke, 2012). La gimnasia requiere una flexión y extensión extremas de la columna, así como saltos y levantamiento de cargas que incrementan el dolor de espalda (Sweeney et al., 2019). Específicamente, la hiperextensión repetida y las fuerzas de rotación predisponen a las gimnastas a la espondilólisis o espondilolistesis (Kruse & Lemmen, 2009). Por estos motivos, los/as gimnastas pueden estar en mayor riesgo de lesiones lumbares debido a las fuerzas excesivas aplicadas columna vertebral durante algunos de los movimientos en el deporte (Purcell & Micheli, 2009).

En la misma línea, la danza clásica requiere de un esfuerzo mecánico repetitivo en estructuras fisiológicas, como la realización de ejercicios de estiramiento que propician un rango de movimiento extremo. También se practican movimientos coordinados muy complicados que, realizados a alta velocidad, podrían afectar a partes del organismo sensibles a la maduración de los/as jóvenes pudiendo alterar la morfología de ligamentos y vértebras durante el crecimiento. Estas tensiones repetitivas también pueden afectar los sistemas controlando el desarrollo de las curvaturas de la columna vertebral (Moller & Masharawi, 2011). Entre las posiciones más destacadas que pueden influir en la aparición de dolor de espalda destacamos aquellas en las que se produce una extensión lumbar: arabesques y cambres combinados en dehors. Las bailarinas también pueden sufrir otras dolencias, tales como las cervicalgias (incluyendo cefaleas) y las dorsalgias (Lozano et al., 2008).

Como explican Andújar y Santonja (1996), hay que diferenciar entre postura correcta y postura viciosa:

> La postura correcta es toda aquella que no sobre carga la columna ni a ningún otro elemento del aparato locomotor» y postura viciosa «la que sobrecarga a las estructuras óseas, tendinosas, musculares, vasculares, etc, desgastando el organismo de manera permanente, en uno o varios de sus elementos, afectando sobre todo a la columna vertebral.

En base a estos argumentos, se plantearon las siguientes preguntas de investigación: ¿cómo han vivido las participantes su relación con su cuerpo en la práctica de gimnasia rítmica y danza clásica?, ¿qué papel ha jugado el dolor de espalda en su vida como deportistas y en su vida como estudiantes de secundaria?, ¿cómo han gestionado o gestionan el DLI en caso de haberlo experimentado?, y ¿qué papel ha tenido la Educación Física como asignatura en su forma de ver el deporte practicado y su relación con su cuerpo?

Teniendo en cuenta esta problemática, resulta interesante poder utilizar una metodología de estudio de tipo cualitativo en el cual se pueda recoger información, profundizar y comprender mejor la perspectiva que tienen las personas adolescentes, que practican actividades deportivas a nivel competitivo, sobre la salud y el cuidado de la espalda. Su percepción y experiencia puede ser aprovechada para prevenir futuras situaciones no deseables en la práctica de estas actividades. Para el diseño y elaboración de intervenciones educativas más específicas sobre la salud de la espalda en el contexto escolar, será de gran ayuda contar con testimonios personales de deportistas. Por estos motivos, el objetivo principal de este trabajo fue explorar las percepciones de estudiantes de secundaria practicantes de actividades escénicas (gimnasia rítmica y danza clásica) sobre la salud y el cuidado de la espalda.

Metodología

Paradigma

El trabajo realizado se corresponde con un tipo de paradigma interpretativo, basado principalmente en la investigación cualitativa, entendida como "cualquier tipo de investigación que produce resultados a los que no se ha llegado por procedimientos estadísticos u otro tipo de cuantificación" (Paz, 2003).

Entendemos que para el objetivo aquí presentado la perspectiva cualitativa es la más adecuada porque se puede abordar la realidad subjetiva e intersubjetiva como objetos legítimos de conocimientos científicos, aunque ya se ha afirmado que no hay una sola forma, posición u orientación de hacer investigación cualitativa (Flick, 2015).

Tipo de diseño de estudio

Para el desarrollo de este trabajo se aplicó un diseño estudio de casos múltiples y transversal. Según Crowe et al. (2011) el enfoque de estudio de casos múltiples permite exploraciones en profundidad y multifacéticas de problemas complejos en su entorno de la vida real.

Se seleccionó este tipo de diseño, por ser adecuado cuando el conocimiento existente sobre el fenómeno es pequeño (Yin, 2009).

Por otro lado, los casos múltiples se conciben como una estrategia metodológica más robusta y fiable en términos de investigación que solo el uso de un caso (Mohajan, 2018), porque permite obtener varias evidencias empíricas y permite al investigador/a analizar en cada caso y en varios casos (Gustafsson, 2017). Esta estrategia se utiliza para estudiar las diferencias y similitudes entre los casos, para predecir resultados similares o predecir resultados opuestos (Yin, 2009). Por estas razones, hemos optado por más de un caso y por múltiples unidades de análisis (estudiantes y docentes).

Los estudios de casos múltiples pueden ser intrínsecos o instrumentales. Los intrínsecos hacen referencia al aprendizaje sobre un caso particular, en cambio, los instrumentales son aquellos en los que se tiene una pregunta de investigación y se necesita obtener una comprensión general o bien se pretende tener una idea de un problema (Buchanan & Jones, 2010). Este estudio tiene como finalidad obtener una comprensión general sobre la salud y los cuidados de la espalda en adolescentes practicantes de gimnasia rítmica y danza clásica mediante el uso de una serie de estudios de casos instrumentales.

Participantes

La muestra (n = 4) estuvo compuesta por 3 estudiantes del Instituto de Educación Secundaria (IES) y una profesora de la asignatura de inglés de este mismo instituto con el objetivo de conseguir varios puntos de vista. Las 3 alumnas tenían la misma edad (16 años) por lo que cursaban 1º de bachillerato, y la participación de la profesora se incluyó porque su entrevista se enfocó en base a las experiencias, percepciones y sentimientos generados durante su adolescencia, dicha profesora tenía 30 años en el momento de ser entrevistada.

Las participantes en la investigación fueron seleccionados por indicación del profesor de Educación Física del IES mediante un proceso de muestreo no probabilístico de conveniencia para permitir una muestra homogénea.

Todas las participantes provenían de la misma zona geográfica (ciudad de Valencia). Además, tenían como característica común la práctica de gimnasia rítmica o la danza clásica desde la infancia (inicios entre los 4 y los 8 años) y la aparición de algún episodio de dolor de espalda y DLI a lo largo de su trayectoria deportiva. Dos practicaron gimnasia rítmica y las otras dos participantes practicaban danza clásica.

Cabe destacar que, para mantener el anonimato de las 4 personas entrevistadas en este trabajo, se asignó un código a cada una de ellas, en función del orden en el que se realizaron las entrevistas: E1 (Entrevistada número 1, danza clásica), E2 (Entrevistada número 2, gimnasia artística), E3 (Entrevistada número 3, danza clásica) y E4 (Entrevistada número 4, gimnasia rítmica).

Declaración ética

Todas las personas entrevistadas participaron voluntariamente en el estudio. La dirección de los centros, los tutores de clase y los padres fueron informados por escrito del estudio y manifestaron su consentimiento. El estudio también fue aceptado por el Comité de Ética en Investigación Experimental de la Universitat de València con el número de registro H1509086047576.

Recogida de datos

Los datos fueron recogidos por medio de entrevistas semiestructuradas durante los meses de febrero y marzo de 2021 de forma telemática: 2 alumnas el 15 de febrero, 1 alumna el 16 de febrero y 1 la docente el 3 de marzo. Cada reunión tuvo una duración aproximada de 60 minutos y posteriormente fueron transcritas de forma escrita para poder realizar el análisis cualitativo pertinente de forma fiable y objetiva. Al comienzo de la recogida de testimonios se expusieron a los entrevistados los objetivos de la investigación, el compromiso de confidencialidad de los datos recogidos, y se solicitó el permiso para grabar las entrevistas con el fin de analizar su contenido a posteriori.

En relación con los dolores o problemas de espalda y en especial el DLI que se recogieron, éstos se definieron como la prevalencia a lo largo de la vida (dolor informado desde el inicio de sus vidas hasta el día de la entrevista). Aunque se planteara hablar sobre los problemas de espalda para cualquier área de la columna (zona lumbar, zona dorsal o zona cervical), los investigadores tenían el objetivo de centrar el tema en el DLI. Como se ha explicado en la introducción el DLI es el síntoma más común y prevalente en la población adolescente.

El valor de los datos cualitativos no depende del número de personas entrevistadas, sino más bien de la capacidad que tiene la persona investigadora para conocer adecuadamente a un pequeño número de personas con unas características particulares (Fontana & James, 2005). En este estudio, se contó con la participación de tres investigadores para llevar a cabo la entrevista: dos profesores e investigadores con más de 10 años de experiencia y especialistas en la temática, y un estudiante de postgrado con formación en la metodología de la investigación.

La entrevista es la técnica más común en la investigación cualitativa (Silverman, 2019). En dichas entrevistas se persigue comprender las perspectivas de las personas participantes, en base a su experiencia, permitiendo a la persona entrevistada hablar libremente, sin direccionar sus puntos de vista, ajustándose así a los objetivos de la investigación exploratoria e inductiva (Seidman, 2006).

Las entrevistas las podemos clasificar en estructuradas, semiestructuradas y no estructuradas (Stuckey, 2013). Cada tipo de entrevista tiene una finalidad diferente. Las entrevistas estructuradas se relacionan con los estudios más de carácter cuantitativo, ya que se pretende que el entrevistado responda solamente a cuestiones cerradas.

Las no estructuradas permiten estudios más profundos y especialmente direccionados para una investigación fundamental. Las entrevistas semiestructuradas son las más utilizadas en la investigación cualitativa, y especialmente en el uso de estudio de casos, para conseguir aprovecharse de las ventajas de los dos tipos anteriores. Así pues, se consigue seguir una estructura general y al mismo tiempo se permite la posibilidad de poder improvisar y salirse del guion para indagar y ayudar al entrevistado/a a contestar mejor (Myers, 2019). Este tipo de entrevistas trata de reunir la mayor cantidad de información de las personas participantes, pero siguiendo unas pautas que permitan centrarse en una investigación concreta.

El hecho de tener una estructura es debido a la necesidad de dar una respuesta a las preguntas de investigación formuladas. La creación del guion para hacer la entrevista semiestructurada permite, por un lado, orientar la entrevista en sí, centrándose en lo esencial del estudio y, por otro lado, se da la libertad a los encuestados para responder de forma más amplia a las cuestiones.

La aplicación de técnicas de investigación cualitativas se ha considerado oportunas porque, en términos generales, aportan resultados satisfactorios cuando se estudian fenómenos complejos (Fernández & Quintero, 2013).

De esta manera, las entrevistas semiestructuradas que se llevaron a cabo con las cuatro participantes siguieron las categorías y preguntas guía que se muestran en la tabla 1.

Con esta guía de la entrevista se pretendió mantener un orden que podía ir variando en función de la evolución de la conversación. Se formularon unas preguntas concretas y específicas para promover una reunión dinámica y fluida. Por otro lado, se creyó conveniente formular un extenso y complementario número de ítems por categoría para ofrecerle opciones a los investigadores de escoger los ítems más convenientes en caso de que algunas preguntas no consiguieran extraer suficiente información a las participantes. Así pues, cuando se detectaba desinterés, desconocimiento o simplemente no se tenían argumentos se formulaban nuevas cuestiones para recuperar la motivación. Durante el desarrollo de la entrevista, el experto y moderador de la misma estuvo pendiente de mostrar interés por las respuestas y de mantener una escucha activa para intentar crear un ambiente de confort en el diálogo.

Análisis

Al tratarse de un estudio de tipo cualitativo basado en entrevistas en profundidad, el análisis realizado se ha llevado a cabo en base a las recomendaciones de García, Gil y Rodríguez (1994). El proceso de análisis ha sido el siguiente:

1. Separación de unidades con un significado propio por medio de criterios de tipo gramatical (por ejemplo, una oración).
2. Reducción de datos
    a) Categorización: se establecieron categorías y subcategorías para todas aquellas unidades de significado que tenían características propias
    b) Codificación: a cada categoría se le asignó un código con el objetivo de hacerlo más visual.
    c) Síntesis y agrupamiento: se agruparon todas las unidades de significado en las categorías/ subcategorías correspondientes.
3. Elaboración de un esquema conceptual donde se agrupen las metacategorías, categorías, subcategorías.
4. Obtención de resultados: al tratarse de datos de tipo textual y no numéricos, se ha llevado a cabo la comparación y la contextualización para la obtención de resultados.
5. Proceso para obtener conclusiones.

Tabla 1. Guía entrevista semiestructurada

Categorías	Preguntas guía
Bienvenida y explicación del motivo del estudio	Informar sobre la participación voluntaria y grabar el consentimiento informado. No empezar directo con las preguntas, sino antes intentar crear un buen clima de distensión.
Introducción	1. ¿Qué modalidad deportiva practicas o practicabas (gimnasia artística/ gimnasia rítmica/ Danza/ Baile…)? 2. ¿Cuántos años llevas en dicha disciplina o cuántos años la has practicado? 3. ¿Puedes contarnos brevemente cuál es la rutina de una persona que practica tu disciplina?
Estilo de vida	1. ¿Cómo es tu jornada lectiva y de carga de trabajo a lo largo del día? 2. ¿Pasas muchas horas sentada en el trabajo/clase? ¿Y en casa? 3. ¿Realizas algún tipo de deporte/actividad física en tu tiempo libre? 4. ¿Cuántas horas le dedicas a la semana? 5. ¿Cómo es tu alimentación a lo largo de la semana? 6. ¿Cuántas horas al día ves la televisión (TV)/usas el ordenador/móvil?
Dolor de espalda: DLI	1. ¿Has padecido alguna vez dolor de espalda y en especial DLI? 2. ¿Desde cuándo notas DLI? 3. ¿Podrías explicarme cómo es ese dolor? 4. ¿Durante todo el tiempo que llevas con dolor, ha ido variando su intensidad? 5. ¿En qué momento del día te duele más? 6. ¿En qué tipo de actividades cotidianas te molesta más? 7. ¿El deporte que practicas o practicabas te provocaba o crees que influía en el DLI?
Sentimientos generados hacia el dolor	1. ¿Cómo te sientes cuando experimentas el DLI? 2. ¿Cómo afecta este dolor en tu rendimiento académico? 3. ¿Te sientes incapaz de realizar tareas de la vida cotidiana por este motivo? 4. ¿Has empezado con algún tipo de terapia? (SI/NO) →¿Por qué crees que si/no ha funcionado? (Las terapias que hayas realizado) 5. ¿Crees que puede haber otras soluciones? 6. ¿Te ves en un futuro/largo plazo con las mismas limitaciones provocadas por el dolor? ¿Por qué? 7. ¿Cómo crees que tu problema de espalda afecta a tu bienestar y la calidad de tu vida hoy?
Conocimientos sobre la salud de la espalda	1. ¿Qué grado de salud de la espalda consideras que tienes y por qué? (Pregunta relacionada con la percepción del dolor)→ ¿Cuál es tu percepción de salud en general? ¿Y de tu espalda en específico? 2. ¿Dónde has aprendido a cuidarte? ¿A través de qué métodos / terapias? 3. ¿Crees que la actividad física, bien enfocada, puede ser una herramienta para disminuir el dolor? 4. ¿Ha cambiado tu percepción del deporte debido al dolor lumbar? ¿Cómo veías antes la AF? ¿Y ahora? (antes del DLI) 5. ¿Te has preocupado de la "salud" antes de tus problemas? 6. ¿Consideras que ahora sabes más sobre cómo cuidar tu espalda? ¿Cómo cuidas hoy tu espalda y cómo ha evolucionado el trato que le das?
Práctica deportiva y tiempo libre	1. ¿Qué actividad extraescolar/deporte practicas/ practicabas en tu tiempo libre? 2. ¿Cómo crees que afecta este dolor a tu práctica deportiva/musical? 3. ¿Te ha ayudado a conocerte mejor?
Perspectivas de futuro	1. ¿Crees que tu situación actual ha condicionado y va a condicionar tu vida actual y futura? ¿Cómo y por qué? 2. ¿Tus problemas de espalda han cambiado tu visión del potencial de salud que se le otorga a la actividad y el ejercicio físico?

Fuente: elaboración propia.

Resultados

Tras el análisis de toda la información aportada a través de las entrevistas, se establecieron las siguientes categorías:

1. Tipos de entrenamientos.
2. Aportaciones de la práctica deportiva
3. Rutinas o hábitos diarios
4. Primeros episodios de DLI
5. Causas del DLI
6. Conocimientos sobre la salud y cuidados de la espalda
7. Percepciones y sentimientos al experimentar DLI
8. Posibles soluciones al DLI
9. Percepción de salud a nivel general
10. Perspectivas de futuro en torno al DLI
11. Recomendaciones para gestionar mejor el DLI

Categoría 1: Tipos de entrenamientos.

Dicha categoría se basó en aspectos generales, relacionados con los entrenamientos de las deportistas en su día a día. Se subcategoriza, por una parte, los inicios en el entrenamiento y por otra parte las rutinas de entrenamiento.

En cuanto a los inicios en los entrenamientos en su especialidad, todas las respuestas indicaron que los comienzos se realizaron en etapas previas a la adolescencia: "Empecé a los 8-9 años" (E2); "Empecé con ballet desde los 4 años hasta los 21" (E4); "Empecé a los 4 años y medio, de manera profesional a los 9" (E3).

En la subcategoría relacionada con las rutinas de entrenamiento, encontramos comentarios en los que describían su día a día "Los entrenamientos eran casi siempre los mismos con una primera parte de calentamiento, luego flexibilidad y para finalizar el baile" (E2), mientras que otros comentarios analizan el

tiempo empleado en su modalidad "le dedicaba más de 15 horas a la semana" (E4).

Categoría 2: Aportaciones de la práctica deportiva

En relación a todo aquello que les ha otorgado el deporte o la actividad expresiva se encontraron diversos comentarios. Se ha subcategorizado en: aportaciones a nivel físico, emocional, valores y tiempo.

Las aportaciones a nivel físico se muestran en 3 de las 4 alumnas, en comentarios como "A nivel físico me siento musculada y tonificada para otras cosas" (E1) o "A nivel físico, supongo que estar en forma, ser activa".

La variable emocional apareció en comentarios de 2 de las 4 alumnas: "Cuando no consigues algo, frustración". (E1); "A nivel emocional, a la hora de bailar soy otra persona y expreso mis sentimientos de cualquier manera" (E3).

La subcategoría relacionada con los valores y el esfuerzo apareció en algunos comentarios como "Sobre todo valores como persona, compañerismo, responsabilidad, madurez, gestión de emociones (nervios, frustración…)" (E2); "E1: Suelo llegar a lo que quiero. Si lo trabajas al final lo consigues".

Una sola persona entrevistada consideró que el tiempo es una de las aportaciones del ballet: "Siempre he tenido tiempo para todo. Fue una de las cosas que me aportó la danza clásica" (E4).

Categoría 3: Rutinas o hábitos diarios

La categoría de rutinas estuvo relacionada con todo aquello que consideran importante en su día a día, independientemente o no de la gimnasia/danza. Por ello, se ha subcategorizado en estilo de vida y en alimentación.

En cuanto al estilo de vida, todos los comentarios excepto uno, explicaban la falta de tiempo, exceso de trabajo o déficit de horas de sueño: "Supone un gran esfuerzo (la jornada lectiva). Estoy acostumbrada porque llevo desde los 8 años" (E1); "No estoy muy parada: me levanto, voy a clase, como, descanso o hago trabajos, voy a entrenar (toda la tarde) y sigo estudiando" (E2); "Me resta (horas de sueño), desgraciadamente" (E3). Únicamente una alumna respondió desde un punto de vista positivo "No (no me supone mucha carga), porque es algo que me gusta. Para mí no es una obligación. Es una manera de despejarme" (E3).

La alimentación es otro de los puntos en los que se observaron comentarios algo similares. Tres de las personas entrevistadas admitieron que llevaban una dieta equilibrada e incluso un seguimiento por parte de una persona experta en nutrición: "No la controlo como tal (la alimentación), no me fijo en las calorías porque en casa se come equilibrado" (E1); "Algunas temporadas nos restringían un poco (no comer chocolate y cosas así). Aun así, en casa comemos bastante equilibrado" (E2); "Actualmente voy a un nutricionista para controlar mi alimentación y para saber las cantidades de macronutrientes, fruta, verdura que debo ingerir" (E3). La profesora entrevistada admite que "En esa época no comía demasiado bien, me alimentaba de azúcares. Para las madres no se le da la misma importancia que ahora" (E4).

Categoría 4: Primeros episodios de DLI

Esta categoría se relacionó, por una parte, con la prevalencia de DLI a lo largo de la vida. De las cuatro participantes tres (E2, E3 y E4) manifestaron haber padecido DLI. Por su parte, E1 manifestó que solo había experimentado molestias en la zona cervical.

En relación con la fecha (entendida como la edad) en la cual empezó el dolor, y por otra, con los síntomas iniciales. Las tres alumnas (E2, E3 y E4) coincidieron con los inicios del dolor, más concretamente en los inicios de la adolescencia: "Alrededor de 1º/2º ESO" (E1), "Todo empezó a los 12 años" (E2), "Hace 5 años (es decir, a sus 11 años)" (E3).

De las cuatro personas entrevistadas, solamente una manifiesta que el DLI se ha mantenido hasta la actualidad y lo sigue padeciendo: "No a nivel de antes, pero sí. Un día que duermo mal, o hago algún esfuerzo sí que lo noto" (E3). El resto de participantes (E1, E2 y E4) afirman no tener síntomas de dolor de espalda ni DLI actualmente e incluso expresan dichas percepciones en pasado.

Los síntomas (duración, intensidad…) fueron explicados por las tres participantes con DLI: "Al principio pensaba que eran agujetas, no sabía qué era. Era algo que me duraba un par de días y luego se me iba" (E2); "Aprendí a convivir con el dolor lumbar el cual padecía de forma continua, aunque unas veces lo notaba más que otras, en función de la intensidad de los entrenamientos" (E3); "La primera vez que dejé de bailar empezó a ser más grave. Pero las cefaleas y el dolor de cuello empezaron un poco antes, sobre todo cuando reduje las horas de entrenamiento" (E4).

Categoría 5: Causas del DLI

Las 4 personas entrevistadas resaltaron 5 aspectos claves que ellas consideraban que podían estar relacionados con el DLI: la falta de fuerza, la actividad realizada, la ejecución del movimiento, el estrés o el profesor/entrenador.

La causa relacionada con la falta de fuerza fue descrita por una alumna y la profesora: "Conforme me iba exigiendo y el musculo no estaba "trabajado" me sucedía más" (E1), "Al dejar de hacer ballet (antes no porque mis músculos estaban fuertes) empezó mi cuerpo a cambiar, se pinzó y se salió el disco" (E4).

Dos alumnas consideraron que la gimnasia rítmica/danza (de forma general) fue la desencadenante de dichas molestias: "(Lo achaco) Alguna vez por la danza" (E1), "Obviamente pienso que sí que puede ser la causa (La gimnasia). La gimnasia rítmica es un deporte que busca los extremos, posturas viciadas y buscar el límite" (E2).

La ejecución de algún movimiento específico dentro de la lógica interna de la danza/gimnasia fue otro de los puntos clave en el inicio de DLI: "Al curvar la espalda (cambre), extensión lumbar. O si no lo mismo, pero adelantando la pelvis" (E1), "A la hora de levantar la pierna, necesitaba rotarla desde la cadera y no desde la rodilla. Cuando lo realizaba la rodilla estaba hacia dentro (valgo) y me hacía daño en las lumbares" (E3).

Únicamente una alumna lo achaca al estrés: "También soy una persona que cuando se estresa mucho todas las molestias van a la espalda, por mi postura corporal" (E2).

Por último, la influencia del profesor/a o entrenador/a es importante, según la profesora entrevistada, para prevenir el DLI: "Si no tienes un buen profesor/a, ya que es una disciplina que maneja mucho el cuerpo y si no sabe anatomía puedes acabar con muchas lesiones" (E4).

Categoría 6: Conocimientos sobre la salud y cuidados de la espalda

Esta categoría estuvo relacionada con los conocimientos que han ido adquiriendo las 4 personas entrevistadas desde los inicios del dolor de espalda hasta la actualidad. Entre los conocimientos adquiridos encontramos: la musculatura, las emociones, las capacidades físicas y la técnica.

La primera subcategoría estuvo relacionada con la musculatura implicada. Tres de las cuatro personas entrevistadas consideraron que la musculatura es muy importante para prevenir lesiones, y como un exceso de entrenamiento puede repercutir negativamente en la salud de la espalda: "Yo al menos intento prepararme la musculatura. Hago mis ejercicios de espalda para mantenerme recta" (E3), "en la gimnasia rítmica los músculos que estabilizan están más extendidos, pierden esa rigidez" (E2).

Una de las alumnas comentó que aprendió a relacionar el nivel de dolor con sus emociones: "He aprendido a saber por qué me viene ese dolor: si estoy estresada, por la postura, etc." (E2).

En cuanto a la subcategoría relacionada con las capacidades físicas, la flexibilidad fue uno de los aspectos a los que más importancia le dieron y del cual aprendieron en su trayectoria como deportistas: "Porque con estiramientos se va el dolor" (E1), "Pero también tengo esa flexibilidad que creo que es importante" (E3).

Por último, E4 le dio gran importancia a la técnica y la ejecución del movimiento y en su discurso se dejó entrever los conocimientos que adquirió en cuanto a ejercicios que pueden ser contraproducentes en la espalda: "hay ciertos movimientos que son peligrosos. La postura base puede llegar a ser muy forzada. Te pide una retroversión de la cadera y levantar el cuello. Y que elimines las dos curvas naturales de la columna".

Categoría 7: Percepciones y sentimientos al experimentar DLI

En esta categoría se agruparon todas las intervenciones por parte de las personas entrevistadas en las que mostraban sus sentimientos y percepciones hacia el DLI. Todas ellas (E2, E3 y E4) mostraron sentimientos predominantemente negativos y pesimistas.

La primera subcategoría se relacionó con la incapacidad, entendida como la situación en la que por impedimento físico se limitan algunas actividades: "Realmente es algo (el DLI) que te impide bastantes cosas. El hecho de sentarte mucho tiempo ya molesta. Te cuesta más concentrarte" (E2), "Realmente no ha sido algo que me haya limitado a hacer vida normal, pero sí que tuve que dejarme el pádel" (E2), "Cuando empecé las oposiciones, aun sabiendo lidiar con esos problemas, me pasaba muchas horas estudiando, y había días que no podía estudiar por el dolor de cabeza" (E4).

La segunda subcategoría se relacionó con el sentimiento de culpabilidad: "Yo simplemente pensaba que lo había hecho mal, porque si me he hecho daño es porque ese paso, ese movimiento lo he hecho mal" (E1), "Al principio nunca lo pensé y le echaba la culpa al ballet. Simplemente yo lo había hecho mal y había llegado a un punto de no retorno" (E4).

Otra de las subcategorías que se analizaron en las entrevistas fue la relacionada con la frustración como consecuencia del DLI: "La frustración siempre estaba, ya que no podía dar el 100% de mí" (E4), "Cualquier tipo de dolor te reduce la moral. Como conllevaba dolor de cabeza, también cambiaba el carácter: no quieres que nadie te mire, te grite o te hable" (E4).

Por último, la aceptación al dolor fue otra subcategoría que se dejó ver en algunas intervenciones de las alumnas y la profesora: "Al final el cuerpo es muy sabio y se acaba adaptando al dolor. Como ahora mismo no es algo que me impida hacer vida diaria" (E2), "Ahora es algo con lo que ya he aprendido a vivir: necesito estirar todos los días, una higiene postural, voy al fisio cada cierto tiempo" (E4).

Categoría 8: Posibles soluciones al DLI

Esta categoría se vinculó con todos aquellos comentarios en los que se aportaron posibles soluciones al dolor de espalda: fisioterapeuta, estiramientos y movilidad, técnica, ejercicio físico y otros.

Todas ellas aportaron propuestas, aunque cada una desde un enfoque distinto. Dos alumnas consideraron que la fisioterapia les funcionó a corto plazo, más concretamente la terapia manual: "He ido al fisio muy regularmente. En sí el masaje notaba que era lo que mejor me iba" (E2), "Tuve ese problema y fui al fisio y me lo solucionó" (E3).

Los estiramientos y la movilidad son otra subcategoría importante que las alumnas consideraron para intervenir en la lesión: "Porque con estiramientos se va el dolor" (E1), "Estirar y ejercicios: huevito, Cat-camel, mantener posturas, etc. Especialmente de movilidad" (E2), "Los estiramientos pienso que son esenciales" (E4).

La técnica correcta de los ejercicios e incluso su modificación fue otro factor clave que algunas de las alumnas comentaron para solucionar el dolor: "Buscaba una solución, preguntaba cómo se hace o lo adaptaba a mi cuerpo" (E1), "Me corrigió la técnica la profesora y ya se me fue el dolor." (E3).

El ejercicio físico también fue considerado fundamental para la salud de la espalda: "Sí, la fisio me recomendó la natación" (E2), "Creo que el EF es esencial. Un profesional me dijo que empezara a ir al gimnasio" (E4), "Para mí, ganar fuerza a nivel de tren superior fue un descubrimiento" (E4).

Por último, dos comentarios destacaban que la solución podría estar en otras terapias: "Sí, la osteopatía me ha dado mucha calidad de vida" (E4), "Como ha sido tanto tiempo. Ponerme calor, cremas, estiramientos, posturas durmiendo" (E2).

Categoría 9: Percepción de salud a nivel general

Otra categoría analizada en nuestro estudio fue la percepción de salud general que tenían las personas entrevistadas. Dos alumnas tenían una percepción positiva de su salud: "Me considero saludable" (E1), "A nivel global me considero una persona sana. No es algo que me limite la vida" (E2). Únicamente E4 consideró que durante su adolescencia tenía un grado de salud de espalda bajo: "Pésimo (Grado de salud de espalda), estudiaba mucho" (E4).

Categoría 10: Perspectivas de futuro en torno al DLI

Las perspectivas de futuro se subcategorizaron en optimistas y pesimistas. Una alumna enfocó su futuro desde un punto de vista positivo "Si tuviera una lesión, seguiría bailando" (E3). Otra de las alumnas, más concretamente la que sufrió de forma más prolongada el dolor lumbar (E2) fue algo más pesimista: "Pienso que va a ser algo que voy a tener ahí, en mayor o menor medida, depende de la época. Será algo que esté ahí, pero que no me va a limitar".

Categoría 11: Recomendaciones para gestionar mejor el DLI

La última categoría estaba relacionada con los consejos que las personas entrevistadas darían a otras compañeras, para prevenir o mejorar la salud de su espalda. Dicha categoría se subdividió en: el foco externo y el foco interno.

Los comentarios dirigidos al foco externo fueron dos: "A parte de buscar esa solución, darles consejos, masaje, estirándoles" (E2), "Hacer mucho caso a la gente que sabe, ejercicios que te dicen" (E1). Los comentarios dirigidos al foco interno fueron mencionados por 2 de las personas

entrevistadas, pero estos fueron más extensos y detallados: "Empezaría a escucharme un poco antes. También que cuando tuviera un dolor no forzara, supiera cuando es el momento de parar" (E2), "1) Poner fuerza no significa tensionar. 2) Momentos de rendimiento alto siempre tiene que ir acompañados de saber relajarse. 3) Cuida tu cuerpo como si fuera un templo" (E4).

Discusión

El objetivo del presente estudio fue obtener una comprensión general sobre la salud y los cuidados de la espalda en adolescentes practicantes de gimnasia rítmica y danza clásica mediante el uso de una serie de estudios de casos instrumentales. Dentro de los problemas de espalda, se concretó en la zona lumbar por ser la más común y frecuente entre la población estudiada.

Prevalencia de dolor lumbar en la adolescencia

Aunque nuestro estudio no fuera un estudio epidemiológico, cabe destacar que, de las cuatro personas entrevistadas, tres de ellas sufrieron algún episodio de dolor lumbar inespecífico y una de ellas explicó que solo sufrió dolor de espalda, pero a nivel cervical. Además, cabe destacar que la aparición de los síntomas lo situaron en torno a los 11-12 años, con el inicio de la adolescencia tal y como se describe en la literatura (Leboeuf-Yde & Kyvik, 1998). Por lo tanto, la mayoría de las adolescentes encuestadas experimentaron problemas con la espalda coincidiendo con los datos que refleja la literatura en relación a la prevalencia de DLI entre personas jóvenes (Bento et al., 2020; James et al., 2018; Jeffries et al., 2007).

En relación con la duración del dolor, dos de las tres participantes que manifestaron experimentar DLI indicaron que este fue de manera recurrente e intermitente. De manera convencional, el DLI es categorizado desde el punto de vista de su duración como agudo (duración inferior a 4 semanas), sub-agudo (duración entre 4 y 12 semanas) y crónico (duración superior a 12 semanas) (Spitzer et al., 1987).

Diferentes estudios epidemiológicos establecieron un rango del 7-27% de DLI recurrente la población escolar (Burton et al., 1996; Harreby et al., 1999; Jones & Macfarlane, 2009; Jones et al., 2004; Vikat et al., 2000). Estos jóvenes registraron una calidad de vida más reducida, y utilizaron más la atención médica y el consumo de analgésicos (Harreby et al., 1999) como dos de las participantes de este estudio que actualmente siguen necesitando al profesional sanitario para mitigar los dolores de la zona lumbar (E3 y E4). Además, el DLI recurrente durante la adolescencia podría ser precursor del DLI crónico en la edad adulta (Harreby et al., 1995; Salminen et al., 1999).

Salud de la espalda y la práctica deportiva

En nuestro estudio, se seleccionaron cuatro participantes que en ese mismo momento practicaban o habían practicado gimnasia rítmica o actividades escénicas como la danza clásica. Una de las categorías que consideramos relevante en nuestro estudio fue la denominada "Causas del DLI". Durante el transcurso de las entrevistas, las participantes confirmaron que el nivel de exigencia y las horas de entrenamientos eran muy altas: E1 entrenaba 4 días a la semana, E2 le dedicaba 12 horas de entrenamiento semanal repartidas en 4 días, E3 le dedica actualmente 3 o 4 horas al día y E4 llegó a entrenar más de 15 horas a la semana durante la adolescencia. Según autores como Kujala et al. (1992) y McMeeken et al. (2002), el hecho de practicar un deporte institucionalizado y dedicar una alta carga de entrenamiento (entendida como horas de práctica) puede ser un factor de riesgo que desencadene en episodios de dolor lumbar.

Otros factores de riesgo que se aprecian en nuestros resultados y van en línea con las aportaciones de otros autores (Bento et al., 2020; Lynch et al., 2006) son el estrés o las horas al día en posición sedente. Ninguna de las personas entrevistadas les otorgó gran importancia a estos factores, sin embargo, todas ellas pasaban muchas horas sentadas debido al horario lectivo. Además, admitieron que llevaban un nivel de vida muy ocupado, con mucha carga de actividades y responsabilidades semanales debido a los estudios y a los duros entrenamientos.

La percepción que tenían las cuatro personas entrevistadas sobre las causas de dolor lumbar fue otra de las categorías analizadas y estaba muy relacionada con la de otros autores. Entre ellas destacamos, en primer lugar, las continuas extensiones y rotaciones de tronco: todas ellas confirman tanto en la gimnasia rítmica como en la danza (aunque esta última en menor proporción) que se buscan los extremos y posturas disarmónicas, lo cual puede repercutir negativamente en la salud de la espalda (Cugusi et al., 2020; Hart et al., 2018; Henn et al., 2020; Paxinos et al., 2019; Solomon et al., 2017; Sweeney et al., 2019). Sin embargo, una de las diferencias sustanciales entre ambas disciplinas son los saltos. Aldazabal (2010) afirma en su estudio que los saltos con desplazamiento previo, tan comunes en la gimnasia rítmica, muestran un pico de impacto muy elevado, lo que puede incrementar el riesgo de lesión en gimnastas. Contrariamente, en la danza clásica los movimientos son más controlados y se producen menos saltos. Además, la amplia experiencia y formación académica del profesorado de los conservatorios de danza proporciona un mayor conocimiento a las alumnas, las cuales deben examinarse de conceptos relacionados con la biomecánica, la anatomía, la fisiología, etc.

El déficit de fuerza es otro factor intrínseco al que las deportistas le otorgaron mucha relevancia como causa de lesiones y problemas de espalda, pues esta capacidad física, según ellas, es fundamental para evitar desequilibrios e hiperlaxitud debido al excesivo desarrollo de la flexibilidad. Esta capacidad, la flexibilidad, se trabaja de forma distinta en el ámbito federativo y el educativo. En este último, no son necesarias tantas sesiones ni ejercicios tan forzados y extremos (Ruiz & Miñarro, 2020).Por otra parte, el papel del entrenador/a o profesor/a para evitar una lesión lo consideraron crucial, pues es la persona encargada de controlar las cargas de entrenamiento y la técnica. Esto quedó reflejado en nuestro trabajo y se observa en otros estudios de tipo cualitativo (Fawcett et al., 2020). Nuestros resultados evidenciaron diferentes percepciones con relación a esta subcategoría: algunas deportistas consiguieron mejorar su lesión gracias a las indicaciones del entrenador/a, mientras que otras confirmaron que esta misma persona había sido la principal causante de los síntomas.

Uno de los factores de riesgo en la aparición de dolor lumbar según estudios Fawcett et al. (2020) es el equipamiento deportivo, el calzado o el tipo de suelo utilizado durante la práctica deportiva. Sin embargo, en nuestros resultados no fue un factor mencionado por parte de las personas entrevistadas.

Perspectivas de futuro y consejos a otras compañeras

En cuanto a las categorías relacionadas con la percepción de la salud de la espalda y las perspectivas de futuro, las alumnas fueron muy optimistas y consideraban que tenían una buena salud en general. Esto puede ser muy positivo, pues el hecho de adquirir conductas disruptivas o negativas, falta de confianza, preocupación o falta de

control sobre el dolor se relaciona con la aparición de dolor lumbar (Lynch et al., 2006).

Sin embargo, las alumnas, a lo largo de las entrevistas afirmaron que seguirían practicando su modalidad (danza o gimnasia) pese a que las lesiones o problemas de espalda a causa de su práctica se mantuviera a lo largo del tiempo. Los motivos que mencionaron fueron: que les gustaba mucho la actividad que practicaban, que hay que vivir con el dolor o que dicha lesión o síntoma no les iba a limitar. Estas aportaciones coinciden con las de autores como Cogusi et al. (2020), el cual afirma que el hecho de continuar practicando el deporte durante la lesión o problema puede aumentar el riesgo y la magnitud de esta.

La categoría relacionada con "consejos a otras compañeras" son aportaciones que realizaron las alumnas y que respondían a la siguiente pregunta: ¿Qué consejos le darías a una compañera de entrenamientos para prevenir el dolor que estas sufriendo tú ahora mismo? Las alumnas mencionaron diferentes estrategias que estaban relacionadas con las aportaciones de diferentes autores: la importancia de tener un buen profesional de la actividad física que dirija los entrenamientos/clases (Fawcett et al., 2020) o el control de las emociones (Bento et al., 2020; Lynch et al., 2006).

Conocimientos sobre la salud de espalda y su cuidado

Nuestros resultados mostraron como los conocimientos sobre la salud de espalda en las cuatro personas entrevistadas eran probablemente algo mayores que la población adolescente en general, los cuales muestran unos bajos niveles en referencia a estos conceptos (Minana-Signes & Monfort-Panego, 2015; Miñana-Signes et al., 2019). Esto puede ser debido a las experiencias tanto positivas como negativas que han tenido las alumnas sobre la salud de la espalda a lo largo de su trayectoria deportiva. El papel de los programas de intervención en el ámbito educativo sobre la salud de la espalda puede ser fundamental especialmente en el área de educación física, donde además de enseñar conocimientos teóricos, el alumnado debe ser capaz de llevarlo a la práctica con en su día a día (Miñana-Signes et al., 2021). Sin embargo, los resultados evidencian como, al menos en nuestro trabajo, las alumnas y la profesora no habían adquirido dichos conocimientos por medio de la escuela, sino que habían tenido que recurrir a consejos de diferentes profesionales del ámbito de la salud para solucionar los síntomas (fisioterapeutas, médicos, osteópatas, etc.).

Principales limitaciones

Las principales limitaciones han estado vinculadas con la búsqueda de literatura científica de tipo cualitativo, ya que existen pocas investigaciones de este tipo, especialmente sobre la salud de la espalda y la educación. Por este motivo, en el apartado de discusión se ha tenido que recurrir a otro tipo de estudios, especialmente de tipo cuantitativo.

Por otra parte, otra de las limitaciones ha sido la no presencia de un grupo control (que no muestre síntomas de dolor de espalda o DLI), pues nos hubiera permitido comparar ambos grupos en referencia a los estilos de vida, los conocimientos sobre la salud de la espalda, las percepciones o los sentimientos.

El tamaño de la muestra ha sido óptimo para realizar un estudio de casos múltiple, pero consideramos que un mayor número de esta puede proporcionar datos mucho más enriquecedores y de esta forma extraer un mayor número de conclusiones.

En relación con las preguntas relacionadas con los sentimientos generados hacia el dolor de espalda, cabe destacar que existía cierta complejidad en que las participantes pudieran realizar un análisis adecuado de las causas de su dolor de espalda sin la ayuda del entrevistador/a. Debido a esta situación los investigadores creyeron conveniente no ahondar en esta variable y limitarse a conocer si se había experimentado algún episodio de dolor de espalda y en especial de DLI.

Conclusión

Como conclusión principal se puede explicar que las adolescentes participantes en actividades escénicas como la gimnasia rítmica competitiva y la danza clásica profesional perciben que requieren una alta dedicación que puede incurrir en un exceso de ejercicio físico. Experimentaron que dichas actividades a su vez requieren una movilización y alta demanda de la participación de la columna vertebral que podría repercutir en problemas en dicha zona. Por ello consideran que la persona profesional encargada de dirigir estas actividades es un agente clave para evitar futuros problemas de salud de la espalda. En general, se reconoce que el nivel de conocimientos sobre la salud y el cuidado de la espalda es elevado debido a la experiencia en la gestión de los dolores y por las consultas a profesionales sanitarios durante su trayectoria como deportistas.

Como conclusiones más específicas podemos decir que:

1. Las cuatro participantes analizadas experimentaron algún episodio de dolor de espalda y tres de ellas sufrieron DLI a lo largo de sus vidas, causado, según ellas por la práctica deportiva (gimnasia rítmica y danza).
2. La percepción y los sentimientos generados a raíz del DLI eran predominantemente negativos, entre los que destacamos frustración, incapacitación, culpabilidad y aceptación.
3. Explicaron que la actividad practicada requería el desarrollo de ejercicios con continuas extensiones y rotaciones de tronco, así como busca movimientos extremos y posturas viciosas.
4. En relación a la duración de los entrenamientos las participantes confirmaron que el nivel de exigencia y las horas de entrenamientos eran muy altas.
5. Las experiencias que han tenido a lo largo de sus vidas a nivel deportivo y de lesiones les han permitido aprender conceptos sobre la salud y cuidados de la espalda de forma autónoma o con ayuda de diferentes profesionales del ámbito de la salud.
6. Vinculado con la anterior conclusión, las entrevistas no reflejan que las alumnas hayan alcanzado ningún conocimiento sobre la salud de la espalda a través del ámbito educativo. Este hecho debe ser tenido en cuenta por el profesorado, pues todos aquellos alumnos y alumnas que no están vinculados con el ámbito deportivo en su jornada extraescolar no recibirán estrategias y métodos para la prevención de esta lesión tan común.

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CULTURA, CIENCIA Y DEPORTE

Decisional analysis of finishing in basketball

Análisis decisional de la finalización en baloncesto

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Short title:
Finishing in basketball

How to cite this article:
Serna, J., Muñoz-Arroyave, V., March-Llanes, J., & Lavega-Burgués, P. (2022). Decisional analysis of finishing in basketball. *Cultura, Ciencia y Deporte*, *17*(53), 173-192. https://doi.org/10.12800/ccd.v17i53.1896

Received: 29 march 2022 / Accepted: 15 june 2022

Abstract

The present study investigated the decision making linked to the basketball player's shooting and blocking shots based on the Strategic Logic proposed by the coach. A Spanish team which played in EBA League was studied in 4 games in the 2010-2011 season. 7440 motor decisions (ballhandler decisions and his defender) were analyzed using the ad hoc instrument called SODB. Among the most relevant conclusions it is worth mentioning: a) the importance of having a well-defined Coach's Strategic Logic in both offense and defense; b) the interest of assessing the match between the Coach's Strategic Logic and the players' individual decision making; c) a clear trend in the tight decision making of both the ballhandler (offensively) and the player who block shots (defensively) , confirming that the players respected the Coach's Strategic Logic; d) the main variable that helped predict the success of both the ballhandler and the rival of the ballhandler was the correct decision making of the players rather than the game system used; e) shooting and blocking shots in a correct way (following Coach's Strategic Logic) is related to success; and finally, f) the shot-block binomial is a relationship that depends more on the individual competence of the players involved than on the Coach's Strategic Logic.

Keywords: observational methodology, decision making process in basketball, tactical performance analysis, coach's strategy.

Resumen

El presente estudió investigó la toma de decisiones motrices vinculadas al lanzamiento y al tapón del jugador de baloncesto en función de la Lógica Estratégica propuesta por el entrenador. Participaron 13 jugadores de un equipo de Liga EBA entre 18 y 28 años de edad en la temporada 2010-2011. Se analizaron todas las decisiones que tomaba el jugador con balón y su rival (defensor) en 4 partidos (2 amistosos y 2 de entrenamiento) mediante el instrumento ad hoc denominado SODB. Entre las conclusiones más relevantes se destaca: a) una clara tendencia en la toma de decisiones ajustadas tanto del jugador con balón como del rival del jugador con balón, confirmando que los jugadores respetaban el plan estratégico del entrenador; b) la variable que ayudó a predecir el éxito tanto del jugador con balón como del rival del jugador con balón fue la correcta toma de decisiones de los jugadores más que el sistema de juego utilizado; c) lanzar y taponar de manera ajustada a la Lógica Estratégica del entrenador tiene relación con el éxito; y finalmente, d) el binomio lanzamiento-tapón es una relación que depende más de la competencia individual de los jugadores implicados que de la Lógica Estratégica del entrenador.

Palabras clave: análisis observacional, toma de decisiones, sistema de juego, análisis del rendimiento táctico, estrategia del entrenador.

Introduction

Basketball has traditionally been classified from the point of view of the type of motor relationship established, as a sport of cooperation-opposition (Parlebas, 2001). But, because the opposition is the key relationship that modifies the score of the match and the one that finally determines who is the winner and loser of the duel, this sport can also be interpreted as an opposition-cooperation sport (Serna et al., 2017). In this type of duels, Lavega (2004) argues that when two teams face each other, a series of processes are activated in athletes such as reading and interpreting the decisions of both teammates and opponents, issuing messages for teammates to decipher, sending wrong messages to confuse rivals, decoding messages from rivals, adapting to uncertainty; in short, the process of motor decision-making (TDM) of players is activated (Arias-Estero et al., 2018; Courel-Ibáñez et al., 2018; Suárez-Cadenas et al., 2017) and consequently their motor intelligence (Serna et al., 2014).

As provided by other research (Arias-Estero et al., 2018; Courel-Ibáñez et al., 2017; Dugas, 2006; Gréhaigne et al., 2001; Gamero et al., 2021; Jiménez-Sánchez et al., 2012; Lasierra et al., 2020) it is interesting that coaches can have instruments to measure the TDM of their players in order to, firstly, correctly diagnose their players and, secondly, optimally program their training tasks for improving improve these specific motor decisions (DM). To proceed with this evaluation of the TDM of basketball players, Serna et al. (2014) contribute that it is necessary to define the possible DMs that a basketball player can take by distinguishing four strategic roles, two associated with the attacking team (player with the ball and player without the ball) and two others associated with the defending team (rival of the player with the ball or rival of the player without the ball).

Of this limited number of DMs that a basketball player can perform, in this research we tried to focus on the strategic roles that can alter the score more directly, such as the player with the ball (JCB) and the rival of the player with the ball (RJCB); that is, those players who can score or can prevent the opponent from scoring. That is why it could be said that the JCB's competence will be greatly influenced by both his correct decision making when shooting and the efficiency at the moment of shooting (scoring); and exactly the same for the RJCB, who must be competent in taking the correct DMs to avoid the opponent's shot and effective in blocking or disturbing the opponent's shot as much as possible (Serna & Muñoz, 2015).

In this scenario, the basketball coach has to help the players to establish a collective order that favors cooperation among the members of the same team. This is why coaches design a Strategic Logic (LE) specific to their team. This LE aims to create a guide for the players in order to achieve collective success (Muñoz et al., 2015; Serna et al., 2021). The development of this LE, will consider the individual characteristics of the players and should organize the TDM of these, so that the team works in a coordinated and harmonious way (Lasierra et al., 2020; Serna & Muñoz, 2015).

The LE is composed of different strategies when the team is attacking and another when the team is defending. The main goal of the LE of the offensive team (ECB) is to finish scoring thanks, to a large extent, to finish with uncontested shots or with the greatest possible advantage (Alsasua et al., 2022; Gómez et al., 2013; Ibáñez et al., 2009); while the main goal of the defending team (ESB) is getting the ball, block shots or, at least, to bother the offensive team's shot (scoring) and, if it occurs, to control the defensive rebound (Gómez et al., 2006; Leite et al., 2014).

The LE of ECB and the ESB must consider the different phases of the game (fastbreak, transition and half-court offense) (Gómez et al., 2013; Piñar et al., 2014). From the point of view of the TDM of the ECB players, it is not the same to attack in a situation of disorganization of the ESB (fastbreak), as in a situation of momentary reorganization of the opposing team (offensive transition) or in a situation of clear organization (half-court offense) (Gómez et al., 2013). In parallel, the LE of the ESB must have structured how to reorganize in the defensive balance (in this research, called unorganized defense), how to act in the defensive transition and, of course, the organization and rules in half-court defense (Gómez et al., 2006).

When the ESB is defending in half-court, there are different types of defensive systems depending on whether he defends in man man-to-man organization (each player defends an opponent), zone (each player is responsible for a defensive space) or mixed (some players are in man-to-man and others in zone) (Gómez et al., 2006). These strategic possibilities of the ESB will require adjustments of the players in their TDM since each defensive system has singularities. In the same way that facing these defensive systems will cause adjustments in the LE of the ECB since he will have to adjust his offensive strategies and, therefore, his TDM, depending on the defense he is facing; since it is not the same to attack against a man-to-man defense than against a zone defense or a mixed defense (Serna et al., 2014; Serna & Muñoz, 2015).

Also, with the objective of improving the team performance and of each of its players, it should be evaluated if the TDM of the players is in accordance with the LE proposed by the coach. The TDM of the players must be in accordance with the coach's LE, but without adopting a submissive attitude. It is about adjusting decisions in an effective way with the goal of solving the particular motor situation (Serna & Muñoz, 2015).

Therefore, these individual DMs can be categorized as: a) adjusted DMs (DMs accepted by the LE defined by the coach); b) unadjusted DMs (DMs not accepted by the LE defined by the coach); and, c) anti-regulation DMs (DMs that violate the rules and should be sanctioned by the referee) (Serna et al., 2014).

For all of the above, the research goals were: a) to study the predictive variables to obtain success in shots; b) to study the predictive variables to prevent success in shots of the offense team; and, c) to evaluate the level of adjustment of the DMs linked to JCB and RJCB finishing, according to LE proposed by the coach.

Method

The research design was nomothetic because each player was analyzed, follow-up because several matches were observed and multidimensional by considering different levels of response within the observation instrument (Anguera et al., 2011).

Participants

The sample consisted of 13 players from an EBA League team of the 2010-2011 season, with an age range between 18 and 28 years, (Mage = 22.3 years, SD = 3.12). Four unofficial games were played (two friendly games and two training games) which were filmed and subsequently analyzed. All participants gave their consent to voluntarily

participate in the study. The observational sample was 7440 records; of these, data linked to JCB and RJCB finishing were analyzed. Therefore, 468 MDs from the JCB and 423 MDs from the RJCB were studied in greater depth.

Procedure and instrument

In order to identify the DMs of JCB and RJCB, the Basketball Decision Observation System (SODB) was used. It is a system, based on the *ad hoc* Observational Methodology that evaluates the decisions made by players on the basketball court as according to the coach's strategy (Serna et al., 2013). This observational tool is composed of 5 criteria and 40 categories (Table 1). The images were processed with the MOTS program (Castellano et al., 2008) which allowed the use of the SODB instrument by recording the time of each observation and creating code matrices collected in an Excel sheet.

Data analysis

For data analysis, contingency tables were carried out using the adjusted residuals when necessary, as the contrast statistic in the case of univariate tests. The technique called CHAID 9 (Chi-square automatic interaction detector) classification trees was also used as a technique to analyze the effect of the independent variable on the dependent variable, in this case, a cross-validation system was applied and 50 was considered as the minimum number of cases in the terminal nodes, and 100 cases in the branch nodes. Other characteristics were: tree size control (minimum node size, split size: 10; maximum tree levels: 3), validation method (10-fold cross-validation) and statistical significance ($p < .05$), the other options were applied with the default parameters of the program. The Answer-Tree® SPSS Classification Trees ™ 13.0 module was used.

Results

JCB Finishing: Variables predictive of performance.

To study the performance in JCB finishing, successful shots were identified as those that ended in a basket or with a foul received in the shooting action, while failure was identified when there was a missed shot or a turnover.

Table 1. Criteria and categories of the SODB observational tool

Criteria	Categories
Player	
Defensive systems (ESB)	Man-to-man (IND)
	Zone (ZON)
	Mixed (MIX)
	Unorganized defense (DSC)
DM of player with the ball (JCB)	Passer (PS)
	Receiver (REC)
	Forwarder (PG)
	Protector (PT)
	Offensive retriever (REP)
	Playing one and one (DO)
	Playing ball screen (DC)
	Time manager (TP)
	Shooter (LZ)
	Offensive rebounder (RA)
DM of rival of the player with the ball (RJCB)	Pass interceptor (IP)
	Pass denier (DP)
	Pass controller (CP)
	Reception interceptor (IR)
	Reception denier (DR)
	Reception controller (CR)
	Forward controller (CA)
	Orientator (OR)
	Stealer (DES)
	One-on-one defender (CO)
	Ball screen defender (CCO)
	Time manager controller (CT)
	Shot blocker (TB)
	Double team player (DB)
	Collaborator (CL)
	Defensive retriever (RD)
	Defensive rebounder (RB)
TDM Assessment	Adjusted (AJUS)
	Unadjusted (DESA)
	Anti-regulation (ANTI)
Finishing	Successful (EXI)
	Failure (FRA)

CHAID classification trees (Figure 1) identified DM assessment as the first predictive variable for performance in JCB finishing. Significant differences ($p < .001$, $x2 = 86.516$, $gl = 1$) were observed between adjusted DMs (65.6%) and unadjusted DMs (34.4%). When DMs were adjusted (node 2), the percentage of success was higher (61.2%) than failure (38.8%), whereas in unadjusted DMs (node 1) (shots and turnovers are included) this trend was reversed, as those completions failed most of the time (83.9%) and were successful in a much lower percentage (16.1%). Only 27.4% of the unadjusted DMs (node 4) ended with successful shots, as opposed to 72.6% that were unsuccessful.

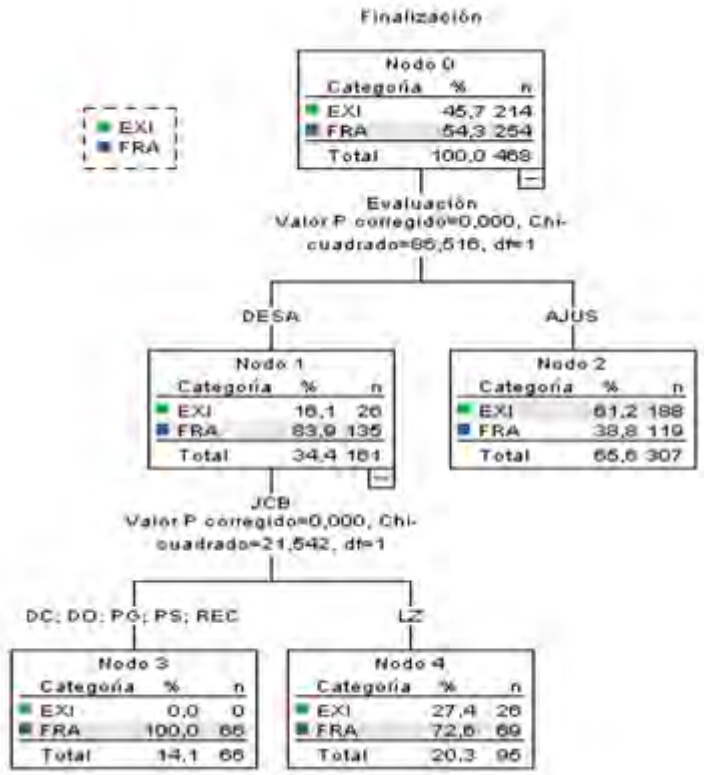

Figure 1. Influence of JCB's DM on the success of offensive finishing
Note: EXI (success); FRA (failure); DESA (unadjusted); AJUS (adjusted); JCB (player with the ball); DC (playing ball screen); DO (playing one-on-one); PG (forwarder); PS (passer); REC (receiver).

JCB Finishing: Relationship between DM level of adjustment and ESB defensive systems

When analyzing in greater depth the level of adjustment of these DMs linked to the finishing of the JCB before the different ESB game systems (Table 2), it was found, firstly, that the DMs in the finishing were mostly adjusted (76.4%) compared to the unadjusted ones (23.6%) in all the situations analyzed. Secondly, a statistically significant relationship was found between these variables (x2 = 11.158; gl = 3; p = .011), specifically between DMs taken in unorganized situations (when the JCB finishes in fastbreaks) and DMs that occurred in the man-to-man game system.

RJCB Finishing: performance predictors

To study the performance in the RJCB finishing, successful DMs were identified as those DMs that allowed either getting the ball or causing a missed shot by the opposing team. Failure was identified when a basket was produced by the offense team.

When studying the predictive strength of the effectiveness of RJCB behavior at the time of finishing (Figure 2), the evaluation of DMs was identified as the first predictive variable for achieving defensive success. Significant differences ($p < .001$, $x2 = 26.471$, $gl = 1$) were observed between the two types of DMs, with a predominance of adjusted DMs (69.3%) over unadjusted DMs (30.7%). At node 0, it is necessary to highlight the success of RJCB defensive actions to avoid shots (66.9%) with respect to those of failure (33.1%).

When the DMs were adjusted (node 1) the percentage of success in defense (74.7%) was higher than failure (25.3%), while in the unadjusted DMs (node 2) the defensive results were similar in failure (50.8%) and success (49.2%), despite the DMs were unadjusted, there was a 49.2% chance of getting the ball successfully. In the adjusted DMs the stopper (TB) (node 4) left a high percentage of success (68.4%).

Table 2. Level of adjustment of the JCB's shots according to ESB game system

Defensive Game Systems		Shooter Assesment		
		Adjusted	Unadjusted	Total
Unorganized	Count	97	14	111
	% within organisation	87.4	12.6	100%
	Adjusted residuals	3.2*	-3.2	
Man-to-man	Count	145	60	205
	% within organisation	70.7	29.3	100%
	Adjusted residuals	-2.7*	2.7	
Mixed	Count	23	8	31
	% within organisation	74.2	25.8	100%
	Adjusted residuals	-.3	.3	
Zone	Count	42	13	55
	% within organisation	76.4	23.6	100%
	Adjusted residuals	.0	.0	
TOTAL	Count	307	95	402
	% within organisation	76.4	23.6	100%

***** ($p < .001$)

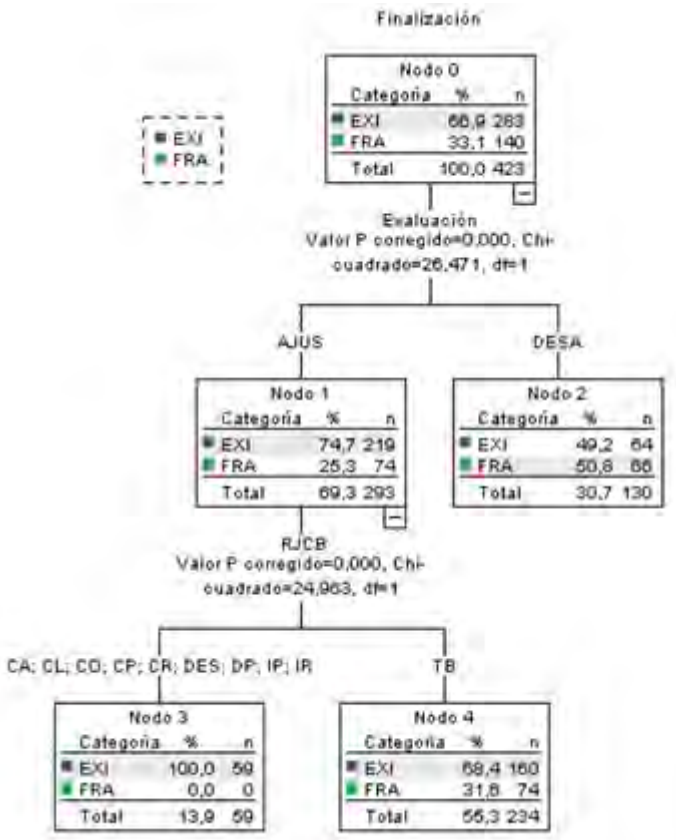

Figure 2. Influence of RJCB DM on the performance of defensive finishing
Note: EXI (success); FRA (failure); DESA (unadjusted); AJUS (adjusted); RJCB (rival of the player with the ball); CA (forward controller); CL (collaborator); CO (one-on-one defender); CP (pass controller); CR (reception controller); DES (stealer); DP (pass denier); IP (pass interceptor); IR (reception interceptor); TB (shoot blocker)

RJCB Finishing: Relationship between the level of adjustment of RJCB DMs and ESB defensive systems

Of all the DMs of the RJCB, attention is focused on those linked to the Shot Blocker (TB) to study the confrontation between the attacker and the defender at the moment of shooting.

When analyzing the relationship between the TB level of adjustment and the ESB game systems (Table 3), it was observed that there was no statistically significant relationship between both variables (x2 = 6.036; gl = 3; p = .110). However, a trend towards adjusted DMs was observed in all the ESB game systems (unorganized defense = 54.5%; man-to-man = 69.2%; mixed = 59.4%; zone = 63.9%) but less than in the JCB DMs.

Table 3. Level of adjustment of the Shot blocker according to ESB's defensive system

Defensive Game Systems		Shot Blocker Assessment		Total
		Adjusted	Unadjusted	
Unorganized	Count	48	40	88
	% within organisation	54.5	45.5	100.0%
	Adjusted residuals	-2.1	2.1	
Man-to-man	Count	139	62	201
	% within organisation	69.2	30.8	100.0%
	Adjusted residuals	2.1	-2.1	
Mixed	Count	19	13	32
	% within organisation	59.4	40.6	100.0%
	Adjusted residuals	-.6	.6	
Zone	Count	53	30	83
	% within organisation	63.9	36.1	100.0%
	Adjusted residuals	-.1	.1	
TOTAL	Count	259	145	404
	% within organisation	64.1	35.9	100.0%

Discussion

The objectives of this research were, firstly, to study the predictive variables of the performance in shooting at the basket. Secondly, to study the predictive variables to prevent success in the opposing team's drives to the basket and, finally, to evaluate the level of adjustment of the TDM linked to the finishing of the JCB and the RJCB according to the LE proposed by the coach.

How to be successful at shooting in basketball?

The first variable that predicted success finishing was that the shot taken was adjusted to the LE proposed by the coach. This data confirms the importance of following the coach's indications and that the players make shots that are framed in the idea of collective play (Serna et al., 2021). It could be affirmed the idea that following the LE and making shots that have a collective game thinking approach towards success (Serna et al., 2017).

The results obtained suggest that the coach's LE can help to find the shot in a comfortable situation for the shooter, but, in the end, the success of the attack will depend, fundamentally, on the individual competence of the player in this DM. It is for this reason that basketball should be called an opposition-cooperation sport since the LE of the team (cooperation relationship) is at the service of individual competition in reaching the protected space of the opposing team (opposition relationship) (Serna et al., 2017).

JCB TDM in accordance with the LE proposed by the coach

As confirmed in previous research (Serna et al., 2014), each coach's LE will originate a singular tendency of the players' TDM. Therefore, it is necessary that players have the ability to adapt their TDM according to the changing situations as they arise in the real game situation (Courel-Ibáñez et al., 2017; Jiménez-Sanchez et al., 2012).

This confirms the contributions of previous research (Serna et al., 2014), which observed a clear predominance of adjusted DMs, an aspect that confirms that the players generally respected the LE proposed by the coach. The reason for such a high frequency of adjusted JCB DMs in these investigations could be due to a low level of opposition on the part of the RJCB because the matches studied were friendly or training matches, confirming the contributions of other investigations (Dawson et al., 2004).

One of the findings of this study was that the best shots were made in the Unorganized system, i.e. in fastbreaks. This fact can be intrerpreted, probably, thanks to the lack of organization of the defending team in this type of situation, which allows non- defended shots and, therefore, with a higher probability of success (Erčulj & Štrumbelj, 2015; Gómez et al., 2015; Ortega, 2010). In contrast, the individual defense was the one that caused less comfortable shots due to the fact that it is a proximity-oriented defense in the individual duel (Csataljay et al., 2013).

How to make the ESB a success?

This research confirms that the variable that best predicts the success of the ESB is the level of adjustment of the DMs to the coach's LE, which reinforces the idea of following the LE to achieve success getting the ball (Serna et al., 2017).

Of all the DMs studied linked to the RJCB finishing, Shot Blocker has to be logically highlighted. The results obtained show that blok shots in a tight way achieves a high percentage of success for the ESB. Therefore, it is essential to maintain the opposition until the last instant of the JCB shots, as indicated by different investigations (Fierro, 2002; Gómez et al., 2006; Sampaio et al., 2004).

In spite of the RJCB DMs being unadjusted, there was a 49.2% probability of successfully getting the ball. From this data, it can be deduced that the ESB could be successful not because it had made good decisions but because the JCB did not have a sufficient level of success. Thus, the importance of shotting performance as a fundamental variable in this sport is reiterated (Erčulj & Štrumbelj, 2015; Gómez et al., 2015).

RJCB TDM in accordance with the LE proposed by the coach

When delving deeper into the RJCB MDs, a predominance of adjusted MDs was observed. Previous research (Serna et al., 2014) had found a percentage close to 50% of unadjusted DMs when studying all the RJCB DMs, confirming that, for different reasons, there was no syntony between all the coach's LE and the players' behavior. However, in this

research, where the focus is placed on the moment of finishing and only on the DM of blocking (not only valued as the fact of touching the ball but also as trying to disturb the opponent's shot as much as possible), it is observed that the tendency is to follow the coach's LE. These findings open a reflection for coaches based on defining which are the key DMs of the RJCB and where the coach's ESB LE has to put the focus of attention (Serna & Muñoz, 2015). It should be taken into account that, in this research, in two of the four matches, the RJCB was aware of the offensive LE of his opponent (training matches) with which he could have clues to be able to anticipate in some situation.

To conclude, it is observed that the intention to block or bother the shot is a DM that depends on the individual competence of the player, independently of the coach's game system. Therefore, it is a key DM in the training of players that will have a transfer to any game system proposed by the coach (Serna & Muñoz, 2015).

Conclusions

From all the above it can be concluded that for sports performance in team sports such as basketball it is essential to have defined, by the coach, a strategic plan or LE and objectively evaluate whether the players respect this plan. These data will provide key information for the training process of the team and of each player in particular.

This study has identified that the variable that best predicts the success of both the ECB and ESB is that the players follow the coach's LE. When studying both the JCB and RJCB the variable that best predicts success is the correct decision making of the players, ahead of the particular system of play proposed by the coach.

A clear trend of adjusted DMs of both JCB and RJCB has also been found, a fact that confirms that players respect the coach's LE.

It could be argued in this research that the shot-block binomial is a relationship that is independent of the coach strategy and depends primarily on individual competence of both JCB and RJCB rather than on the coach's LE.

Acknowledgments

This study has been funded by the Ministry of Science and Innovation through projects DEP2010-21626-C03-01, DEP2010-21626-C03-02, DEP2010-21626-C03-03.

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CULTURA, CIENCIA Y DEPORTE

Análisis decisional de la finalización en baloncesto

Decisional analysis of finishing in basketball

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Título abreviado:
Finalización en baloncesto

Cómo citar el artículo:
Serna, J., Muñoz-Arroyave, V., March-Llanes, J., & Lavega-Burgués, P. (2022). Análisis decisional de la finalización en baloncesto. *Cultura, Ciencia y Deporte, 17*(53), 173-192. https://doi.org/10.12800/ccd.v17i53.1896

Recibido: 29 marzo 2022 / Aceptado: 15 junio 2022

Resumen

El presente estudió investigó la toma de decisiones motrices vinculadas al lanzamiento y al tapón del jugador de baloncesto en función de la Lógica Estratégica propuesta por el entrenador. Participaron 13 jugadores de un equipo de Liga EBA entre 18 y 28 años de edad en la temporada 2010-2011. Se analizaron todas las decisiones que tomaba el jugador con balón y su rival (defensor) en 4 partidos (2 amistosos y 2 de entrenamiento) mediante el instrumento ad hoc denominado SODB. Entre las conclusiones más relevantes se destaca: a) una clara tendencia en la toma de decisiones ajustadas tanto del jugador con balón como del rival del jugador con balón, confirmando que los jugadores respetaban el plan estratégico del entrenador; b) la variable que ayudó a predecir el éxito tanto del jugador con balón como del rival del jugador con balón fue la correcta toma de decisiones de los jugadores más que el sistema de juego utilizado; c) lanzar y taponar de manera ajustada a la Lógica Estratégica del entrenador tiene relación con el éxito; y finalmente, d) el binomio lanzamiento-tapón es una relación que depende más de la competencia individual de los jugadores implicados que de la Lógica Estratégica del entrenador.

Palabras clave: análisis observacional, toma de decisiones, sistema de juego, análisis del rendimiento táctico, estrategia del entrenador.

Abstract

The present study investigated the decision making linked to the basketball player's shooting and blocking shots based on the Strategic Logic proposed by the coach. A Spanish team which played in EBA League was studied in 4 games in the 2010-2011 season. 7440 motor decisions (ballhandler decisions and his defender) were analyzed using the ad hoc instrument called SODB. Among the most relevant conclusions it is worth mentioning: a) the importance of having a well-defined Coach's Strategic Logic in both offense and defense; b) the interest of assessing the match between the Coach's Strategic Logic and the players' individual decision making; c) a clear trend in the tight decision making of both the ballhandler (offensively) and the player who block shots (defensively) , confirming that the players respected the Coach's Strategic Logic; d) the main variable that helped predict the success of both the ballhandler and the rival of the ballhandler was the correct decision making of the players rather than the game system used; e) shooting and blocking shots in a correct way (following Coach's Strategic Logic) is related to success; and finally, f) the shot-block binomial is a relationship that depends more on the individual competence of the players involved than on the Coach's Strategic Logic.

Keywords: observational methodology, decision making process in basketball, tactical performance analysis, coach's strategy.

Introducción

El baloncesto ha sido tradicionalmente clasificado desde un punto de vista del tipo de relación motriz que se establece, como un deporte de cooperación - oposición (Parlebas, 2001). Pero, debido a que la oposición es la relación clave que modifica el marcador del partido y la que finalmente determina quién es el ganador y el perdedor del duelo, este deporte también puede ser interpretado como un deporte de oposición-cooperación (Serna et al., 2017). En este tipo de duelos, Lavega (2004) argumenta que al enfrentarse dos equipos, se activan en los deportistas una serie de procesos como puede ser la lectura e interpretación de las decisiones tanto de los compañeros como de los adversarios, la emisión de mensajes para que los compañeros los descifren, enviar mensajes erróneos para confundir a los rivales, descodificar mensajes de los rivales, la adaptación a la incertidumbre; en definitiva, se activa el proceso de la toma de decisiones motrices (TDM) de los jugadores (Arias-Estero et al., 2018; Courel-Ibáñez et al., 2018; Suárez-Cadenas et al., 2017) y en consecuencia su inteligencia motriz (Serna et al., 2014).

Como aportan otras investigaciones (Arias-Estero et al., 2018; Courel-Ibáñez et al., 2017; Dugas, 2006; Gréhaigne et al., 2001; Gamero et al., 2021; Jiménez-Sánchez et al., 2012; Lasierra et al., 2020) resulta interesante que los entrenadores puedan tener instrumentos de medición de la TDM de sus jugadores con la finalidad de, en primer lugar, diagnosticar correctamente a sus jugadores y, en segundo lugar, programar de forma óptima las tareas de sus entrenamientos de cara a mejorar esas decisiones motrices (DM) concretas. Para proceder a esta evaluación de la TDM de los jugadores en baloncesto Serna et al. (2014) aportan que es necesario definir las posibles DM que puede tomar un jugador de baloncesto distinguiendo cuatro roles estratégicos, dos asociados al equipo atacante (jugador con balón y jugador sin balón) y otros dos asociados al equipo defensor (rival del jugador con balón o rival del jugador sin balón).

De este número limitado de DM que un jugador de baloncesto puede realizar, en esta investigación se trató de poner la atención en los roles estratégicos que pueden alterar de manera más directa el marcador como son el jugador con balón (JCB) y el rival del jugador con balón (RJCB); es decir, aquellos jugadores que pueden anotar o pueden evitar la anotación del rival. Es por ello que se podría decir que la competencia del JCB vendrá muy influenciada tanto por su correcta toma de decisión a la hora de realizar el lanzamiento como la eficacia en el momento de lanzar (anotar); y exactamente lo mismo el RJCB, el cual deberá ser competente en tomar las DM correctas para evitar el lanzamiento del rival y eficaz para taponar o molestar en la mayor medida posible el lanzamiento de su rival (Serna y Muñoz, 2015).

En este escenario, el entrenador de baloncesto tiene que ayudar a los jugadores a poner un orden colectivo que favorezca la cooperación entre los miembros del mismo equipo. Es por ello, que los entrenadores diseñan una Lógica Estratégica (LE) específica de su equipo. Esta LE pretende crear una guía para los jugadores con el objetivo de alcanzar el éxito colectivo (Muñoz et al., 2015; Serna et al., 2021). La elaboración de esta LE, tendrá en cuenta las características individuales de los jugadores y deberá organizar la TDM de estos, para que el equipo funcione de manera coordinada y armónica (Serna y Muñoz, 2015; Lasierra et al., 2020).

La LE está compuesta por una organización del juego cuando el equipo es atacante y otra cuando el equipo es defensor. El objetivo de la LE del equipo atacante (ECB) es finalizar anotando gracias, en gran medida, a finalizar con lanzamientos sin oposición o con la mayor ventaja posible (Alsasua et al., 2022; Gómez et al., 2013; Ibáñez et al., 2009); mientras que el objetivo del equipo defensor (ESB), es la recuperación del balón, el tapón o, al menos, molestar el lanzamiento (puntear) del equipo rival y, en el caso de producirse, controlar el rebote defensivo (Gómez et al., 2006; Leite et al., 2014).

La LE, tanto del ECB como del ESB, debe tener en cuenta las diferentes fases de juego (contraataque, transición y juego posicional) (Gómez et al., 2013; Piñar et al., 2014). Desde el punto de vista de la TDM de los jugadores del ECB, no es lo mismo atacar ante una situación de desorganización del ESB (contraataque), que ante una situación de reorganización momentánea del equipo rival (transición ofensiva) o en una situación de clara organización (ataque posicional) (Gómez et al., 2013). Paralelamente, la LE del ESB debe tener estructurado cómo reorganizarse en el balance defensivo (en esta investigación, denominada defensa Desorganizada), cómo actuar en la transición defensiva y, por supuesto, la organización y las normas en la defensa posicional (Gómez et al., 2006).

Cuando el ESB está situado en una organización posicional, hay diferentes tipos de sistemas defensivos en función de si defiende en una organización individual (cada jugador defiende a un rival), zonal (cada jugador es responsable de un espacio defensivo) o mixta (algunos jugadores están en individual y otros en zonal) (Gómez et al., 2006). Estas posibilidades estratégicas del ESB exigirán ajustes de los jugadores en su TDM ya que cada sistema defensivo tiene singularidades. De la misma manera que enfrentarse a estos sistemas defensivos provocará ajustes en la LE del ECB ya que tendrá que ajustar su sistema de juego ofensivo y, por tanto, su TDM, en función de la defensa a la que se enfrente; ya que no es lo mismo atacar contra una defensa individual que contra una defensa zonal o una defensa mixta (Serna et al., 2014; Serna & Muñoz, 2015).

Asimismo, con el objetivo de mejorar el rendimiento del equipo y de cada uno de sus jugadores, se debería evaluar si la TDM de los jugadores se ajusta a la LE propuesta por el entrenador. La TDM de los jugadores debe tener concordancia con la LE del entrenador, pero sin adoptar una actitud de sumisión. Se trata de ajustar las decisiones de modo lógico y eficaz con el objetivo final de resolver favorablemente la situación motriz en concreto (Serna y Muñoz, 2015).

Por tanto, estas DM individuales pueden ser categorizadas como: a) DM ajustadas (DM aceptadas por la LE definida por el entrenador); b) DM desajustadas (DM no aceptadas por la LE definida por el entrenador); y, c) DM antirreglamentarias (DM que violan el reglamento y deberían ser sancionadas por el árbitro) (Serna et al., 2014).

Por todo lo expuesto anteriormente, los objetivos de esta investigación fueron: a) estudiar las variables predictivas para obtener el éxito en los lanzamientos a canasta; b) estudiar las variables predictivas para impedir el éxito en los lanzamientos a canasta del equipo rival; y, c) evaluar cual fue el nivel de ajuste de las DM vinculadas a la finalización del JCB y del RJCB en función de la LE propuesta por el entrenador.

Método

El diseño de esta investigación fue nomotético ya que se analizó a cada uno de los jugadores, de seguimiento

porque se observaron varios partidos y multidimensional al considerar diferentes niveles de respuesta dentro del instrumento de observación (Anguera et al., 2011).

Participantes

La muestra estuvo compuesta por 13 jugadores de un equipo de Liga EBA de la temporada 2010-2011, con un rango de edad entre 18 y 28 años, (Medad = 22.3 años, DT = 3.12). Se disputaron cuatro partidos no oficiales (dos partidos amistosos y dos de entrenamiento) que se filmaron y posteriormente se analizaron. Todos los participantes dieron su consentimiento para participar voluntariamente en esta. La muestra observacional fue de 7440 registros, de estos, se analizaron los datos vinculados con la finalización tanto del JCB como del RJCB. Por eso, finalmente se procedieron a estudiar con mayor profundidad: 468 DM del JCB y 423 DM del RJCB.

Procedimiento e instrumento

Para identificar las DM del JCB y del RJCB se utilizó el Sistema de Observación de las Decisiones en Baloncesto (SODB). Es un sistema, basado en la Metodología Observacional *ad hoc* que evalúa las decisiones que toman los jugadores en la pista de baloncesto en función del sistema de juego del entrenador (Serna et al., 2013). Este sistema de observación está compuesto por 5 criterios y 40 categorías (tabla 1). El tratamiento de las imágenes se realizó con el programa MOTS (Castellano et al., 2008) el cual permitió la utilización del instrumento SODB registrando el tiempo de cada observación y creando matrices de códigos recogidos en una hoja Excel.

Análisis de los datos

Para el análisis de los datos, se llevaron a cabo tablas de contingencia utilizando los residuos ajustados cuando fue necesario, como estadístico de contraste en el caso de pruebas univariantes. También se empleó la técnica denominada árboles de clasificación CHAID 9 (detector de interacción automática de Chi-cuadrado) como técnica para analizar el efecto de la variable independiente sobre la dependiente, en este caso, se aplicó un sistema de validación cruzada y se consideró 50 como número mínimo de casos en los nodos terminales, y 100 casos en los nodos filiales. Otras características fueron: control de tamaño del árbol (tamaño mínimo de nodo tamaño de divisiones: 10; niveles máximos de árbol: 3), método de validación (10 veces validación cruzada) y significación estadística ($p < .05$), las demás opciones fueron aplicadas con los parámetros por defecto del programa. Se empleó el módulo de Answer-Tree® SPSS Árboles de Clasificación ™ 13.0

Resultados

Finalización del JCB: Variables predictivas de la eficacia

Para estudiar la eficacia en la finalización del JCB, se identificaron como lanzamientos exitosos los que acabaron en canasta o con falta recibida en la acción de tiro, mientras que el fracaso fue identificado cuando se produjo error (fallo) en el lanzamiento o pérdida en la posesión del balón.

Tabla 1. Criterios y categorías del instrumento de observación SODB

Jugador	Categoría de observación
Sistema del equipo sin balón (ESB)	Individual (IND)
	Zonal (ZON)
	Mixta (MIX)
	Desorganizada (DSC)
DM del jugador con balón (JCB)	Pasador (PS)
	Receptor (REC)
	Progresador (PG)
	Protector (PT)
	Recuperador de ataque (REP)
	En Desmarque de oposición (DO)
	En Desmarque de Coop.- Opos. (DC)
	Temporizador (TP)
	Lanzador (LZ)
	Reboteador de ataque (RA)
DM del rival del jugador con balón (RJCB)	Interceptador de pase (IP)
	Disuador de pase (DP)
	Controlador de pase (CP)
	Interceptador de recepción (IR)
	Disuador de recepción (DR)
	Controlador de recepción (CR)
	Controlador de avance (CA)
	Orientador (OR)
	Desposeedor (DES)
	Controlador de oposición (CO)
	Controlador de cooperación-oposición (CCO)
	Controlador de temporización (CT)
	Taponador (TB)
	Doblador (DB)
	Colaborador (CL)
	Recuperador de defensa (RD)
	Reboteador en defensa (RB)
Evaluación de TDM	Ajustada (AJUS)
	Desajustada (DESA)
	Antirreglamentaria (ANTI)
Finalización	Éxito (EXI)
	Fracaso (FRA)

Los árboles de clasificación CHAID (figura 1) identificaron la evaluación de las DM como la primera variable predictiva de la eficacia en la finalización del JCB. Se observaron diferencias significativas ($p < .001$, $x^2 = 86.516$, gl = 1) entre las DM ajustadas (65.6%) y las DM desajustadas (34.4%). Cuando las DM fueron ajustadas (nodo 2), el porcentaje de éxito fue superior (61.2%) al de fracaso (38.8%), mientras que en las DM desajustadas (nodo 1) (se incluyen lanzamientos y pérdidas de la posesión del balón) esta tendencia se invirtió, ya que esas finalizaciones fracasaron en la mayoría de las veces (83.9%) y tuvieron éxito en un porcentaje mucho menor (16.1%). Sólo el 27.4% de las DM desajustadas (nodo 4), finalizaron con lanzamientos en éxito, a diferencia del 72.6% que fueron errados.

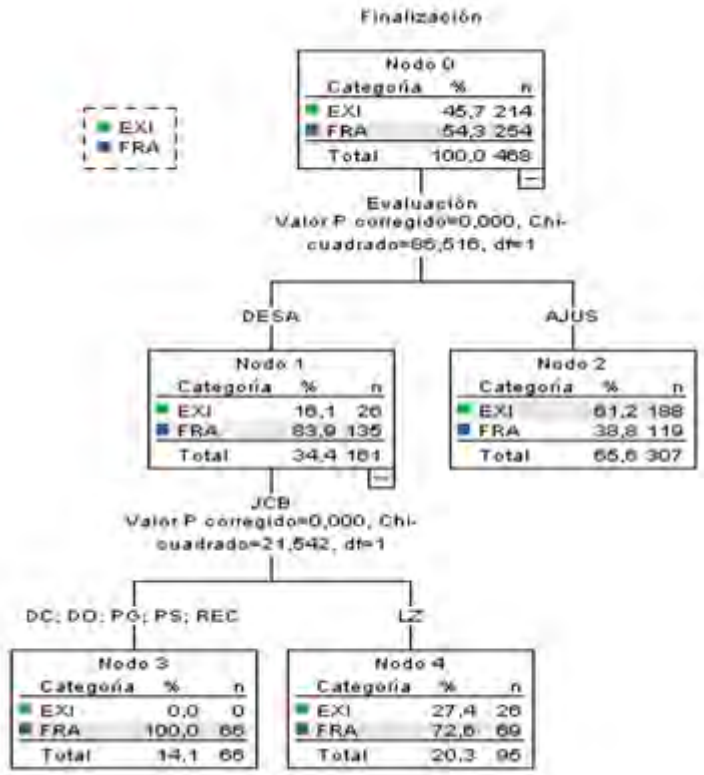

Figura 1. Influencia de la DM del JCB en el éxito de la finalización ofensiva
Nota: EXI (éxito); FRA (fracaso); DESA (desajustada); AJUS (ajustada); JCB (jugador con balón); DC (en desmarque de cooperación-oposición); DO (en desmarque de oposición); PG (progresador); PS (pasador); REC (receptor)

Finalización del JCB: Relación entre nivel de ajuste de DM y sistemas defensivos del ESB

Al analizar con mayor profundidad el nivel de ajuste de dichas DM vinculadas a la finalización del JCB ante los diferentes sistemas de juego del ESB (tabla 2) se encontró, en primer lugar, que las DM en las finalizaciones fueron mayoritariamente ajustadas (76.4%) en comparación con las desajustadas (23.6%) en todas las situaciones analizadas. En segundo lugar, se encontró una relación estadísticamente significativas entre estas variables (x^2 = 11.158; gl = 3; p= .011), concretamente entre las DM que se toman en situaciones desorganizadas (cuando el JCB finaliza en contraataque) y las DM que se producían en el sistema de juego individual.

Finalización del RJCB: Variables predictivas de la eficacia

Para estudiar la eficacia en la conclusión o finalización del RJCB, se identificaron como DM exitosas aquellas DM que permitían o bien recuperar el balón o bien provocar un lanzamiento errado del equipo rival. El fracaso fue identificado cuando se produjo una canasta por parte del equipo atacante.

Al estudiar la fuerza predictiva de la eficacia del comportamiento del RJCB en el momento de la finalización (figura 2), se identificó la evaluación de las DM como la primera variable predictiva para conseguir el éxito defensivo. Se observaron diferencias significativas (p < .001, x^2 = 26.471, gl = 1) entre los dos tipos de DM, con un predominio de las DM ajustadas (69.3%) sobre las DM desajustadas (30.7%). En el nodo 0 es necesario destacar el éxito de las acciones defensivas del RJCB para evitar las finalizaciones (66.9%) respecto a las de fracaso (33.1%).

Cuando las DM fueron ajustadas (nodo 1) el porcentaje de éxito en la defensa (74.7%) fue superior al de fracaso (25.3%), mientras que en las DM desajustadas (nodo 2) los resultados defensivos fueron parecidos en el fracaso (50.8%) y en el éxito (49.2%), a pesar de que las DM fueron desajustadas, hubo un 49.2% de probabilidades de recuperar el balón de manera exitosa. En las DM ajustadas el taponador (TB) (nodo 4) dejó un alto porcentaje de éxito (68.4%)

Tabla 2. Nivel de ajuste de los lanzamientos del JCB en función del sistema de juego del ESB

Sistemas de juego		Evaluación Lanzador		Total
		Ajustadas	Desajustadas	
Desorganizado	Recuento	97	14	111
	% dentro de organización	87.4	12.6	100%
	Residuos corregidos	3.2*	-3.2	
Individual	Recuento	145	60	205
	% dentro de organización	70.7	29.3	100%
	Residuos corregidos	-2.7*	2.7	
Mixto	Recuento	23	8	31
	% dentro de organización	74.2	25.8	100%
	Residuos corregidos	-.3	.3	
Zonal	Recuento	42	13	55
	% dentro de organización	76.4	23.6	100%
	Residuos corregidos	.0	.0	
TOTAL	Recuento	307	95	402
	% dentro de organización	76.4	23.6	100%

Nota: * (p< .001)

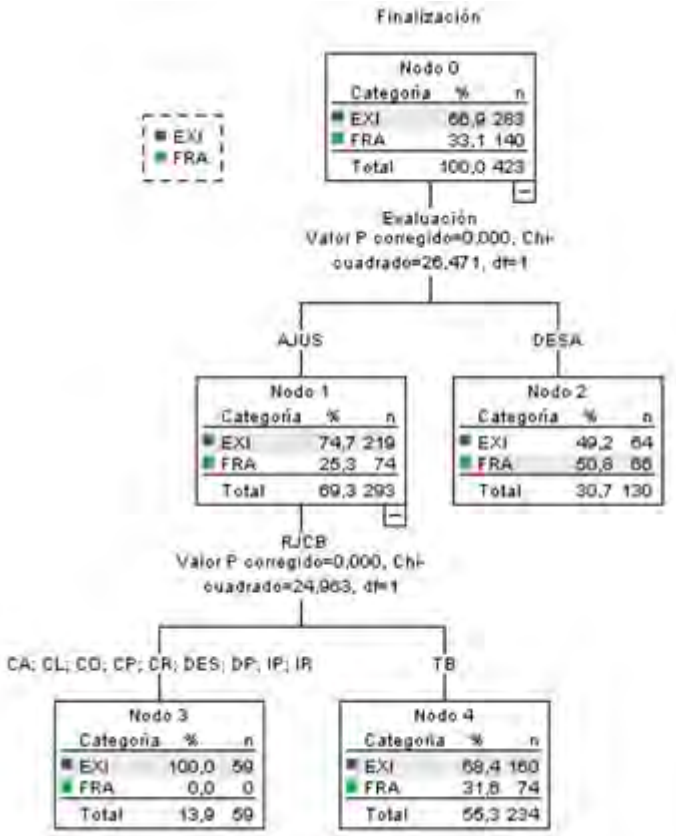

Figura 2 . Influencia de la DM del RJCB en el éxito de la finalización defensiva

Nota: EXI (éxito); FRA (fracaso); DESA (desajustada); AJUS (ajustada); RJCB (rival del jugador con balón); CA (controlador de avance); CL (colaborador); CO (controlador de oposición); CP (controlador de pase); CR (controlador de recepción); DES (desposeedor); DP (disuador de pase); IP (interceptador de pase); IR (interceptador de recepción); TB (taponador)

Finalización del RJCB: Relación entre el nivel de ajuste de las DM del RJCB y los sistemas defensivos del ESB

De todas las DM del RJCB se centra la atención en las vinculadas al Taponador (TB) para estudiar el enfrentamiento entre el atacante y el defensa en el momento de la finalización.

Al analizar la relación entre el nivel de ajuste del TB y los sistemas de juego del ESB (tabla 3) se observó que no hubo relación estadísticamente significativa entre ambas variables (x^2 = 6.036; gl = 3; p = .110). Sin embargo, se observó en todos los sistemas de juego del ESB una tendencias a las CMD ajustadas (desorganizado = 54.5%; individual = 69.2%; mixto = 59.4%; zonal = 63.9%) pero menor que en las DM del JCB.

Tabla 3. Nivel de ajuste del Taponador en función del sistema defensivo del ESB

Sistemas de juego		Evaluación Taponador		Total
		Ajustadas	Desajustadas	
Desorganizado	Recuento	48	40	88
	% dentro de organización	54.5	45.5	100.0%
	Residuos corregidos	-2.1	2.1	
Individual	Recuento	139	62	201
	% dentro de Organización	69.2	30.8	100.0%
	Residuo corregido	2.1	-2.1	
Mixto	Recuento	19	13	32
	% dentro de Organización	59.4	40.6	100.0%
	Residuo corregido	-.6	.6	
Zonal	Recuento	53	30	83
	% dentro de Organización	63.9	36.1	100.0%
	Residuo corregido	-.1	.1	
TOTAL	Recuento	259	145	404
	% dentro de Organización	64.1	35.9	100.0%

Discusión

Los objetivos de esta investigación fueron, en primer lugar, estudiar las variables predictivas de la eficacia en los lanzamientos a canasta. En segundo lugar, estudiar las variables predictivas para impedir el éxito en los lanzamientos a canasta del equipo rival.Y, finalmente, evaluar el nivel de ajuste de la TDM vinculadas a la finalización del JCB y del RJCB en función de la LE propuesta por el entrenador.

¿Cómo obtener el éxito en los lanzamientos a canasta?

La primera variable que predijo el éxito en la finalización es que el lanzamiento realizado fuese ajustado a la LE propuesta por el entrenador. Este dato confirma la importancia de seguir las indicaciones del entrenador y que los jugadores hagan lanzamientos que se enmarquen en la idea de juego colectivo (Serna et al., 2021). Se podría afirmar la idea que seguir la LE y hacer lanzamientos que tengan un pensamiento de juego colectivo aproximan hacia el éxito (Serna et al., 2017).

Los resultados obtenidos sugieren que la LE del entrenador puede ayudar a encontrar el lanzamiento en una situación cómoda para el tirador, pero, al final, el éxito del ataque dependerá, fundamentalmente, de la competencia individual del jugador en esta DM. Es por este motivo que el baloncesto debería ser denominado deporte de oposición-cooperación ya que la LE del equipo (relación de cooperación) está al servicio de la competencia individual en alcanzar el espacio protegido del equipo rival (relación de oposición) (Serna et al., 2017).

TDM del JCB en función de la LE propuesta por el entrenador

Tal y como se confirmó en investigaciones anteriores (Serna et al., 2014), cada LE de los entrenadores originará una tendencia singular de la TDM de los jugadores. Por tanto, es necesario que los jugadores tengan la capacidad de adaptar su TDM en función de las situaciones cambiantes que se van presentando en la situación real de juego (Courel-Ibáñez et al., 2017; Jiménez-Sanchez et al., 2012).

Se confirman las aportaciones de investigaciones previas (Serna et al., 2014), que observaron un claro predominio de las DM ajustadas, aspecto que confirma que los jugadores respetaban, en líneas generales, la LE propuesta por el entrenador. El motivo de esa frecuencia tan elevada de DM del JCB ajustadas en estas investigaciones, podría deberse a un bajo nivel de oposición por parte del RJCB debido a que los partidos estudiados eran amistosos o de entrenamiento, confirmando las aportaciones de otras investigaciones (Dawson et al., 2004).

Un hallazgo de este estudio fue que los lanzamientos en mejores condiciones fueron realizados ante el sistema Desorganizado, es decir en contraataque. Este hecho puede ser intrerpretado, probablemente, gracias a la falta de organización del equipo defensor en este tipo de situaciones, que permite lanzamientos sin oposición y, por tanto, con mayor probabilidad de éxito (Erčulj y Štrumbelj, 2015; Gómez et al., 2015; Ortega, 2010). En cambio, la defensa individual fue la que provocó lanzamientos menos cómodos debido a que es una defensa orientada a la proximidad en el duelo individual (Csataljay et al., 2013).

¿Cómo conseguir el éxito del ESB?

Esta investigación confirma que la variable que mejor predice el éxito del ESB es el nivel de ajuste de las DM a la LE del entrenador con lo que se refuerza la idea de seguir la LE para conseguir el éxito en la recuperación del balón (Serna et al., 2017).

De todas las DM estudiadas vinculadas a la finalización del RJCB, se tiene que destacar, lógicamente, taponar. Los resultados obtenidos muestran que al taponar de una manera ajustada se consigue un alto porcentaje de éxito para el ESB. Por tanto, es fundamental mantener la oposición hasta el último instante del lanzamiento del JCB, tal y como lo indican diferentes investigaciones (Fierro, 2002; Gómez et al., 2006; Sampaio et al., 2004).

A pesar de que las DM del RJCB fuesen desajustadas, había un 49.2% de probabilidades de recuperar el balón de manera exitosa. De este dato se deduce que el ESB podía tener éxito no porque hubiera tomado buenas decisiones sino porque el JCB no tuvo el nivel de acierto suficiente. De esta manera, se reitera la importancia de la eficacia en el lanzamiento como variable fundamental en este deporte (Erčulj y Štrumbelj, 2015; Gómez et al., 2015).

TDM del RJCB en función de la LE propuesta por el entrenador

Al profundizar en las DM del RJCB, se observó un predominio de las DM ajustadas. En anteriores investigaciones (Serna et al., 2014) se había encontrado un porcentaje próximo al 50% de DM desajustadas al estudiar todas las DM del RJCB, confirmando que, por diferentes motivos, no había sintonía entre toda la LE del entrenador y el comportamiento de los jugadores. Pero, en esta investigación, donde se pone la atención en el momento de la finalización y únicamente en la DM de taponar (no valorada únicamente como el hecho de tocar el balón sino el tratar de molestar al máximo el lanzamiento del rival), se observa que la tendencia es a seguir la LE del entrenador. Estos hallazgos abren una reflexión para los entrenadores basada en definir cuáles son las DM clave del RJCB y dónde tiene que poner el foco de atención la LE del ESB del entrenador (Serna y Muñoz, 2015). Se ha de tener en cuenta que, en esta investigación, en dos de los cuatro partidos, el RJCB era conocedor de la LE ofensiva de su rival (partidos de entrenamiento) con lo que podría tener indicios para poder anticiparse en alguna situación.

Para finalizar, se observa que la intención de taponar o molestar el lanzamiento es una DM que depende de la competencia individual del jugador, independientemente del sistema de juego del entrenador. Es por ello, que es una DM clave en el entrenamiento de los jugadores que tendrá transferencia a cualquier sistema de juego que proponga el entrenador (Serna y Muñoz, 2015).

Conclusiones

Por todo lo anterior se puede concluir que para el rendimiento deportivo en deportes de equipo como el baloncesto es fundamental tener definido, por parte del entrenador, un plan estratégico o LE y evaluar de manera objetiva si los jugadores respetan dicho plan. Estos datos ofrecerán una información clave para el proceso de entrenamiento del equipo y de cada uno de los jugadores de manera particular.

Este estudio ha identificado que la variable que mejor predice el éxito tanto del ECB como del ESB es que los jugadores sigan la LE del entrenador. Al estudiar tanto al JCB como al RJCB la variable que mejor predice el éxito es la correcta toma de decisiones de los jugadores, por delante del sistema de juego concreto propuesto por el entrenador.

También se ha encontrado una tendencia clara de las DM ajustadas tanto del JCB como del RJCB, hecho que confirma que los jugadores respetan la LE del entrenador.

Se podría afirmar en esta investigación que el binomio lanzamiento–tapón es una relación independiente del sistema de juego y que depende fundamentalmente de la competencia individual, tanto del JCB como del RJCB más que de la LE del entrenador.

Agradecimientos

Este estudio ha sido financiado por el Ministerio de Ciencia e Innovación a través de proyectos los proyectos DEP2010-21626-C03-01, DEP2010-21626-C03-02, DEP2010-21626-C03-03.

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Evaluation of anthropometric parameters in a national sample of Mexican older adults

Evaluación de los parámetros antropométricos en una muestra nacional de adultos mayores mexicanos

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Short title:
Anthropometric assessment of Mexican older adults

How to cite this article:
López-Solís, R., Villa-Romero, A.R., Martínez-Salazar, M.F., Bautista-Ortiz, L.F., Adame, J.F.J., Antunez-Bautista, P.K., Ortiz-Rodríguez, M.A. (2022). Evaluation of anthropometric parameters in a national sample of Mexican older adults. *Cultura, Ciencia y Deporte*, *17*(53), 193-201. https://doi.org/10.12800/ccd.v17i53.1846

Received: 17 december 2021 / Accepted: 22 june 2022

Abstract

The purpose of this study was to describe anthropometric parameters in a population of Mexican older adults (OA). 516 OA (277 women, 239 men) aged ≥ 65 years were interviewed. Anthropometry and a sociodemographic data questionnaire were performed. Means and standard deviations, prevalence (%) and confidence intervals are reported in the results. SPSS v20.0 was used in the statistical analysis. The combined prevalence of overweight and obesity in our population was 77%. The mean WHR values obtained were (0.97 in men and 0.89 in women). Finally, the percentage of fat in men was 30.6% and in women it was 39.8%. The results of this investigation showed significant differences between men and women in most of the anthropometric measures and nutrition indicators. The prevalence of overweight and obesity reported in the Mexican elderly population was higher than that reported in other studies, which shows an important public health problem in Mexican older adults. More studies are needed at the national level on nutritional parameters in the elderly in order to detect cardiovascular risk factors in a timely manner.

Keywords: anthropometry, nutritional surveys, mexican older adults.

Resumen

El propósito de este estudio fue describir los parámetros antropométricos en una población de adultos mayores (AM) mexicanos. Se entrevistó a 516 AM (277 mujeres, 239 hombres) con ≥ 65 años de edad. Se realizó antropometría, y un cuestionario de datos sociodemográficos. En los resultados se reportan medias y desviaciones estándar, prevalencias (%) e intervalos de confianza. En el análisis estadístico se utilizó el SPSS v20.0. La prevalencia conjunta de sobrepeso y obesidad en nuestra población fue de 77%. Los valores medios de Indice Cintura-Cadera obtenidos fueron (0.97 hombres y 0.89 en mujeres). Por último, el porcentaje de grasa en hombres fue 30.6 % y en mujeres fue 39.8 %. Los resultados de esta investigación arrojaron diferencias significativas entre hombres y mujeres en la mayoría de las medidas antropométricas e indicadores de nutrición. La prevalencia de sobrepeso y obesidad reportada en la población mexicana de edad avanzada fue más alta que lo reportado en otros estudios, lo que muestra un importante problema de salud pública en los en adultos mayores mexicanos. Se requieren más estudios a nivel nacional sobre los parámetros nutricionales en AM con el fin de detectar de forma oportuna factores de riesgo cardiovascular.

Palabras clave: antropometría, encuestas nutricionales, adultos mayores mexicanos.

Introduction

Most developing and middle-income countries are undergoing demographic and epidemiological transitions, generated by changes in mortality profiles (from communicable diseases to chronic noncommunicable diseases), increased life expectancy, declining fertility rates, migratory processes (which have transformed the population into a predominantly urban one), as well as by advances in medical care, leading to the fact that in Mexico the age group of 60 years and older is the fastest growing population segment, with an annual rate in 2010 of 3 - 4% (López-Ortega & Arroyo, 2016). According to data from the INEGI (Instituto Nacional de Estadística y Geografía, 2020) around 12% of the total Mexican population corresponded to the group of older adults (OA) aged 60 years.

At the individual level the aging process produces physiological and nutritional changes that should be considered in the care of OA (Menezes & Marucci, 2005), these changes are manifested by a decrease in height, weight loss, loss of muscle mass and increase in fat mass, as well as by a redistribution of adipose tissue, with accumulation of fat in the trunk and viscera (Batsis et al., 2014; Gómez-Cabello et al., 2011; Sánchez-García et al., 2007; Silva et al., 2015). Anthropometry provides detailed information on the different components of the body structure from physical measurements, especially the muscle and fat components, and has proven to be important indicator of the nutritional status of a population, in addition, it is an inexpensive, non-invasive method that is easy and quick to perform (Menezes & Marucci, 2005; Sánchez-García et al., 2007; Silva et al., 2015). Likewise, anthropometric measurements are associated with functional and health outcomes. For example, an increase in measures of adiposity has been associated with increased frailty, increased risk of falls, reduced functional performance, increased dependency, cardiometabolic risk and cardiovascular problems (Gregson et al., 2019; Khosravian et al., 2021; Kioh et al., 2019; Wojzischke et al., 2021; Xu et al., 2020; Zhang et al., 2021). On the other hand, a low body mass index (BMI) is also related to greater frailty and dependence (Xu et al., 2020; Zhang et al., 2021). Therefore, anthropometric assessment is an essential feature of geriatric assessment (Sánchez-García et al., 2007).

Variations in lifestyle during their different stages (sedentary and physical activity patterns), sex differences, social factors (such as educational level), other environmental factors affecting genetic potential, as well as differences in health status led to heterogeneous changes in OA that can be reflected in anthropometric characteristics (Gómez-Cabello et al., 2011; López-Ortega & Arroyo, 2016; Sánchez-García et al., 2007). The combination of these factors makes geographic, sociocultural and ethnic variations in anthropometric and nutritional characteristics frequent, and consequently reference values derived from populations in one geographic area may not be applicable to other populations even if they belong to the same age group. This makes it necessary to obtain specific data by country and even in populations within countries, considering different ages, ethnic groups, and men and women separately (López-Ortega & Arroyo, 2016; Sánchez-García et al., 2007). Therefore, the aim of this study was to describe the anthropometric parameters and nutritional indicators in a population of Mexican OA, beneficiaries of the Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE), performing a comparative analysis by sex.

Methods

Participants

Cross-sectional population-based study conducted in Mexico (2017). The sample size was 516 OA (≥ 65 years, 277 women, 239 men). Interviews, anthropometric measurements, were conducted in ISSSTE hospital delegations.

Ethics

All participants were informed of the purpose and methods of this study and signed informed consent before enrollment. The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Committee of Ethics in Research of the National Institute of Public Health, Cuernavaca, Morelos, Mexico (ref. 613-CI-210-2007).

Anthropometric measurements

Height was measured with a mobile stadiometer (Seca 213, Germany), with an accuracy of 0.5 cm, with the subject's head in the Frankfurt plane. Body weight was determined to the nearest 100 g using a digital scale (Seca 354, Germany). Subjects were upright, barefoot, fasting and wearing light clothing, which was accounted for by subtracting 300 g from the average weight. Height and weight were measured in duplicate, and the average of each variable was used for calculations and analysis. BMI was calculated as body weight (kg) divided by height (m) squared. The World Health Organization categories, normal (BMI 18.5 - 25), overweight (BMI 25 - 30) and obese (BMI ≥ 30), were used for comparisons with previously published data from Mexican groups or populations from other countries. The thickness of the skinfolds, biceps (BSF), triceps (TSF), subscapular (SSSF), and suprailiac (SISF) were measured in triplicate with a plicometer (Harpenden 120, United Kingdom), with millimeter approximation, and with the mean of the four measurements the percentage of body fat (%BF) was estimated according to the equations of Siri (1961), Brožek et al. (1963), Rathbun - Pace (1945), and Wilmore - Behnke, (1969). Waist circumference (WC) and hip circumference (HC) were measured with a fiberglass tape measure (Seca 120, Germany). Subjects were asked to stand on a flat surface in a relaxed position with their feet together. WC was measured as the smallest horizontal circumference between the costal margins and the iliac crests at minimal respiration. The HC was taken as the largest circumference at the level of the greater trochanter (widest portion of the hip) on both sides. Measurements were taken to the nearest 0.1 cm. Two measurements of WC and HC were made, and the mean of the two readings was taken as the final value. The waist-hip ratio (WHR) was calculated as the WC (cm) divided by the HC (cm).

General questionnaire

The questionnaires included information on participants' health care coverage. The following categories were used for educational level: elementary (6 years of education), middle school (6 - ≤ 9 years of education), high school (> 9 - ≤ 12 years of education), and bachelor's, master's, and doctoral degrees (≥ 12 years of education). Tobacco use was self-reported and categorized as "current" for those subjects who had smoked at least 100 cigarettes during their lifetime and currently smoked, "ex-smoker" for those who had smoked at least 100 cigarettes during their lifetime and no longer smoked; and "never." Other variables included in this analysis were "sex" and "age" stratified as 65-69, 70-74, 75-79 and over 80 years.

The variable "Region" was stratified as northern region (Baja California, Baja California Sur, Chihuahua, Coahuila, Nuevo León, Sinaloa, Sonora and Tamaulipas), central-western region (Distrito Federal, Estado de México, Hidalgo, Morelos, Puebla, Querétaro and Tlaxcala), central (Aguascalientes, Colima, Durango, Guanajuato, Jalisco, Michoacán, Nayarit, San Luis Potosí and Zacatecas) and southern (Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatán).

Statistical analysis

Analyses were performed with SPSS 20.0. All tests were stratified by sex. Normality of all variables was assessed using Kolmogorov-Smirnov test. Descriptive statistics of the sample were calculated. Significant differences in prevalence were calculated using Chi.. Differences between group means were analyzed by ANOVA.

Results

Table 1 shows the characteristics of the participants. Of the total study population, 239 (46.32%) were men and 277 (53.68%) were women. The mean age in men was 71.4 years and in women 70.9 years, with no significant differences. Similarly, there were no significant differences in BMI, level of schooling and region of residence. The combined prevalence of overweight and obesity in this population was 77% according to the parameters used. The level of schooling with the highest prevalence was the ≥ 12 years category (Bachelor's, Master's and PhD), however, a similar proportion of the population had only primary education or lower (35.3% vs 30.2%). Height, weight, smoking and WC were higher in men than in women. On the other hand, HC, skinfolds and total body fat were higher in women.

The mean weight was 8 kg higher in men than in women (73.7 kg vs. 65.7 kg), likewise, height was 11.3 cm higher (162.7 cm vs. 151.4 cm), despite these differences, BMI was similar in both sexes (27.7 kg/m. and 28.3 kg/m. respectively). There was a high prevalence of overweight and obesity according to BMI without significant differences between men and women (overweight 48.9% and 46.1%; obesity vs. 26.4% and 32.3% respectively). The WC was higher in men (98.9 cm vs. 94.3 cm), on the other hand, women had a higher HC (105 cm vs. 101.4 cm), values that were reflected in the WHR which was significantly lower in women than in men (0.89 vs. 0.97). The skinfolds showed higher values in women than in men; the greatest differences were found in the BSF (37%, higher in women), followed by the TSF (33.1%), SISF (24%) and SSSF (7%), in the latter, although the differences were smaller, they were also considered significant ($p < .05$). As expected, a higher %BF was found in women than in men (39.8% vs. 30.6%).

Table 1. Characteristics of participants

	Men (n = 239)	Women (n = 277)	Total (n = 516)
Age (years)	71.4 ± 5.62	70.9 ± 5.49	71.1 ± 5.55
Height (cm)	162.7 ± 6.94	151.4 ± 7.41	156.5 ± 9.12***
Weight (kg)	73.7 ± 11.58	65.7 ± 14.84	69.4 ± 14.01***
BMI (kg/m^2)	27.7 ± 3.85	28.3 ± 4.08	28.1 ± 3.98
BMI status (%)			
Normal weight	24.7	21.6	23.0
Overweight	48.9	46.1	47.4
Obese	26.4	32.3	29.6
WC (cm)	98.9 ± 10.75	94.3 ± 10.97	96.4 ± 11.10***
HC (cm)	101.4 ± 9.21	105.0 ± 10.32	103.3 ± 9.98***
WHR	0.97 ± 0.08	0.89 ± 0.08	0.93 ± 0.09***
TSF (mm)	16.0 ± 7.72	21.3 ± 7.93	18.9 ± 8.25***
BSF (mm)	11.6 ± 6.75	15.9 ± 7.96	13.9 ± 7.73***
SSSF (mm)	21.3 ± 7.79	22.8 ± 7.87	22.1 ± 7.86*
SISF (mm)	20.4 ± 8.84	25.3 ± 8.89	23.1 ± 9.19***
Total body fat (%)	30.6 ± 5.41	39.8 ± 4.17	35.6 ± 6.64***
Level of schooling (%)			
Less than elementary school	0.9	0.4	0.6
Primary	30.8	28.6	29.6
Secondary	19.5	22.0	20.8
High school	11.3	15.7	13.7
Bachelor's + Master's + PhD	37.6	33.3	35.3
Smoking habit (%)			
Smoker	9.6	3.2	6.2***
Ex-smoker	39.3	12.6	25.0***
Never smoked	51.0	84.1	68.8***
Region of residence (%)			
Central-West	28.9	39.0	34.3
Central	20.5	24.2	22.5
North	24.3	20.6	22.3
South-Southeast	26.4	16.2	20.9

Abbreviations: *BMI*, body mass index; *WC*, waist circumference; *HC*, hip circumference; *WHR*, waist-hip ratio; *TSF*, tricipital skinfold; *BSF*, bicipital skinfold; *SSSF*, subscapular skinfold; SISF, suprailiac skinfold. Significant differences between men and women by ANOVA: **p* < .05, ***p* < .01, ****p* < .001.

In Table 2 when stratifying by age group, weight, WC and WHR showed no difference between men and women aged ≥ 80 years, while in the rest of the groups there were differences. And it was this same age group the only one in which significant differences were found in BMI being higher in women than in men. A lower weight was observed in men aged ≥ 80 years with respect to the other age groups, contrary to what was observed in women of the same age group who had the highest weight. The HC was significantly higher in women in the groups aged 65-69 years and, in the group, aged ≥ 80 years. Total body fat calculated by different formulas was significantly higher in women in all cases, of these formulas the one that yielded higher values of total body fat was the Rathburn Pace formula, both in men and women in all age groups.

Table 2. Anthropometric values according to age group and sex of the older adults. Mean ± standard deviation

	Men Media±DE	Women Media±DE	*p*		Men Media±DE	Women Media±DE	*p*
Weight (kg)				**Bicipital skinfold (mm)**			
65-69	74.1±11.0	67.0±12.0	< .0001	65-69	11.0±5.1	17.0±8.0	< .0001
70-74	76.0±13.0	64.0±12.0	< .0001	70-74	13.0±10.0	15.5±6.2	.057
75-79	74.0±12.0	62.4±9.0	< .0001	75-79	13.0±6.2	15.0±7.0	.293
≥ 80	68.2±10.2	69.0±31.4	.899	≥ 80	10.3±5.0	16.0±13.0	.033
Height (cm)				**Subscapular skinfold (mm)**			
65-69	163.0±7.0	153.0±6.0	< .0001	65-69	21.2±8.0	24.0±8.1	.009
70-74	164.0±6.1	150.1±6.0	< .0001	70-74	23.0±9.2	23.0±7.2	.919
75-79	161.1±8.1	150.0±6.0	< .0001	75-79	22.0±7.4	21.0±8.0	.508
≥ 80	162.0±8.2	152.0±15.0	.002	≥ 80	19.1±6.0	21.4±8.1	.229
***BMI* (kg/m^2)**				**Suprailiac skinfold (mm)**			
65-69	28.0±4.0	29.0±5.0	.155	65-69	20.4±8.0	26.0±9.2	< .0001
70-74	28.2±4.2	28.3±5.0	.816	70-74	20.4±11.2	25.0±9.0	.008
75-79	28.3±4.0	28.0±4.4	.682	75-79	21.2±9.3	23.0±8.1	.408
≥ 80	26.1±4.0	29.0±4.1	.026	≥ 80	20.0±7.2	28.0±9.0	.001
Waist circumference				**Siri-specific (%*BF*)**			
65-69	98.4±10.2	93.4±11.0	< .0001	65-69	30.4±5.1	40.3±4.3	< .0001
70-74	101.0±12.4	95.1±12.0	.013	70-74	31.0±6.1	40.0±4.0	< .0001
75-79	100.2±10.0	94.0±12.0	.017	75-79	32.0±5.1	39.0±4.1	< .0001
≥ 80	96.3±10.5	98.0±9.0	.633	≥ 80	30.0±5.3	40.1±4.0	< .0001
Hip circumference				**Brozeck-specific (%*BF*)**			
65-69	101.0±9.1	106.0±10.4	< .0001	65-69	29.3±5.0	39.0±4.0	< .0001
70-74	103.0±10.0	105.0±11.1	.306	70-74	30.0±6.0	38.0±4.0	< .0001
75-79	103.0±11.0	104.0±11.0	.679	75-79	30.4±5.0	37.0±4.0	< .0001
≥ 80	100.0±7.1	105.0±7.3	.017	≥ 80	29.0±5.0	38.2±4.0	< .0001
Waist-hip ratio				**Rathburn - Pace (%*BF*)**			
65-69	0.97±0.09	0.88±0.08	< .0001	65-69	34.0±6.0	45.1±5.0	< .0001
70-74	0.98±0.07	0.91±0.08	< .0001	70-74	35.0±7.0	44.3±4.4	< .0001
75-79	0.98±0.10	0.90±0.09	.001	75-79	35.4±6.0	43.2±5.0	< .0001
≥ 80	0.96±.06	0.93±0.07	.121	≥ 80	33.1±6.0	45.0±5.0	< .0001
Tricipital skinfold (mm)				**Wilmore - Behnke (%*BF*)**			
65-69	15.3±6.4	23.0±8.0	< .0001	65-69	29.0±5.2	39.1±4.4	< .0001
70-74	17.0±10.0	20.1±7.0	.032	70-74	30.0±6.3	38.4±4.0	< .0001
75-79	17.3±8.0	19.3±6.0	.250	75-79	30.2±5.2	37.3±4.2	< .0001
≥ 80	16.0±7.0	21.4±12.2	.032	≥ 80	28.2±5.4	39.0±4.1	< .0001

BMI, body mass index; *%BF*, body fat percentage; $p \leq .05$ was considered significant

Table 3 shows the BMI by age group and sex. No significant differences in BMI were found between age groups in both men and women. Table 4 shows the WC and WHR by age group and sex. The differences in WC and WHR between age groups were not significant in both men and women. A high prevalence of abdominal obesity was observed according to WC, mainly in men (65.7%). The prevalence of elevated WHR was similar in men and women (10.1% vs. 9.8%). Regarding the percentage of body fat, no significant differences were found between age groups in both sexes, as can be seen in Table 5.

Table 3. Body mass index according to age groups and sex of older adults

		Age groups										
		65-69 years old		70-74 years old		75-79 years old		≥ 80 years old		Total		*P*
	BMI	n	%	n	%	n	%	n	%	n	%	
Men	18.5 - < 25	24	22.2	15	25.0	7	21.2	10	38.5	56	24.7	.590
	25 - < 30	57	52.8	26	43.3	17	51.5	11	42.3	111	48.9	
	≥ 30	27	25.0	19	31.7	9	27.3	5	19.2	60	26.4	
Women	18.5 - < 25	25	18.4	17	23.6	9	27.3	7	25.0	58	21.6	.914
	25 - < 30	64	47.1	33	45.8	15	45.5	12	42.9	124	46.1	
	≥ 30	47	34.6	22	30.6	9	27.3	9	32.1	87	32.3	
Total	18.5 - < 25	49	20.1	32	24.2	16	24.2	17	31.5	114	23.0	.682
	25 - < 30	121	49.6	59	44.7	32	48.5	23	42.6	235	47.4	
	≥ 30	74	30.3	41	31.1	18	27.3	14	25.9	147	29.6	

BMI, body mass index; $p \leq .05$ was considered significant

Table 4. Waist circumference (WC) and waist-hip ratio (WHR) according to age groups and sex of the older adults

Waist circumference (cm)											
	65-69 years old		70-74 years old		75-79 years old		≥ 80 years old		Total		*p*
	n	%	n	%	n	%	n	%	n	%	
Men											
≥ 102	78	67.8	37	59.7	21	60.0	21	77.8	157	65.7	.323
< 102	37	32.2	25	40.3	14	40.0	6	22.2	82	34.3	
Women											
≥ 88	51	36.4	26	36.1	14	40.0	9	30.0	100	36.1	.868
< 88	89	63.6	46	63.9	21	60.0	21	70.0	117	63.9	
Waist-hip ratio											
Men											
≥ 1.00	9	8.7	6	10.9	3	9.4	4	15.4	22	10.1	.779
< 1.00	95	91.3	49	89.1	29	90.6	22	84.6	195	89.9	
Women											
≥ 0.85	15	12.3	5	7.4	3	10.0	1	3.8	24	9.8	.499
< 0.85	107	87.7	63	92.6	27	90.0	25	96.2	222	90.2	

$p \leq .05$ was considered significant

Table 5. Percentage of body fat according to age groups and sex of older adults. Mean ± standard deviation

	65-69 years old	70-74 years old	75-79 Years old	≥ 80 years old	Total	*p*
Siri-specific (%*BF*)						
Men	30.4±5.1	31.0±6.1	32.0 ± 5.1	30.0 ± 5.3	31.0 ± 5.4	.709
Women	40.3 ± 4.3	40.0 ± 4.0	39.0 ± 4.1	40.1 ± 4.0	40.0 ± 4.2	
Brozeck-specific (%*BF*)						
Men	29.3 ± 5.0	30.0 ± 6.0	30.4 ± 5.0	29.0 ± 5.0	30.0 ± 5.0	.709
Women	39.0 ± 4.0	38.0 ± 4.0	37.0 ± 4.0	38.2 ± 4.0	38.1 ± 4.0	
Rathburn - Pace (%*BF*)						
Men	34.0 ± 6.0	35.0 ± 7.0	35 ± 6.0	33.2 ± 6.0	34.3 ± 6.1	.709
Women	45.1 ± 5.0	44.3 ± 4.4	43.2 ± 5.0	45.0 ±5.0	45.0 ± 5.0	
Wilmore - Behnke (%*BF*)						
Men	29.0 ± 5.2	30.0 ± 6.3	30.2 ± 5.2	28.2 ± 5.4	29.2 ± 6.0	.709
Women	39.1 ± 4.4	38.4 ± 4.0	37.3 ± 4.2	39.0 ± 4.1	39.0 ± 4.3	

%BF, body fat percentage; $p \leq .05$ was considered significant

Discussion

The present study describes the anthropometric and body composition parameters in Mexican OA beneficiaries of the ISSSTE.

Based on data from the 2012 National Health and Nutrition Survey (ENSANUT 2012) Lopez-Ortega and Arroyo (2016) reported that in Mexico only 9.3% of OA had secondary or higher education. In our population 69.8% of the subjects exceeded secondary education and since educational level is one of the basic aspects of socioeconomic status (Vera-Romero & Vera-Romero, 2013), it can be considered as an indicator of the higher socioeconomic level of the studied population with respect to the general population of OA in Mexico.

In our study population 31.2% had ever smoked in life or currently smoked, which is below that found by Guimaraes et al. (2014), who conducted a study in Mexico City with OA and reported a smoking prevalence of 45.4%, which was similar to that found by Batsis et al. (2014) in US OA (46%), likewise, Easton et al. (2018) found a smoking and ex-smoking prevalence of 41.5% in OA (≥ 50 years) in Mexico, a figure similar to that reported by Gavriilidou et al. (2015) who reported a prevalence of 39.5% in Swedish OA. When differentiating by sex, in our results we found that the prevalence of tobacco use was 3 times higher in men than in women (48.9% vs. 15.8%) which agrees with what was found by Guimaraes et al. (64.8% vs. 20.2%).

The mean height in men was 162.7 cm, very similar to that reported by Sánchez-García et al. (2007) and López-Ortega and Arroyo (2016) in Mexican OA who indicated a mean of 163.2 cm and 161.9 cm respectively, on the other hand, it is lower when compared to that reported in studies conducted in other Latin American countries; Miranda et al. (2019) found a mean of 170 cm in Holguín, Cuba, similar to that of Diaz et al. (2015) who reported 169.2 cm in OA from Arica, Chile. Regarding females the mean height was 151.4 cm, slightly lower than that observed by Sánchez-García et al., (2007) but higher than López-Ortega and Arroyo (2016) who were 152.6 cm and 148.3 cm respectively. Referring to weight, the mean in males and females was higher than that found in the two studies mentioned above, being in the case of males 73.7 kg, 70.3 kg and 70.5 kg respectively, and in females 65.7 kg, 62.7 kg and 63.3 kg respectively.

While in other studies it has been observed that weight and height are lower in older age groups (Gavriilidou et al., 2015; Lopez-Ortega & Arroyo, 2016; Sánchez-García et al., 2007), in our study this was only observed in the weight of men aged ≥ 80 years, and in the case of women it was the reverse presenting higher weight in the older group, while in height there were no differences between the older groups with respect to the rest of the groups for both sexes. It is known that the gradual decrease in height with age is a result of vertebral compression and bone degenerative diseases, while weight loss may be related to sarcopenia due to atrophy and senility (Gavriilidou et al., 2015; Gomez-Cabello et al., 2011), that this was not clearly observed in the present study could be related to the fact that the population is limited to ISSSTE entitled individuals, whose characteristics might not be entirely the same as those of the general population, moreover, to assess weight and height decline more appropriately a longitudinal study would be necessary.

The mean BMI in this study was like that found by Batsis et al. (2014) in the United States and by Chavarría et al. (2017) in Chillán, Chile (28.1 kg/m., 27.1 kg/m. and 27.9 kg/m., respectively). Another study done in male OA from the province of Arica, Chile showed a mean BMI of 27.6 kg/m., a figure that is like the BMI of our population, which was 27.7 kg/m. in men (Díaz et al., 2015). In this study the mean BMI was similar between men and women in all age groups, except for the group ≥ 80 years, where it was significantly higher in women. As in our study Gavriilidou et al. (2015) and Sánchez-García et al. (2007) found similar BMI in men than in women, but without distinguishing by age groups (27.5 kg/m. vs. 27.2 kg/m. and 26. 4 kg/m. vs. 26.8 kg/m. respectively), on the other hand, López-Ortega and Arroyo (2016) and Gómez-Cabello et al. (2011) described that the mean BMI was higher in women than in men in all age ranges.

The joint prevalence of overweight and obesity in our population without differentiating sex was 77%, a high figure compared to what was found by López-Ortega and Arroyo (2016) who reported 68.9% in Mexican OA and by Miranda et al. (2018) who reported 64.5% in Cuban OA, likewise, Chavarría et al. (2017) reported lower prevalence of overweight and obesity (47%) in Chilean OA, however, in the latter study the large differences could be partly explained by the criteria used to classify nutritional status (overweight, BMI 28-31.9 kg/m.; obesity, BMI ≥ 32 kg/m.). In contrast to previous studies, the prevalence of overweight and obesity found by Gómez-Cabello et al., (2011) in Spanish OA was 84.3% exceeding the prevalence of the present investigation.

Describing the results according to gender, our study as well as that of Gómez-Cabello et al., 2011 showed that the most frequent nutritional status in both sexes was overweight (men 48.9% and 58.4%; women 46.1% and 43.1% respectively), however, the prevalence found of obesity in women by these authors was higher than ours (40. 9% vs. 32.3%) and in men very similar (26.6% vs. 26.4%), contrasting, in the study of López-Ortega and Arroyo, (2016) obesity was what predominated in women with 37.3%, and in the study of Chavarría et al., (2017) obesity was most prevalent in men with 39%. Despite the high prevalence of overweight and obesity found in this study, which is consistent with those found by other authors, some studies have associated elevated BMI in OA with lower mortality risk (Batsis et al., 2014; Chang et al., 2012). On the other hand, a high BMI in OA is also associated with dependence and cardiovascular problems (Gregson et al., 2019; Wojzischke et al., 2021). The fact that no underweight OA were found may reflect a favorable socioeconomic and cultural environment of the population studied (Chavarría et al., 2017; Osuna-Padilla et al., 2015).

The mean WC in men was 98.9 cm exceeding the mean found in Mexico by other authors which was 95.5 cm and 96.7 cm (Sánchez-García et al., 2007; López-Ortega & Arroyo, 2016); and resembling the values found in Swedish (99.7 cm) and Spanish (98.5 cm) population (Gavriilidou et al., 2015; Gómez-Cabello et al., 2011), however, it must be considered that in European population the stature is higher and therefore the fat distribution cannot be considered comparable despite the similarity of the values. As for the WC of women, it agrees with what was found in Mexican population by Sánchez-García et al. (2007) and López-Ortega and Arroyo (2016; 94.3 cm vs 93.7 cm and 95.5 cm, respectively), being higher than in European women (90.1 cm and 92.4 cm; Gavriilidou et al., 2015; Gómez-Cabello et al., 2011). When comparing WC between men and women, this study found that the mean was significantly higher in men, while López-Ortega and Arroyo (2016) reported no differences. The differences in body composition between men and women are attributed to the different patterns of use of energy substrates, men tend to oxidize more lipids while women tend to store them and have a greater sensitivity to insulin, which is influenced by the action of sex hormones and adipokines in each sex and is reflected in the patterns of visceral fat deposition and regional adipose tissue distribution (Ethun, 2016; Wei et al., 2019).

However, age-related alterations in sex steroid levels (decreased estrogen levels in postmenopausal women and decreased androgen levels in men) play a role in the differences between older men and women (Ethun, 2016).

The prevalence of WC (≥ 88 cm) in women reported in this study, despite being high, was lower than that found by López-Ortega and Arroyo (2016) in Mexico and Gómez-Cabello et al. (2011) in Spain (36.1% vs. 72.2% and 62.5% respectively), on the other hand, in men the prevalence of WC ≥ 102 was higher than in the two previous studies (65.7% vs. 33% and 34.1% respectively). Elevated WC has been associated with increased risk of frailty, dependency, cardiovascular disease and increased risk of mortality in OA (Gavriilidou et al., 2015; Hollander et al., 2012; Wojzischke et al., 2021; Xu et al., 2020), likewise, in post-menopausal women it has been associated with increased risk of hip fracture (Meyer et al., 2016) and in elderly women with type 2 diabetes mellitus it has been suggested that central adiposity may increase the risk of dementia (West et al., 2016).

Regarding the HC the mean was 101.4 cm and 105 cm for men and women respectively, values that are higher than those reported by López-Ortega and Arroyo (2016) in Mexican population that were 98 cm and 102.8 cm in the same order, on the other hand, Sánchez-García et al. (2007) reported values like ours (100.2 cm and 104 cm respectively). Similarly, in Sweden the mean HC found by Gavriilidou et al. (2015) was close to ours in both sexes (101.6 cm in men and 103.7 cm in women).

The mean values of WHR obtained in both sexes were lower than those of López-Ortega and Arroyo (2016) in Mexican general population (0.97 vs. 0.99 in men and 0.89 vs. 0.93 in women). Regarding the prevalence of subjects with central distribution of adipose tissue (WHR ≥ 1.0 in men or ≥ 0.85 in women), the data obtained in this study were low compared to what was found in other studies in Mexican population (9.9% vs. 43.24%, 69.2% and 65.7%; Easton et al., 2018; López-Ortega & Arroyo, 2016; Sánchez-García et al., 2007). When divided by sex the prevalence of high WHR in men was 10.1% compared to 19.1% and 42% found by Sánchez-García et al. and López-Ortega and Arroyo respectively; and in the case of women the difference was greater (9.8% vs. 73.7% and 86% respectively).

Of the studies that focus on analyzing the body composition of OA, few report skinfold measurements. BSF and TSF in men were larger than those found by Velázquez-Alva et al. (1996) in OA from Mexico City (16 mm and 11.6 mm vs. 14.5 mm and 9.8 mm respectively), while SSSF and SISF were smaller (21.3 mm and 20.4 mm vs. 22.3 mm and 25 mm respectively). When comparing our data with those of Diaz et al. (2015) in male OA from Arica, Chile it was found that all the folds evaluated by them were lower than ours (TSF 13.5 mm, BSF 7.9 mm and SSSF 20.6 mm), this could be related to the fact that their population was composed of soccer players, in this sense López-Fuenzalida et al. (2016) found an inverse association between the level of physical activity with the sum of skinfolds in adults. Similarly, the skinfolds evaluated by Gavriilidou et al. (2015) in Sweden were lower than those of this study in both sexes (TSF 14.1 mm and 20.8 mm; SSSF 19.4 mm and 19.6 mm for men and women, respectively). It should be noted that in the studies, including ours, all the skinfolds reported were greater in women than in men.

The percentage of body fat in men was like that found by Velázquez-Alva et al. (1996) in Mexico City and slightly higher than that reported in Spain by Gómez-Cabello et al. (2011; 30.6% vs. 31.7% and 28.9% respectively), while in women it was like that of both studies (39. 8% vs. 40.5% and 39.4% respectively), however, the equations used for estimation were different in the first study and in the second the method used for calculation was bioimpedance, which limits these comparisons.

The differences found with other studies conducted at the national level demonstrate that additional research is required to allow a more specific characterization of anthropometric measurements, considering factors such as lifestyle, socioeconomic level and level of physical

activity, and including minority populations such as those living in nursing homes or in rural communities.

Strengths and Limitations

It is worth noting these results were obtained from a sample of OA from different regions of the country, so the data from this study may be useful in the evaluation of the nutritional status of OA in Mexico; however, it should be considered that the results were obtained from the ISSSTE population, and do not include populations that do not have access to health services. In the same way, in this study the information collected in the ISSSTE delegations did not allow the anthropometric parameters to be related to any indicator of quality of life or the health status of the population. On the other hand, skinfolds were reported in this study, which is important given that there are few studies that describe them.

Conclusions

The results of this investigation showed significant differences between men and women in most of the anthropometric measurements and nutrition indicators; on the one hand, men were taller, heavier, had a higher WC and WHR, while HC, skinfolds (TSF, BSF, SSSF and SISF) and fat percentage were higher in women. No differences were found in BMI and in the prevalence of overweight and obesity, likewise, there were no differences in the prevalence of elevated WHR, while central obesity indicated by WC was more prevalent in the case of men. Unlike other studies, it was not possible to observe a decrease in anthropometric parameters in the older age groups.

Conflicts of Interest

The authors declared that they had no conflicts of interest.

Acknowledgments

María Araceli Ortiz Rodríguez was funded by PRODEP research project 511-6/17-7762, and the SNI program (CVU 449164) of CONACYT.

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Resumen de Visibilidad, Calidad Editorial y Científica e Impacto de CCD (modificado a partir de la Tabla Resumen de la Memoria Anual de CCD)

Visibilidad
ISI Web of Science, SCOPUS, EBSCO, MIAR, LATINDEX, REDIB, REDALYC, DIALNET, COMPLUDOC, RECOLECTA, ERIH PLUS, CEDUS, REDINET, SPORTDISCUS, PSICODOC, DOAJ, ISOC, IN-RECS, DULCINEA, SCIRUS, WORLDCAT, LILACS, GTBib, RESEARCH GATE, SAFETYLIT, REBIUN, Universal Impact Factor, Index Copernicus, e-Revistas, Cabell's Directory, SJIF, DLP, Fuente Académica Plus, ERA, BVS, PRESCOPUS RUSSIA, JournalTOCs, Viref, Genamics

Calidad
REDALYC: Superada
LATINDEX: (Total Criterios Cumplidos: 33/33)
CNEAI: (Total Criterios Cumplidos: 18/18)
ANECA: (Total Criterios Cumplidos: 22/22)
ANEP: Categoría A
CIRC (2020): Categoría B
Valoración de la difusión internacional (DICE): 14.25
DIALNET: gB
MIAR (2020): 9.7
ARCE 2014 (FECYT): Sello de calidad - Actualizado 2020
ERIH PLUS (European Reference Index for Humanities and Social Sciences): Indexada

Impacto
SCOPUS: 0.44 (SJR). Índice H (2019): 9. Segundo cuartil en Health (Social Science), Physical Therapy, Sports Therapy and Rehabilitation. Tercer cuartil en Sports Science.
Emerging Sources Citation Index (ESCI)
Índice H (2013-17): 11. Mediana H: 18. Posición 36/96
Scientific Journal Impact Factor SJIF 2020: under evaluation
Nivel CONICET (Res. 2249/14): Grupo 1

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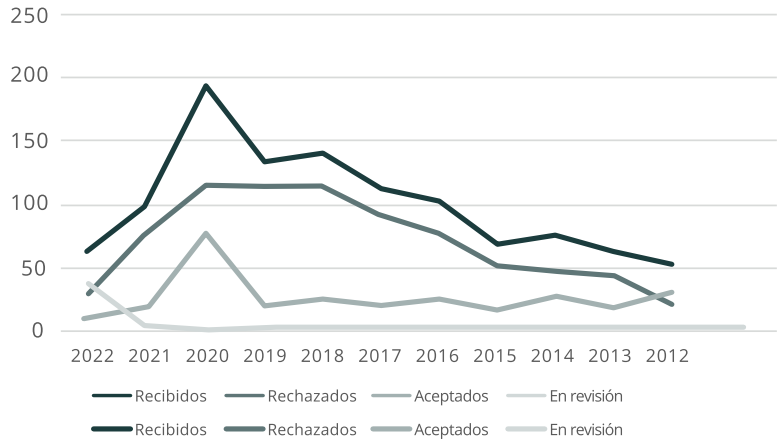

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La Revista *Cultura, Ciencia y Deporte* considerará para su publicación trabajos de investigación relacionados con las diferentes áreas temáticas y campos de trabajo en Educación Física y Deportes, que estén científicamente fundamentados. Dado el carácter especializado de la revista, no tienen en ella cabida los artículos de simple divulgación, ni los que se limitan a exponer opiniones en vez de conclusiones derivadas de una investigación contrastada. Los trabajos se enviarán telemáticamente a través de nuestra página web: http://ccd.ucam.edu, en la que el autor se deberá registrar como autor y proceder tal como indica la herramienta.

1. CONDICIONES

Todos los trabajos recibidos serán examinados por el Editor y por el Comité de Redacción de *Cultura, Ciencia y Deporte,* que decidirán si reúne las características indicadas en el párrafo anterior, para pasar al proceso de revisión por pares a doble ciego, por parte del Comité Asesor. Los artículos rechazados en esta primera valoración serán devueltos al autor indicándole los motivos por los cuales su trabajo no ha sido admitido. Así mismo, los autores de todos aquellos trabajos que, habiendo superado este primer filtro, no presenten los requisitos formales planteados en esta normativa, serán requeridos para subsanar las deficiencias detectadas lo más rápidamente posible. La aceptación del artículo para su publicación en *Cultura, Ciencia y Deporte,* exigirá el juicio positivo de los dos revisores, y en su caso, de un tercero. Durante este proceso, los derechos del artículo serán de la Revista *Cultura, Ciencia y Deporte*, a no ser que el autor/es soliciten que no se continúe con la revisión de su trabajo. La publicación de artículos no da derecho a remuneración alguna. Los derechos de edición son de la revista y es necesario su permiso para cualquier reproducción. El envío de un artículo a *Cultura, Ciencia y Deporte* implica la cesión de derechos a la revista, permitiendo que el artículo pueda ser publicado. En un plazo de cuatro meses se comunicará al autor la decisión de la revisión.

2. ENVÍO DE ARTÍCULOS

2.1 Normativa general

El artículo se enviará a través de la url: http://ccd.ucam.edu/index.php/revista/login. Todo el texto debe escribirse atendiendo a las directrices presentes en **el template de la revista** (https://docs.google.com/document/d/1YjojriyIgd0VUNS9Jk55gPbdf5oEcuN_/edit?usp=sharing&ouid=109045219128359206476&rtpof=true&sd=true), sin modificar en ningún caso la fuente del texto o el tamaño del mismo. Si su artículo es aceptado para publicación presentará la disposición del template final, por tanto, le rogamos lo revise cuidadosamente antes de proceder a su envío. La extensión máxima recomendada no deberá sobrepasar las 7500 palabras incluyendo Figuras, Tablas y Lista de Referencias.

Cada envío estará compuesto por **dos documentos**. El primero recibirá el nombre de "**artículo con autores**" e incluirá en el manuscrito el nombre de todos los autores que formen parte del trabajo, así como sus afiliaciones, autor de correspondencia, códigos de comités (por ejemplo, comité de ética), proyectos de investigación vinculados, agradecimientos y financiación. El segundo recibirá el nombre de "**artículo anónimo**" en el que se incluirá el título del trabajo, el resumen, las palabras clave, el texto del trabajo y las referencias, sin ningún tipo de indicación que permita a los revisores identificar a los autores del manuscrito.

- En la **primera página** del manuscrito deben ir los siguientes elementos del trabajo (por este orden, presentándose en el orden contrario si el texto del artículo está en inglés). Es importante que no se incluyan los nombres de los autores ni su filiación en el documento titulado "**artículo anónimo**", pero sí deberá hacerse en "**artículo con autores**".
  - **Título** del artículo en español y en inglés (en minúscula ambos, sin punto al final). Se recomiendan 10-12 palabras. Debe ser informativo del contenido y tener fuerza por sí mismo, pues es lo que aparecerá en los índices informativos y llamará la atención de los posibles lectores. Debe procurarse la concisión y evitar un excesivo verbalismo y longitud que no añada información.
  - **Resumen** del trabajo en español y en inglés.
    a. Debe reflejar el contenido y propósito del manuscrito.
    b. Si es la réplica del trabajo de otro autor debe mencionarse.
    c. c) La longitud del resumen no debe sobrepasar las **200 palabras**.
    d. d) En estas 200 palabras debe aparecer: el problema, si es posible en una frase; los participantes, especificando las principales variables concernientes a los mismos (número, edad, género, etc.); la metodología empleada (diseño, aparatos, procedimiento de recogida de datos, nombres completos de los test, etc.); resultados (incluyendo niveles estadísticos de significación); y conclusión e implicaciones o aplicaciones. El resumen **no ha de ser estructurado** (no se deben incluir los encabezados "problema", "participantes", etc.) y debe estar escrito en un único párrafo.
  - **Palabras claves** en español e inglés. Las 4 o 5 palabras que reflejen claramente cuál es el contenido específico del trabajo y no estén incluidas en el título (puede utilizar el Tesauro). En cursiva. Sólo la primera palabra se escribirá con mayúscula. Se separarán con comas y al final se incluirá un punto.
- La **segunda página** se iniciará el **texto completo** del artículo. El cuerpo de texto del trabajo deberá empezar en página independiente de la anterior de los resúmenes y con una indicación clara de los apartados o secciones de que consta, así como con una clara jerarquización de los posibles subapartados:
  - El primer nivel irá en negrita, sin tabular y minúscula.
  - El segundo irá sin negrita, sin tabular y minúscula.
  - El tercero irá en cursiva, sin tabulación y minúscula.
- Tras el texto completo se debe incluir un apartado de **Referencias**. Las citas y referencias tanto dentro del texto como en el apartado específico deben realizarse en normativa **APA 7ª ed**. A continuación, se presenta un resumen de la misma:

Durante el texto.

- Las citas de trabajos de tres o más autores solo incluyen el apellido del primer autor seguido por "et al.". Ejemplo: Fernández et al. (2019).
- Las citas literales se realizarán en el texto, poniendo tras la cita, entre paréntesis, el apellido del autor, coma, el año del trabajo citado, coma y la página donde se encuentra el texto: (Sánchez, 1995, 143).
- Si se desea hacer una referencia genérica en el texto, es decir, sin concretar página, a los libros o artículos de las referencias, se puede citar de la forma siguiente: paréntesis, apellido del autor, coma y año de edición: (Ferro, 2015). Las referencias citadas en el texto deben aparecer en la lista de referencias.
- Las citas incluidas en el mismo paréntesis deben seguir el orden alfabético.
- Siempre que la cita esté incluida en paréntesis se utilizará la "&". Cuando la cita no está incluida en paréntesis siempre se utilizará la "y". Las citas de dos autores van unidas por "y" o "&", y las citas de varios autores acaban en coma e "y" o "&". Ejemplo: Fernández y Ruiz (2008) o Moreno, Ferro, y Díaz (2007).
- Cuando el mismo autor haya publicado dos o más trabajos el mismo año, deben citarse sus trabajos añadiendo las letras minúsculas a, b, c... a la fecha. Ejemplo: Ferro (1994 a, 1994 b).

Al final del artículo-Lista de referencias.

- Los autores se ordenan por orden alfabético, con independencia del número de los mismos. Cuando son varios, el orden alfabético lo determina, en cada trabajo, el primer autor, después el segundo, luego el tercero y así sucesivamente.
- Es obligado utilizar el DOI (Digital Object Identifier) en las citas bibliográficas de los artículos y publicaciones electrónicas:
  Muñoz, V., Gargallo, P., Juesas, Á., Flández, J., Calatayud, J., & Colado, J. (2019). Influencia de los distintos tipos y parámetros del ejercicio físico sobre la calidad seminal: una revisión sistemática de la literatura. *Cultura, Ciencia y Deporte*, *14(40), 25-42*. http://dx.doi.org/10.12800/ccd.v14i40.1223

- Las citas de varios autores estarán separadas por coma e "&". Algunos ejemplos son los siguientes:
  Autor, A. A., Autor, B. B., & Autor, C. C. (2020). Título del artículo. *Título de la revista, xx*(x), xxx-xxx. http://dx.doi.org/xxxxxx
  Autor, A. A. (2020). *Título del trabajo.* Editorial.
  Autor, A. A., & Autor, B. B. (2020). Título del capítulo. En A. Editor, B. Editor, y C. Editor. (Eds.), *Título del libro* (pp. xxx-xxx). Editorial.
  Autor, A. A., Autor, B. B., & Autor, C. C. (en prensa). Título del artículo. *Título de la revista.*

- Además, para la correcta referenciación habrá que considerar:
  - Aunque haya dos autores, se pone coma antes de la "&".
  - Después de ":" (dos puntos) se empieza con mayúscula.
  - Sólo se escribe en mayúscula la primera letra de la primera palabra del título. Sin embargo, para los títulos de las revistas se pone en mayúscula la primera letra de cada palabra.

– Tras las Referencias, se ha de incluir un apartado de **Agradecimientos.** En el mismo se ha de hacer referencia a cualquier entidad financiadora del estudio de investigación.

2.2. Tipos de artículos que se pueden someter a evaluación en *Cultura, Ciencia y Deporte*

2.2.1. Investigaciones originales

Son artículos que dan cuenta de un estudio empírico original configurados en partes que reflejan los pasos seguidos en la investigación. El texto completo debe tener la siguiente estructura:

2.2.1.1. *Introducción.* Problema del que se parte, estado de la cuestión y enunciado del objetivo e hipótesis de la investigación.

Se debe introducir y fundamentar teóricamente el problema de estudio y describir la estrategia de investigación. En el último párrafo el objetivo del trabajo se debe establecer claramente. Cuando se quiera llamar la atención sobre alguna palabra se usarán las cursivas. El uso de subrayado, negrita y mayúsculas no está permitido. Se evitará también, en lo posible, el uso de abreviaturas. Tampoco se admite el uso de las barras, por ejemplo, y/o, alumnos/as. Habrá que buscar una redacción alternativa. En documento aparte, se presentan las directrices generales de estilo para los informes que utilicen el sistema internacional de unidades.

2.2.1.2. *Método.* Descripción de la metodología empleada en el proceso de la investigación. En esta sección debería detallarse suficientemente todos aquellos aspectos que permitan al lector comprender qué y cómo se ha desarrollado la investigación. La descripción puede ser abreviada cuando las técnicas suficientemente conocidas hayan sido empleadas en el estudio. Debe mostrarse información sobre los participantes describiendo sus características básicas y los controles utilizados para la distribución de los participantes en los posibles grupos. Deben describirse los métodos, aparatos, procedimientos y variables con suficiente detalle para permitir a otros investigadores reproducir los resultados. Si utilizan métodos establecidos por otros autores debe incluirse la referencia a los mismos. No olvidar describir los procedimientos estadísticos utilizados. Si se citan números menores de diez se escribirán en forma de texto, si los números son iguales o mayores de 10 se expresarán numéricamente.

Este apartado suele subdividirse en sub-apartados:

- *Participantes.* Debe describirse la muestra (número de personas, sexo, edad, y otras características pertinentes en cada caso) y el procedimiento de selección. Además, en aquellos estudios realizados con humanos o animales es obligatorio identificar el comité ético que aprobó el estudio. Cuando se describen experimentos que se han realizado con seres humanos, se debe indicar que además del comité ético institucional o regional, el estudio está de acuerdo con la Asociación Médica Mundial y la Declaración de Helsinki. No se deben utilizar nombres, iniciales o números que permitan identificar a los participantes.
- *Instrumentos.* Especificar sus características técnicas y/o cualitativas.
- *Procedimiento.* Resumir cada paso acometido en la investigación: instrucciones a los participantes, formación de grupos, manipulaciones experimentales específicas. Si el trabajo consta de más de un experimento, describa el método y resultados de cada uno de ellos por separado. Numerarlos, Estudio 1, Estudio 2, etc.

2.2.1.3. *Resultados.* Exposición de los resultados obtenidos. Los resultados del estudio deberían ser presentados de la forma más precisa posible. La discusión de los mismos será mínima en este apartado. Los resultados se podrán presentar en el texto, en Tablas o Figuras.

Cuando se expresen los datos estadísticos, las abreviaturas deben ir en cursiva, así como al utilizar el *p*-valor (que irá siempre en minúscula). Por ejemplo: *p, F, gl, SD, SEM, SRD, CCI, ICC*. Es necesario que antes y después del signo igual (=) se incluya un espacio. Se debe incluir un espacio también cuando entre el número y la unidad de medida (7 Kg y no 7Kg), pero no se incluirá dicho espacio entre el número y el signo de porcentaje (7% y no 7 %). Los decimales irán precedidos de puntos (9.1 y no 9,1).

No se incluirán los mismos datos que en el texto, en las tablas o en las figuras. Tanto las Figuras como en las Tablas no deben denominarse de ninguna otra manera. Las Figuras y Tablas serán introducidas donde corresponda en el texto, con su numeración correlativa, poniendo la leyenda de las Figuras en su parte inferior y la leyenda de las Tablas en su parte superior.

Las *Tablas* son un resumen organizado de palabras o cifras en líneas o renglones. Todas las tablas deben seguir el formato APA, incluyendo: a) su numeración en número arábigos, b) un título, c) líneas solo horizontales sobre el encabezado, debajo del mismo y al fin de la tabla, sin líneas verticales, y d) fondo de tabla blanco. Los decimales dentro de las tablas deben estar separados por **puntos** (.). Se debe incluir en el pie de la tabla todas aquellas abreviaturas o símbolos utilizados en la misma. El tamaño de la fuente en las tablas podrá variar en función de la cantidad de datos que incluya, pudiéndose reducir hasta 8 cpi máximo.

Tabla 1. Ejemplo 1 de tabla para incluir en los artículos enviados aCCD.

	P5	POT	STD	SDS	SDI	EQG	SDT	ENF	CA	EH	ES	Esuc	F	MT	ED
MT	9.1	21.	9.1	6.1	92.	63.6	9.0	33.3	3.0	30.	15.	12.	0.0	82.1	35.
ED	33.3	13.3	16.7	6.7	23.0	70.0	16.6	26.7	21.1	63.3	0.0	30	10.0	13.3	96.0

Leyenda: MT=Indicar el significado de las abreviaturas

Tabla 2. Ejemplo 2 de tabla para incluir en los artículos enviados a CCD.

Nombre 1	Ítem 1. Explicación de las características del ítem 1 Ítem 2. Explicación de las características del ítem 2 Ítem 3. Explicación de las características del ítem 3
Nombre 2	Ítem 1. Explicación de las características del ítem 1 Ítem 2. Explicación de las características del ítem 2 Ítem 3. Explicación de las características del ítem 3

Las *Figuras* son exposiciones de datos en forma no lineal mediante recursos icónicos de cualquier género. En caso de incluirse fotografías deben ser seleccionadas cuidadosamente, procurando que tengan una calidad de al menos 300 píxeles/pulgada y 8 cm de ancho. Si se reproducen fotografías no se debe poder identificar a los sujetos. En todo caso los autores deben haber obtenido el consentido informado para la realización de dichas imágenes, autorizando su publicación, reproducción y divulgación en *Cultura, Ciencia y Deporte*. Las Figuras deben ser incluidas dentro del texto, incluyendo: a) su numeración en número arábigos, b) un título.

2.2.1.4. *Discusión.* En este apartado se procederá a la interpretación de los resultados y sus implicaciones. Este apartado debe relacionar los resultados del estudio con las referencias y discutir la significación de lo conseguido en los resultados. No debe incluirse una revisión general del problema. Se centrará en los resultados más importantes del estudio y se evitará repetir los resultados mostrados en el apartado anterior. Evitar la polémica, la trivialidad y las comparaciones teóricas superficiales. La especulación es adecuada si aparece como tal, se relaciona estrechamente con la teoría y datos empíricos, y está expresada concisamente. Identificar las implicaciones teóricas y prácticas del estudio. Sugerir mejoras en la investigación o nuevas investigaciones, pero brevemente.

2.2.1.5. *Conclusiones.* Recapitulación de los hallazgos más importantes del trabajo para el futuro de la investigación. Sólo deben relacionarse conclusiones que se apoyen en los resultados y discusión del estudio. Debe comentarse la significación del trabajo, sus limitaciones y ventajas, aplicación de los resultados y trabajo posterior que debería ser desarrollado.

2.2.2. Artículos de revisión

Los artículos de revisión histórica contemplarán los apartados y el formato de las *investigaciones originales*. Las revisiones sobre el estado o nivel de desarrollo científico de una temática concreta deberán ser sistemáticas.

2.2.3. Ensayos

Esta sección de *Cultura, Ciencia y Deporte* admitirá ensayos, correctamente estructurados y suficientemente justificados, fundamentados, argumentamos y con coherencia lógica, sobre temas relacionados con el deporte, que tengan un profundo trasfondo filosófico o antropológico que propicie el avance en la compresión del deporte como fenómeno genuinamente humano. Pretende ser una sección dinámica, actual, que marque la línea editorial y la filosofía del deporte que subyace a la revista. No precisa seguir el esquema de las investigaciones originales, pero sí el mismo formato.

2.3 Información relevante de la revista

La revista Cultura, Ciencia y Deporte se adhiere al "***Code of Conduct and the Best Practices Guidelines for Journals Editors del Committee on Publication Ethics – COPE***" y a las recomendaciones del "***International Committee of Medical Journal Editors - ICJME***". Existe compromiso por parte de la revista para la detección de plagio y otros tipos de fraude en la redacción y presentación de artículos a ***Cultura, Ciencia y Deporte***.

La política editorial de la revista promueve el uso de lenguaje inclusivo en los artículos científicos. Por favor, tenga en cuenta esta directriz y revise su documento antes de remitirlo a la revista.

3 TRATAMIENTO DE DATOS PERSONALES

En virtud de lo establecido en el artículo 17 del Real Decreto 994/1999, por el que se aprueba el Reglamento de Medidas de Seguridad de los Ficheros Automatizados que contengan Datos de Carácter Personal, así como en la Ley Orgánica 15/1999 de Protección de Datos de Carácter Personal, y la Ley Ley Orgánica 3/2018, de 5 de diciembre, de Protección de Datos Personales y garantía de los derechos digitales, la Dirección de *Cultura, Ciencia y Deporte* garantiza el adecuado tratamiento de los datos de carácter personal.

4 INFORMACIÓN RELATIVA A LA CORRECCIÓN DE PRUEBAS / GALERADAS UNA VEZ ACEPTADO EL ARTÍCULO

En caso de aceptación, el autor designado como responsable de correspondencia recibirá un informe de estilo (con aspectos de formato a modificar, en caso de que sea necesario) junto con un documento donde se solicitarán los nombres y apellidos de todos los autores junto a su afiliación (para el encabezado del artículo), la aportación de cada uno de los autores, las redes sociales de los autores y los agradecimientos. Dichos documentos se devolverán completos en un plazo máximo de tres días. Posteriormente, recibirá en su email una prueba de imprenta del artículo en formato PDF. La prueba se revisará y se marcarán los posibles errores con la opción notas de Adobe Acrobat, devolviendo las pruebas corregidas a la redacción de la revista en un plazo máximo de 48 horas. De no recibir estas pruebas en el plazo fijado, el Comité Editorial de la revista podrá decir publicar el artículo en su estado original, no pudiendo hacerse cambios tras su publicación y no haciéndose responsable la revista de cualquier error u omisión que pudiera publicarse; o retrasar su publicación a un número posterior. En esta fase de edición del manuscrito, las correcciones introducidas deben ser mínimas (erratas). El equipo editorial se reserva el derecho de admitir o no las correcciones efectuadas por el autor en la prueba de impresión.

5 INFORMACIÓN SOBRE LA APORTACIÓN DE TODOS LOS FIRMANTES DEL ARTÍCULO

Los autores deberán informar sobre el criterio escogido para decidir el orden de firma y sobre la contribución específica realizada por cada uno de ellos en el trabajo publicado. Esta información se pedirá en la hoja final donde se solicita a los autores sus datos, afiliaciones, aportaciones de los autores, redes sociales y agradecimientos. En la lista de autores firmantes deben figurar únicamente aquellas personas que han contribuido intelectualmente al desarrollo del trabajo. En general, para figurar como autor se deben cumplir los siguientes requisitos: a) haber participado en la concepción y realización del trabajo que ha dado como resultado el artículo en cuestión; b) haber participado en la redacción del texto y en las posibles revisiones del mismo; c) haber aprobado la versión que finalmente va a ser publicada. El equipo editorial de *Cultura, Ciencia y Deporte* rehúsa cualquier responsabilidad sobre posibles conflictos derivados de la autoría de los trabajos que se publican en la revista.

El autor firmante como autor de correspondencia será el encargado de actuar como mediador entre la revista y los demás autores y debe mantener informados a todos los coautores e involucrarlos en las decisiones importantes sobre la publicación. Posteriormente a la aceptación del artículo no se admitirán cambios en el mismo (salvo erratas), por lo que se recomienda contar con el visto bueno de todos los coautores antes de remitir las revisiones a la revista.

6 REGISTRO DE LA FUENTE DE FINANCIACIÓN DE LOS ARTÍCULOS PUBLICADOS

Los autores deberán declarar si el trabajo ha tenido algún tipo de financiación para realizar la investigación que se pretende publicar, así como los proyectos de investigación o contratos financiados de la que es resultado. Esta información se deberá incluir en los metadatos de la revista a la hora de cargar el

artículo en la plataforma. Además, se volverá a pedir esta información en la hoja final donde se solicita a los autores sus datos, filiaciones, aportaciones, redes sociales y agradecimientos.

7 ABONO EN CONCEPTO DE FINANCIACIÓN PARCIAL DE LA PUBLICACIÓN

Las normas de este apartado entran en vigor para los envíos y revisiones realizadas a partir del 29 de octubre de 2019.

De acuerdo con la filosofía de *Open Access* de la revista y con el fin de sufragar parte de los gastos de la publicación en aras de mejorar la calidad de la misma, la visibilidad y la repercusión de la publicación, CCD fija una tarifa de publicación de 120 € (IVA incluido). Este pago deberá hacerse efectivo tras la comunicación de la aceptación del artículo. Para ello tras la aceptación del artículo se debe enviar a gjimenez@ucam.edu el resguardo de la transferencia realizada al nº de cuenta ES02 0081 5089 3800 0109 4420 (CODIGO BIC-SWIFT: BSABESBB), cuyo titular es la "FUNDACIÓN UNIVERSITARIA SAN ANTONIO", indicando en el concepto "Revista CCD + nº del artículo".

Por otra parte, los revisores de artículos CCD tendrán derecho a una publicación sin coste por cada tres artículos que hayan revisado en el tiempo y la forma solicitada por los editores. A tal fin, deben indicar los artículos revisados si quieren beneficiarse de la exención de pago cuando se les solicite el mismo. Los editores están exentos de pago.

8 ACTUALIZACIÓN IMPORTANTE EN LA NORMATIVA DE ENVÍO QUE ENTRARÁ EN VIGOR PARA TODOS LOS ARTÍCULOS ENVIADOS A PARTIR DEL 1 DE ENERO DEL 2021.

Todos los autores que realicen un envío a partir de dicha fecha (en un idioma diferente al inglés), y cuyo artículo finalmente sea aceptado, también deberán remitir la versión definitiva en inglés. En la versión en inglés deberá aparecer el nombre completo del traductor y su email. La intención de este cambio es aumentar la difusión de los artículos publicados en nuestra revista.

9 PROPUESTA DE PUBLICACIÓN DE MONOGRÁFICOS EN *CULTURA, CIENCIA Y DEPORTE.*

Las personas interesadas en proponer la publicación de un monográfico en la *Revista Cultura, Ciencia y Deporte,* deben enviar una descripción de 500-600 palabras (incluidas referencias) a la dirección email de la revista (ccd@ucam.edu). En dicho email, el coordinador o coordinadores del mismo (máximo 3 personas) deben realizar una aproximación a la temática y contenido del monográfico propuesto, así como sus CV.

Una vez aceptada la propuesta de monográfico, se establecerá un período de llamada de artículos *"Call for papers"* y una fecha límite de envíos "*Deadline*" cuya duración será determinada por el coordinador del mismo. El equipo editorial de la *Revista Cultura, Ciencia y Deporte* propondrá la fecha prevista de publicación del monográfico en función de su disponibilidad.

Las funciones del coordinador del monográfico serán, redactar el editorial del mismo, y aportar un listado de posibles revisores que serán seleccionados por el equipo editorial para llevar a cabo las revisiones por pares de los artículos del monográfico. Para que el monográfico sea publicado serán necesarios un mínimo de 10 artículos aceptados. El coordinador del monográfico tendrá la posibilidad de invitar autores para que colaboren con sus manuscritos. La decisión final de aceptación para que un artículo forme parte del monográfico será del equipo editorial, no del coordinador del monográfico.

Todos los manuscritos aceptados para publicación, incluido el editorial, contarán con DOI.

10 PUBLICACIÓN DE ARTÍCULOS EN UN MONOGRÁFICO

Los manuscritos deben presentarse a través de la web *Cultura, Ciencia y Deporte* (https://ccd.ucam.edu), registrándose e iniciando sesión. Durante el proceso de envío, se seleccionará la pestaña con el nombre del monográfico donde se pretende publicar. Se invita a presentar artículos de investigación y de revisión. Los trabajos aceptados se publicarán en la página web de la *Revista Cultura, Ciencia y Deporte*, y contarán con su correspondiente DOI.

Los manuscritos que se presenten no deben haber sido publicados anteriormente, ni estar en consideración para su publicación en otro lugar. Todos los manuscritos se someten a un riguroso proceso de revisión por pares a ciegas. Los manuscritos deben redactarse de acuerdo a las directrices generales de la revista:

https://ccd.ucam.edu/index.php/revista/about/submissions#authorGuidelines y siguiendo las directrices del template de la revista (https://docs.google.com/document/d/1Y-jojriyIgd0VUNS9Jk55gPbdf5oEcuN_/edit?usp=sharing&ouid=109045219128359206476&rtpof=true&sd=true). El coste de procesamiento de artículos para los autores en números especiales (monográficos) de acceso abierto es de 250 euros por artículo (IVA incluido). El coordinador del monográfico no debe abonar ninguna tasa por la edición del editorial y tendrá un artículo gratuito en dicho monográfico. Los artículos presentados deben tener el formato correcto de acuerdo a las normas de publicación de la revista, de lo contrario no serán aceptados. Los envíos pueden realizarse en idioma español o inglés, siendo necesario en caso de que se hayan enviado en español su traducción al inglés por parte de los autores una vez que el artículo haya sido aceptado.

CHECKLIST FORMATO PARA ARTÍCULOS EN *CCD*

- *Texto*: adaptado al template disponible en la página web y en las normas de publicación de la revista.
- *Alineación del texto:* a izquierda y derecha (justificada).
- *Extensión:* no debe sobrepasar las 7500 palabras incluyendo Figuras, Tablas, y Referencias.
- *Primera página:* debe contener los siguientes elementos del trabajo: título del artículo en español y en inglés en minúscula, un resumen del trabajo en español y en inglés, más las palabras claves en español y en inglés. Por este orden, o el contrario si el artículo está escrito en inglés.
- *Segunda página*: se iniciará con el texto completo del artículo. El cuerpo de texto del trabajo deberá empezar en página independiente de la anterior de los resúmenes.
- Indicación clara de los apartados o secciones de que consta, así como con una clara jerarquización de los posibles sub-apartados (primer nivel irá en negrita y sin tabular, segundo irá en cursiva y sin tabular, tercero irá en cursiva y con una tabulación). Todos ellos en minúscula.
- *Título*: Se recomiendan 10-12 palabras.
- *Resumen:* La longitud no debe sobrepasar las 200 palabras.
- *Palabras clave*: 4 ó 5 palabras que reflejen claramente cuál es el contenido específico del trabajo.
- No repetidas del título.
- *Figuras y Tablas*: introducidas donde corresponda en el texto, con su numeración correlativa.
- *Figuras y Tablas*: leyenda de las Figuras en su parte inferior y la leyenda de las Tablas en su parte superior.
- *Figuras y Tablas*: Mantener las tablas simples sin líneas verticales.
- *Figuras y Tablas*: El tamaño de la fuente en las tablas podrá variar en función de la cantidad de datos que incluya, pudiéndose reducir hasta 8 cpi máximo.
- *Citas y referencias:* Deben seguir formato APA 7th edición.
- *Agradecimientos:* se colocan al final del artículo, tras las referencias.
- *Envío*: se incluyen dos manuscritos, uno con el nombre de "**artículo con autores**" y el otro "**artículo anónimo**".

En Murcia, a 5 de octubre de 2021
Cultura, Ciencia y Deporte
ISSN 1989-7413 (digital) doi.10.12800/ccd

CULTURA, CIENCIA Y DEPORTE MANUSCRIPTS SUBMISSION GUIDELINESS

Cultura, Ciencia y Deporte will consider research studies related to the different areas of Physical Activity and Sport Sciences, which are scientifically based. Given the specialized nature of the journal, popular articles will not be accepted, nor will those limited to exposing opinions without conclusions based on academic investigation. Papers should be sent electronically through our website: http://ccd.ucam.edu,where the author must register as an author and proceed as indicated by the tool.

1. CONDITIONS

All manuscripts received will be examined by the Editorial Board of *Cultura, Ciencia y Deporte*. If the manuscript adequately fulfills the conditions defined by the Editorial Board, it will be sent on for the anonymous peer review process by at least two external reviewers, who are members of the Advisory Committee. The manuscripts rejected in this first evaluation will be returned to the author with an explanation of the motives for which the paper was not admitted. Likewise, the authors of those manuscripts that having passed this first filtering process may be subsequently required to alter any corrections needed in their manuscript as quickly as possible. Acceptance of the article for publication in Cultura, Ciencia y Deporte, will require the positive judgment of the two reviewers, and where appropriate, of a third review. Throughout this process, the manuscript will continue to be in possession of the journal, though the author may request that his/her paper be returned if so desired. The publication of articles does not entitle any remuneration. Editing rights belong to the journal and permission is required for any reproduction. The acceptance of an article for publication in the *Cultura, Ciencia y* Deporte implies the author's transfer of copyright to the editor, to allow the paper to be reproduced or published in part or the entire article. Within four months the outcomes from any paper submitted will be communicated to the author.

2 SUBMISSION

2.1 General guideliness

Manuscripts must be submitted via http://ccd.ucam.edu/index.php/revista/login. All text should be written according to the guidelines in the journal template (https://docs.google.com/document/d/1YjojriyIgd0VUNS9Jk55gPbdf5oEcuN_/edit?usp=sharing&ouid=109045219128359206476&rtpof=true&sd=true), without modifying the font or size of the text. If your article is accepted for publication, it will present the layout of the final template, therefore, please review it carefully before submitting it. The maximum recommended length should not exceed 7500 words including Figures, Tables and Reference List.

Each submission will consist of **two documents**. The first will be called "**article with authors**" and will include in the manuscript the name of all authors who are part of the work, as well as their affiliations, author of correspondence, committee codes (e.g., ethics committee), linked research projects, acknowledgements and funding. The second will be called "**anonymous article**" in which the title of the paper, abstract, keywords, text of the paper and references will be included, without any indication that would allow the reviewers to identify the authors of the manuscript.

- On the **first page** of the article, the following elements should be presented (in this order, or the opposite order if the text of the article is in English). It is important not to include the names of the authors or their affiliation in the document entitled "anonymous article", but this should be done in "article with authors".
  - **Title** in Spanish and English (both in lowercase, without full stop). 10 – 12 words are recommended. Since it will be shown on the index information, the title should be informative itself and call the attention of potential readers. The title must be concise and avoid being over long.
  - **Abstract** of the work in Spanish and English.
    a. Should reflect the content and purpose of the manuscript.
    b. If the paper is reproducing another author´s work, it should be acknowledged.
    c. The length of the abstract should not exceed **200 words**.
    d. The abstract should include: the problem, if possible in one sentence; participants, identifying the main variables (number, age, gender, etc.); methodology (design, equipment, procedure data collection, full names of tests, etc.); results (including levels of statistical significance); conclusions and implications or applications. The summary should not be unstructured and **should be written in a single paragraph**.
  - **Key words** in Spanish and English**.** 4 or 5 words that reflect the specific content of the work (in italics and not included in the title). Only the first word is written with a capital letter. Words should be separated with commas, and a full stop at the end of a sentence. plus the key words in Spanish and English, in this order, or the opposite if the item is in English. A full stop should not be included at the end of the title.
- On the **second page** of the article, will start the **full text** of the article. Full text of the article should begin on separate page to the abstracts with a clear indication of the paragraphs or sections and with a clear hierarchy of possible sub-paragraphs: .
  - The first level should be in bold, without tabs and lowercase.
  - The second should be without bold, tabs and lowercase.
  - The third should be in italics, without tabs and lowercase.
- After the full text, a **References** section must be included. Citations and references in the text and in the specific section must be made in **APA 7th ed** regulations. Below is a summary of it:

References through the text.

- References of three or more authors only the first author should appear followed by "et al." For example: Fernandez et al. (2019).
- The literal references will be made in the text, after being reference in parentheses, the author's last name, coma, the year of the cited work, coma and page where the text: (Sanchez, 1995, 143).
- If you want to make a generic reference in the text, i.e. without specifying the page of the book or article, it should be cited as follows: the author's name, comma and year of publication in parentheses: (Ferro, 2015).
- References cited in the text should appear in the reference list.
- The references included in the same parentheses should be in alphabetical order.
- Whenever the reference is included in parentheses: the "&" will be used. When the reference is not included in parentheses, "and" should always will be used. The references of two authors are linked by "and" or "&", and references from various authors end up in a coma plus "and" or "&". For example: Fernandez and Ruiz (2008) or Moreno, Ferro, and Diaz (2007).
- When citing two authors with the same name, the initials of the relevant names must precede them.
- When the same author published two or more pieces of work in the same year, their work should add in the lowercase letters a, b, c. For example: Ferro (1994a, 1994b).

At the end of the manuscript – References list

- Authors are listed in alphabetical order, independently of the number. When various authors are listed, the alphabetical order should be determined in each work by the first author, then the second, then the third successively.
- The DOI (Digital Object Identifier) must be used in the bibliographic citations of articles and electronic publications:

  Muñoz, V., Gargallo, P., Juesas, Á., Flández, J., Calatayud, J., & Colado, J. (2019). Influence of the different types and parameters of the physical exercise on seminal quality: a systematic review of the literature. *Cultura, Ciencia y Deporte, 14(40), 25-42*. http://dx.doi.org/10.12800/ccd.v14i40.1223

- References of various authors will be separated by a comma and "&". Some examples as follows:
  Author, A. A.; Author, B. B., & Author, C. C. (2020). Title. *Journal, xx*(x), xxx-xxx. http://dx.doi.org/xxxxxx
  Author, A. A. (2020). *Title*. Publisher.
  Author, A. A., & Author, B. B. (2020). Title. In A. Editor, B. Editor, & C. Editor. (Eds.),
  Book title (pp. xxx-xxx). Publisher.
  Author, A. A.; Author, B. B., & Author, C. C. (in press). Title. *Journal*
- In addition, for correct referencing:
  - If there are two authors, add a comma before "&".
  - After a ":" (colon) a capital letter should be used.
  - Just type the uppercase for the first letter of the first word of the title for a Book reference. However, titles of journal references are capitalized, using the first letter of each word.

– After the References, a section of **Acknowledgments.** It must be placed in the space set out for this purpose. If is necessary, you can refer to the financing entity of the research study.

2.2 Type of papers that can be submitted for evaluation in CCD

2.2.1 *Original research*

These are articles that account for an empirical study set in original parts that reflect the steps taken in the investigation. The full text must have the following structure:

2.2.1.1. *Introduction.* State the problem of the investigation and the aim and hypothesis of the work. The research problem should be substantiated theoretically, describing the experimental approach to the problem. In the last paragraph, the aim of the work should be established clearly.

Use **italics** to show relevant information. Underline, bold or capital letters are not allowed. The use of abbreviations should be as minimum as possible. See the International System of Units for general style guidelines International System of Units.

2.2.1.1. *Method*. Description of the methodology used in the research process. This section should be detailed enough to allow the reader to understand all aspects regarding what and how the research has been developed. Well known techniques used within the study should be abbreviated. Information about the participants must be displayed to describe their basic characteristics and criteria used for the distribution of participants in any group. The experiment must be reproducible by others and methods, devices, procedures and variables must be detailed. Methods used by other authors should include a reference. All statistical procedures must be described. Numbers lower than ten should be in the form of text, if the numbers are equal to or greater than 10, they should be expressed numerically.

The method is usually divided into subsections:

- • *Participants.* The sample´s characteristics (number, sex, age and other relevant characteristics in each case) and selection process. Studies involving humans or animals must cite the ethical committee that approved the study. When describing experiments that have been performed with human beings, it should be noted that in addition to the institutional or regional ethical committee, the study agrees with the World Medical Association and the Helsinki Declaration. No names, initials or numbers should be used to identify the participants.
- • *Instruments.* Specify technical characteristics.
- • *Procedure.* Summarize each step carried out in the research: instructions to the participants, groups, and specific experimental manipulations. If the study involves more than one experiment, describe the method and results of each of them separately. Numbered, Study 1, Study 2,etc.

2.2.1.3. *Results.* The results must be presented as accurately as possible. The discussion should be minimal and reserved for the Discussion section. The results may be presented as text, tables or figures. To report statistical data, abbreviations should be in italics, as well as when using the *p*-value (which should always be in lowercase). For example: *p, F, gl, SD, SEM, SRD, ICC, ICC*. It is necessary to include a space before and after the equal sign (=). A space must be included also between the number and the unit of measure (not 7Kg but 7 Kg), conversely the space between the number and the percentage sign should not be included (7% and 7% do not). Decimals will be preceded by points (9.1 and not 9,1).

Do not include the same information in the text as used in the tables or figures. The Figures and Tables will be introduced where appropriate in the text, with their correlative numbering, putting the legend of the Figures at the bottom and the legend of the Tables at the top.

Tables are an organized summary of words or figures in lines or lines. All tables must follow the APA format, including: a) their numbering in Arabic numerals, b) a title, c) only horizontal lines above the heading, below it and at the end of the table, without vertical lines, and d) background of white table. Decimals within tables must be separated by dock (.). All abbreviations or symbols used in it should be included at the bottom of the table. The font size in the tables may vary depending on the amount of data that is included, and can be illustrated up to 8 cpi as a maximum.

Table 1. Example Table 1 to include articles sent to *CCD*.

	P5	POT	STD	SDS	SDI	EQG	SDT	ENF	CA	EH	ES	Esuc	F	MT	ED
MT	9.1	21.	9.1	6.1	92.	63.6	9.0	33.3	3.0	30.	15.	12.	0.0	82.1	35.
ED	33.3	13.3	16.7	6.7	23.0	70.0	16.6	26.7	21.1	63.3	0.0	30	10.0	13.3	96.0

Note: P5=Write the meaning of abbreviations.

Table 2. Example Table 2 to include articles sent to *CCD*.

Name 1	Item 1. Explanation of the characteristics of the item 1 Item 2. Explanation of the characteristics of the item 2 Item 3. Explanation of the characteristics of the item 3
Name 2	Item 1. Explanation of the characteristics of the item 1 Item 2. Explanation of the characteristics of the item 2 Item 3. Explanation of the characteristics of the item 3

The Figures are exposures of data in a non-linear way by means of iconic resources of any genre. If photographs are included, they must be carefully selected, ensuring that they have a quality of at least 300 pixels / inch and 8 cm wide. If photographs are reproduced, subjects should not be identified. In any case, the authors must have obtained the informed consent for the realization of these images, authorizing their publication, reproduction and dissemination in CCD. Figures should be included in the text, including: a) their numbering in Arabic numerals, b) a title.

2.2.1.4. *Discussion.* The discussion is an interpretation of the results and their implications. This section should relate the results of the study to theory, and or, previous research with references and discuss the significance of what has been achieved. A general review of the problem must not be included. The discussion will be focused on the most important results of the study and avoid repeating the results shown in the previous paragraph. Avoid controversy, triviality and comparisons theoretical surface. Speculation is appropriate if it appears as such and is closely related to the theory and empirical data. Identify theoretical and practical implications of the study. Suggest improvements in the investigation or further investigation, but briefly.

2.2.1.5. *Conclusions.* Summarize the most important findings of the work for future research. Only conclusions supported by the results of the study and discussion must be presented. The significance of the work, its limitations and advan-

tages, the application of results and future lines of investigation should be presented.

2.2.2. *Review articles.* Historical review articles should use the following the same sections and style from original research. Reviews on the status of an issue should be systematic.

2.2.2. *Essays.* This section of *Cultura, Ciencia y Deporte* will admit essays, properly structured and sufficiently justified, grounded, we argue and with logical coherence, on issues related to sport, that have a deep philosophical or anthropological background that promotes the advance in the compression of sport as a phenomenon genuinely human. It aims to be a dynamic, current section that marks the editorial line and the philosophy of the sport that underlies the journal. You do not need to follow the original research scheme, but the same format.

2.3 Relevant information from the journal

The journal *Cultura, Ciencia y Deporte* adheres to the "Code of Conduct and the Best Practices Guidelines for Journals Editors of the Committee on Publication Ethics - COPE" and the recommendations of the "International Committee of Medical Journal Editors - ICJME". There is a commitment by the journal to detect plagiarism and other types of fraud in the writing and submission of articles to *Cultura, Ciencia y Deporte.*

The journal's editorial policy promotes the use of inclusive language in scientific articles. Please take note of this guideline and review your document before submitting it to the journal.

3 TREATMENT OF PERSONAL DATA

In virtue of what was established in article 17 of the Royal Decree 994/1999, in which the Regulation for Security Measures Pertaining to Automated Files That Contain Personal Data was approved, as well as the Constitutional Law 15/1999 for Personal Data Protection, and Law Organic Law 3/2018, of 5 December, on the Protection of Personal Data and guarantee of digital rights, the editorial committee of *Cultura, Ciencia y Deporte* guarantees adequate treatment of personal data.

4 INFORMATION REGARDING PROOFS AFTER ACCEPTANCE OF THE ARTICLE

In case of acceptance, the author appointed as correspondent will receive a style report (with formatting aspects to be modified, if necessary) together with a document requesting the names and surnames of all authors together with their affiliation (for the head of the article), the contribution of each of the authors, the authors' social networks and acknowledgements. These documents will be returned complete within a maximum of three days. You will then receive a proof of the article in PDF format by email. The proof will be reviewed and any errors marked with the Adobe Acrobat notes option, and the corrected proofs will be returned to the journal's editorial staff within a maximum of 48 hours. If these proofs are not received by the deadline, the journal's Editorial Committee may decide to publish the article in its original state, with no changes made after publication and the journal will not be responsible for any errors or omissions that may be published; or delay publication to a later issue. At this stage of editing the manuscript, corrections made should be kept to a minimum. The editorial team reserves the right to admit or not the corrections made by the author in the proof print.

5 INFORMATION ON THE CONTRIBUTION OF ALL SIGNATORIES TO THE ARTICLE

Authors must inform about the criteria chosen to decide the order of signature and about the specific contribution made by each one of them in the published work. This information will be requested on the final sheet where the authors are asked for their details, affiliations, contributions from the authors, social networks and acknowledgements. Only those persons who have contributed intellectually to the development of the work should appear on the list of signatory authors. In general, in order to appear as an author, the following requirements must be met: a) to have participated in the conception and execution of the work that has resulted in the article in question; b) to have participated in the drafting of the text and possible revisions of the same; c) to have approved the version that is finally going to be published. The editorial team of *Cultura, Ciencia y Deporte* refuses any responsibility for possible conflicts derived from the authorship of the works published in the journal. The author who signs as a correspondent will be responsible for acting as a mediator between the journal and the other authors and must keep all co-authors informed and involved in important decisions about the publication. After the article has been accepted, no changes will be made to it, and it is therefore recommended that all co-authors give their approval before revisions are sent to the journal.

6 SOURCE OF FUNDING FOR PUBLISHED PAPERS

Authors must declare whether the work has had any funding to carry out the research to be published, as well as the research projects or contracts funded as a result. This information must be included in the journal's metadata when the article is uploaded to the platform. In addition, this information will be requested again in the final page where authors are asked for their data, affiliations, contributions, social networks and acknowledgements.

7 PAYMENT IN CONCEPT OF PARTIAL FINANCING OF PUBLICATION

The rules in this section are effective for submissions and revisions send from 29 October, 2019. In accordance with the Open Access philosophy of the journal and in order to cover part of the expenses of the publication in to improve its quality, visibility and impact of the publication, CCD sets a publication fee of €120 (VAT included). This payment must be done after the notification of acceptance of the article.

To do this, after acceptance of the article, the receipt of the transfer made to "FUNDACIÓN UNIVERSITARIA SAN ANTONIO" in the account number ES02 0081 5089 3800 0109 4420 (BIC-SWIFT CODE: BSABESBB) must be sent to gjimenez@ucam.edu, indicating in the concept of the transfer "CCD journal + article number".

Furthermore, reviewers of CCD articles will be entitled to a free publication for every three articles they have reviewed in time and in the form requested by the editors. To this end, they must indicate the reviewed articles if they want to benefit from the exemption of payment when requested. Editors are exempt from payment.

8 IMPORTANT UPDATE IN THE SENDING REGULATIONS AS OF JANUARY 1, 2021.

All authors who submit an article after this date (in a language other than English), and whose article is finally accepted, must also submit the final version in English. The full name of the translator and his/her e-mail address must appear on the English version. The intention of this change is to increase the circulation of articles published in our journal.

9 PROPOSAL FOR THE PUBLICATION OF MONOGRAPHS ON CULTURA, CIENCIA Y DEPORTE

Those interested in proposing the publication of a monograph in the journal Cultura, Ciencia y Deporte should send a 500-600 word description (including references) to the journal's email address (ccd@ucam.edu). In this email, the coordinator or coordinators (maximum 3 people) must provide an approximation of the subject matter and content of the proposed monograph, as well as their CVs.

Once the monograph proposal has been accepted, a "Call for papers" period and a "Deadline" for submissions will be established, the duration of which will be determined by the coordinator of the monograph. The editorial team of the Journal Cultura, Ciencia y Deporte will propose a date for the publication of the monograph according to its availability.

The functions of the coordinator of the monograph will be to write the editorial of the monograph, and to provide a list of possible reviewers who will be selected by the editorial team to carry out the peer reviews of the articles in the monograph. A minimum of 10 accepted articles will be required for the monograph to be published. The coordinator of the monograph will have the possibility to invite authors to collaborate with their manuscripts. The final decision as to whether an article is accepted for inclusion in the monograph will be made by the editorial team, not by the monograph coordinator. All manuscripts accepted for publication, including the editorial, will have a DOI.

10 PUBLICATION OF ARTICLES IN A MONOGRAPH

Manuscripts must be submitted through the Cultura, Ciencia y Deporte website (https://ccd.ucam.edu), by registering and logging in. During the submission process, select the tab with the name of the monograph where you intend to publish. Research and review articles are invited. Accepted papers will be published on the website of the Journal Cultura, Ciencia y Deporte, and will have their corresponding DOI.

Manuscripts submitted must not have been previously published, nor be under consideration for publication elsewhere. All manuscripts undergo a rigorous blind peer review process. Manuscripts should be written according to the general guidelines of the journal: https://ccd.ucam.edu/index.php/revista/about/submissions#authorGuidelines and following the guidelines of the journal's template(https://docs.google.com/document/d/1YjojriyIgd0VUNS9Jk55gPbdf5oEcuN_/edit?usp=sharing&ouid=109045219128359206476&rtpof=true&sd=true). The article processing fee for authors in open access special issues (monographs) is 250 euros per article (including VAT). The coordinator of the monograph is not required to pay any editorial editing fee and will have a free article in the monograph. Articles submitted must be in the correct format according to the journal's publication guidelines, otherwise they will not be accepted. Submissions can be made in Spanish or English, and if the article is submitted in Spanish, it must be translated into English by the authors once the article has been accepted.

CHECKLIST FORMAT FOR ARTICLES IN CCD

- Text: adapted to the template available on the website and in the journal's publication guidelines.
- Text alignment: left and right (justified).
- Length: should not exceed 7500 words including figures, tables, and references.
- First page: should contain the following items of the work: title in Spanish and English in lowercase, a summary of the work in Spanish and English, plus the key words in Spanish and English. By this order, or the opposite if the article is written in English.
- Second page: start with the text. The main document should be in a new page (after abstract).
- Clear indication of paragraphs or sections that comprise, and with a clear hierarchy of
- possible sub-sections (first level will be without tabulating in bold type, second will be in italic without tabulating, and the third will be in italics and with tabulation). All in lowercase letter.
- Title: Recommended 10 to 12 words.
- Abstract: The length of the abstracts should not exceed 200 words.
- Keywords: 4 or 5 words that clearly reflect what the specific content of the work. Do not repeat the title. Only the first word is written with capital. Words separated with commas, and point at the end.
- Figures and Tables: In the text, with consecutive numbering.
- Figures and Tables: Figures caption in the bottom and Tables caption at the top.
- Figures and Tables: Maintain simple tables without vertical lines.
- Figures and Tables: The font size in the tables may vary depending on the amount of data that includes, and can be cut up to 8 cpi.
- References: They must follow the APA 7th edition format.
- Acknowledgements: They must be placed in the application in the space defined for this purpose.
- Submission: two manuscripts are included, one with the name "**article with authors**" and the other "**anonymous article**".

Murcia, 5th October 2021
Cultura, Ciencia y Deporte
ISSN 1989-7413(digital)
doi.10.12800/ccd

MANUAL DE AYUDA PARA LOS REVISORES EN EL PROCESO DE REVISIÓN DE ARTÍCULOS EN CCD*

Estimado revisor, su labor es inestimable. Le estamos extraordinariamente agradecidos. Sin su aportación rigurosa , la calidad de los trabajos que se publican en CCD, no sería tal. Es por ello por lo que estamos completamente abiertos a tantas recomendaciones y aportaciones que sirvan para mejorar el ya de por sí complejo proceso de revisión. En esta nueva etapa de CCD tenemos una premisa: agilidad, eficiencia y rigor de los procesos de revisión. Por ello le pedimos que, por favor, plantee valoraciones sólidas y las argumente de forma constructiva con un objetivo principal: mejorar la calidad del artículo (siempre que sea posible). Además, le recomendamos que tenga en cuenta las premisas para los revisores que marca la *Declaración de Ética y Negligencia de la Publicación* que puede ver en el pie de página.

A continuación se presenta un manual, en el que los revisores de la revista CCD podrán seguir paso a paso todas y cada una de las tareas que deben acometer para realizar un proceso de revisión riguroso y que se ajuste a las características de la plataforma de revisión (OJS) y de la filosofía de la revista. Cualquier duda que le surja, por favor, no dude en contactar con los editores de la revista (rvaquero@ucam.edu y labenza@ucam.edu). Todas y cada una de las fases se describen a continuación:

1. El revisor recibe el e-mail de CCD con la solicitud de revisión de un artículo. Debe decidir si acepta (o no) la petición del editor de sección. Para ello, debe clicar sobre el título del artículo dentro de "Envíos activos".
2. Una vez hecho esto, aparecerá una pantalla como la siguien- te, en la que el revisor debe seleccionar si hará (o no) la revisión. Si se acepta (o no), aparecerá una ventana automática con una plantilla de correo al editor de sección para comunicarle su decisión. Independientemente de su decisión, el revisor debe enviar este correo electrónico. Una vez la revisión es aceptada el revisor debe cumplir las indicaciones que aparecen en la pantalla siguiente.
3. A continuación debe primero abrir y descargar el fichero del manuscrito; y segundo, abrir y descargar la hoja de evaluación de CCD que puede encontrar en el apartado "Normas de revisor" (parte inferior en el epígrafe 1). La revisión y todos los comentarios que el revisor realice deberán plasmarse en esta hoja de evaluación (nunca en el texto completo a modo de comentarios o utilizando el control de cambios). Con ambos documentos descargados se procederá a la revisión propiamente dicha. Es muy importante que el revisor conozca las normas de publicación de CCD, para proceder de forma exhaustiva. Si bien los editores en fases previas del proceso de revisión han dado visto/bueno al formato del artículo, es importante que se conozcan las normas a nivel general para poder evaluar el artículo con mayor rigurosidad.
4. Una vez completada la revisión y rellenada la hoja de evaluación puede escribir algunos comentarios de revisión para el autor y/o para el editor. El comité editorial de CCD recomienda no introducir comentarios específicos en estos apartados. De utilizarse (pues no es obligatorio) se recomienda que hagan una valoración global del artículo, en la que se utilice un lenguaje formal.
5. A continuación debe subir el fichero con la hoja de evaluación del manuscrito actualizada. En este apartado únicamente se debe subir un archivo con la correspondiente evaluación del artículo. No se olvide de clicar en "Subir" o de lo contrario, a pesar de haber sido seleccionado, no se subirá el archivo, y el editor de sección no podrá acceder a él.
6. Por último, se debe tomar una decisión sobre el manuscrito revisado y enviarla al editor. Para ello debe pulsar el botón de enviar el correo, ya que de no ser así el correo no será enviado. Las diferentes opciones de decisión que la plataforma ofrece son las que puede ver en la pantalla. En el caso de considerar que "se necesitan revisiones" o "reenviar para revisión" llegado el momento, el editor se volverá a poner en contacto con usted y le solicitará empezar con la segunda (o siguientes rondas de revisión), que deberá aceptar y volver a empezar el proceso tal y como se explica en el presente manual. Caso de aceptar o rechazar el manuscrito, el trabajo del revisor habrá terminado cuando informe al editor de sección de esta decisión, tal como se ha indicado anteriormente (correo al editor mediante la plataforma).

En la segunda y siguientes rondas de revisión, el revisor se encontrará con dos archivos: uno con el texto completo del manuscrito, en el que el autor ha modificado con otro color distinto al negro en función de las aportaciones sugeridas; y otro fichero adicional con la planilla de evaluación, en la que el autor ha respondido punto por punto en un color distinto al negro, a todas las aportaciones que usted le hizo. Por favor, compruebe que todo está correctamente modificado. Caso de no producirse, responda en la misma hoja de evaluación con tantos comentarios considere, para que el autor pueda "afinar más" y realizar las modificaciones de forma satisfactoria y rigurosa. Este proceso se repetirá tantas veces como los editores de sección consideren oportuno.

Una vez completada la segunda (o siguientes rondas de revisión) del manuscrito, se volverá a tomar una decisión sobre el mismo, y se procederá de la misma manera que en la primera ronda. Una vez se da por finalizada la revisión doble-ciego del manuscrito, desaparecerá de su perfil de revisor, en el que encontrará 0 activos.

Antonio Sánchez Pato
Editor-jefe
(apato@ucam.edu)

*** Se puede acceder a una versión ampliada de este manual en la siguiente url: http://ccd.ucam.edu/index.php/revista/pages/view/revisores**

RESPONSABILIDADES DE LOS REVISORES

1) Los revisores deben mantener toda la información relativa a los documentos confidenciales y tratarlos como información privilegiada.
2) Las revisiones deben realizarse objetivamente, sin crítica personal del autor.
3) Los revisores deben expresar sus puntos de vista con claridad, con argumentos de apoyo.
4) Los revisores deben identificar el trabajo publicado relevante que no haya sido citado por los autores.
5) Los revisores también deben llamar la atención del Editor-jefe acerca de cualquier similitud sustancial o superposición entre el manuscrito en cuestión y cualquier otro documento publicado de los que tengan conocimiento.
6) Los revisores no deben revisar los manuscritos en los que tienen conflictos de interés que resulte de la competencia, colaboración u otras relaciones o conexiones con alguno de los autores, empresas o instituciones en relación a los manuscritos.

INFO FOR REVIEWERS IN THE REVIEW PROCESS FOR ARTICLES IN CCD*

Dear reviewer, your work is essential. We are remarkably grateful. Without your rigorous contribution, the qua-lity of the papers published in CCD would not be the same. That is why we are completely open to recommendations and contributions that can open the already complex process of revision. In this new stage of CDD we have a premise: agility, efficiency and the exactitude of the revision process. Thus, we please ask you solid ratings, and argue constructively with one main objective: to improve the quality of the article. In addition, we recommend you to consider the premises that denotes the Statement of Ethics and Publication Malpractice that can be ob-served in the footer.

Below a manual is presented, where the CCD journal reviewers are going to be able to follow step by step the process in order to perform a rigorous review process that fits the characteristics of the review platform (OJS) and the philosophy of the journal. Any questions that may raise, please do not hesitate to contact the publishers of the journal (rvaquero@ucam.edu y labenza@ucam. edu). Each and every one of the steps are described here:

1. The reviewer receives the e-mail of CCD with the request for revision of an article. You must decide whether to accept (or not) the request of the "Section Editor". For this, you must click on the title of the article under "Active Submissions".
2. Once this is done, a screen like the following one is going to appear in which the reviewer must select whether will (or not) review the article. If accepted (or not) an automatic window ap-pears with a template email to the Section Editor to communi-cate its decision. Regardless its decision, the reviewer must send this email. Once the revision is accepted, the reviewer should fo-llow the directions that appear on the screen below.
3. The next step is to open and download the file of the ma-nuscript; and second, open and download the evaluation sheet that can be found under the "Reviewer Guidelines" (in the sec-tion 1). The review and any comments that the reviewer makes, should be written in the evaluation sheet (not in the full text as a comment). It is very important that the reviewers knows the CCD publishing standards in order to proceed exhaustively. When the editors accept the format of the article, it is crucial that the re-viewers know the general rules, to assess more rigorously the article.
4. After completing the revision and filled the evaluation sheet, you can write some review comments to the author and/or publisher. The CCD editorial committee recommends not to introduce specific comments on these sections. If it needs to be used (not required) make an overall assessment of the article, using a formal language.
5. The next step consists of uploading the manuscript evalua-tion sheet updated. Here, you only need to upload a file with the corresponding evaluation of the article. Make sure you first click on "select file" and then on "upload".
6. Eventually, a decision on the manuscript must be taken and send it to the Editor. Thus, it is needed to press the button to send the email because if not it will not be sent. The different op-tions that can be chosen appear in the screen below. In the case of considering "revisions required" or "resubmit for review", the editor will get in touch with you and ask you to start with the second round (or further rounds), having to accept and start the same process that has been explained. If the manuscript is accepted or declined, the reviewer´s job will be over, informing the Section Editor by email.

In the second and subsequent rounds of review, the reviewer will find two files: one with the full text of the manuscript in which the author has modified with another colour different to black depending on the contributions suggested, and another additional file with the evaluation form, where the author has responded point by point in a different colour to black all contri-butions that the reviewer made. Please, check that everything is correctly modified. If not, answer the same evaluation sheet with the considered comments, so that the author can "refine" and make the changes in a satisfactory and rigorous way. This process will be repeated as many times as the Section Editors consider appropriate.

Once the second (or subsequent rounds of revision) of the ma-nuscript is completed, a new decision will be made, and proceed in the same way as in the first round. Once ends the double-blind review of the manuscript, it will disappear from your reviewer profile, where you will find none "Active Submissions".

Antonio Sánchez Pato
Editor-jefe
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RESPONSIBILITIES OF THE REVIEWERS

1) Reviewers should keep all information relating to confidential documents and treat them as privileged.
2) The revisions must be made objectively, without personal criticism of the author.
3) Reviewers should express their views clearly with supporting arguments.
4) Reviewers should identify relevant published work that has not been mentioned by the authors.
5) Reviewers also should draw the attention of Editor-in-chief about any substantial similarity or overlap between the manuscript in question and any other document of which they are aware.
6) Reviewers should not review manuscripts in which they have conflicts of interest resulting from competitive, collaborative, or other relationships or connections with any of the authors, companies, or institutions connected to the manuscripts.

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ESPAÑA • SEPTIEMBRE 2022 • VOL. 17 • NUM. 53 • PÁGS. 1 A 214

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