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Editorial

The Fall of the Gods: Mental Health and Psychological Well-Being in Sport

La Caída de los Dioses: Salud Mental y Bienestar Psicológico en el Deporte

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For decades, we could even say centuries, elite athletes have occupied a pre-eminent place among the deities of the different peoples and tribal groups that human beings have formed in their evolution. They have represented the most select and unattainable of different societies, and also have incorporated the highest virtue by combining an excellent body with exemplary conduct. Citius, altius, fortius... the Olympus of the gods. Fall or twilight? Being faster, taller, stronger rarely leaves room for manifest, or even latent, human weaknesses.

The power of the culture of success, the "if I wish enough, I can", the "immortality", has been hit at the waterline of the very essence of sport... we thought not, but our gods suffer, and sometimes they fall from their high pedestal. They are human, even if they had (they have) to represent a deity that disguises impulses, emotions, loneliness, sometimes deep hidded, and perhaps for that reason, the discovery is really cruel.

The more or less recent cases of athletes who have publicly expressed mental health problems have helped to make visible a fact that, if it occurred, was denied or at best had to be dealt with privately. It has been evident that - as in the general population - the stigma of suffering from a psychological disorder has represented a barrier to the assumption of this problem and the search for solutions provided by health professionals (Rose et al, 2007).

Simone Biles, Álvaro Morata, Ricky Rubio, Michael Phelps, Andrés Iniesta... and other athletes who have publicly expressed their problems have helped to raise awareness and address the issue through public debate, undoubtedly reducing this fear of stigmatization. These cases represent concrete examples of the epidemiological data that the latest scientific studies have revealed, indicating that active athletes have a significant prevalence of mental disorders, specifically depression between 17 and 57%, anxiety between 21 and 48%, and eating disorders and/or alcohol abuse of 19% (Armino et al., 2021).

Furthermore, women report a higher percentage of mental disorders than men, and more than half of athletes report a lifetime prevalence of mental health disorders, with age being a relevant factor (Gwytter et al, 2024), as symptoms manifested early and recurrent episodes were common (Åkesdotter et al., 2020). Troubles are in sports, as in the general population, emotional problems, psychological distress, and mental health disorders. Gods are human.

But we must ask ourselves, is high-performance sport a breeding ground for emotional, psychological and mental problems that did not "exist" before and now emerge as a defining part of sports practice? We should not, (rigor in hand) demonize sports practice, whether elite, performance or simply competitive. Sports practice is beneficial for mental health and psychological well-being, from many points of view. There is abundant literature and empirical evidence, of the various benefits of practicing physical exercise or sport, to improve symptoms of depression (Dishman et al., 2021; Stanton, & Reaburn, 2014); anxiety and distress (Singh et al., 2023) in a wide range of populations, including the general population across the age range, as well as in people with diagnosed mental health disorders, or people with chronic physical illnesses.

In fact, some authors (Pearce et al., 2022; Singh et al., 2023) go so far as to state that physical activity should be a fundamental approach in the treatment of depression, anxiety and psychological distress, and that various health

professionals should be sufficiently trained to try to encourage any increase in physical activity with the aim of promoting psychological well-being and - if applicable - improving mental health.

At this point the ball is in our court, and it involves the entire group of people (athletes, coaches, technicians, psychologists, doctors, etc.) and institutions (sports federations, governments, regional councils, etc.) involved in sports practice, without forgetting the media, both general, sports and scientific.

So, can something be done? What can we contribute to promote Mental Health and Psychological Wellbeing in the sports field? Without a doubt, the answers to these questions must be inscribed in a broad and ecological framework of the sporting event, where, in addition to the athlete, their entire context and their interaction with it are taken into account.

In this sense, the International Society of Sport Psychology (ISSP) made proposals and work recommendations derived from the discussion and consensus of international experts (Schinke et al., 2022) for the promotion of mental health and which have been recently revised (Schinke et al., 2024), expressing the need for a greater clinical understanding of the mental health of athletes; knowing the role of the sports environment; analyzing the weight of mental health in relation to the careers of athletes, and attending to cultural considerations in relation to sports practice.

Specifically, ISSP suggests (a) promoting new conceptual, theoretical and methodological developments, research findings on elite athletes' mental health and applied directions through education, supervision, publications, expert groups and other public debates in sport psychology involving sport science professionals, athletes, coaches, managers, sport policy makers and the media; (b) further developing existing lines of mental health research on the prevalence of mental disorders among various groups of athletes; forms of treatment; on healthy and unhealthy sport environments; or analysing the existence and why of successful and/or crisis transitions; (c) promote emerging lines of research on the above points but from a cross-cultural perspective, as for example occurs with the stigmatization of psychological problems, especially in non-Western countries; (d) further promote the integration of holistic, developmental and ecological approaches in research and practice to better understand the interaction between risk and protective factors for the mental health of elite athletes and, based on this, carry out evidence-based interventions; and, (e) increase the role of sports psychology professionals in multidisciplinary support teams in relation to mental health monitoring, increasing mental health knowledge of athletes themselves, and trying by all means to eliminate the stigma, and above all, the barrier that it represents to facilitate the complex step of seeking professional help.

From the point of view of this editorial, all these recommendations are absolutely relevant for the promotion of psychological well-being and the prevention of mental health problems in high-performance athletes. Although we could say that we are perhaps talking today demigods, we can think that the fire of Prometheus, the victory of the Olympians, has allowed us to open a Pandora's box that should no longer be closed: we have to work clearly and openly so that the mental health and psychological well-being of athletes will be an unquestionable and faithful companion, the Argos of Ulysses, of the search for performance, and of the practice of sport and exercise, whatever the demands to which we submit ourselves.

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Editorial

La Caída de los Dioses: Salud Mental y Bienestar Psicológico en el Deporte

The Fall of the Gods: Mental Health and Psychological Well-Being in Sport

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Durante décadas, incluso podríamos decir siglos, los deportistas de élite han ocupado un lugar preeminente entre las deidades de los diferentes pueblos y grupos tribales que el ser humano, en su evolución, ha conformado. Han representado lo más selecto e inalcanzable de diferentes sociedades, y han incorporado la máxima virtud conjuntando un cuerpo excelente con una conducta ejemplar. Citius, altius, fortius,... el Olimpo de los dioses. ¿Caída o crepúsculo? El ser más rápido, más alto, más fuerte, rara vez deja lugar a debilidades humanas manifiestas, ni siquiera latentes. El poder de la cultura del éxito, del "si quiero puedo", de la "inmortalidad" se ha visto golpeado en la línea de flotación de la esencia deportiva misma... creíamos que no, pero nuestros dioses sufren, y a veces desde lo más alto del pedestal caen. Son humanos, aunque hayan tenido (tengan) que representar una deidad que enmascaraba pulsiones, emociones, soledades, quizá soterradas, y quizá por ello más crueles... más crueles al descubrirse.

Los casos más o menos recientes de deportistas que han expresado públicamente problemas de salud mental han ayudado a visibilizar un hecho que si se daba, se negaba o en el mejor de los casos debía de tratarse de forma privada. Ha sido evidente que -como en la población general- el estigma de padecer un trastorno psicológico ha representado una barrera para la asunción de este problema y la búsqueda de soluciones por parte de los profesionales de la salud (Rose et al., 2007).

Simone Biles, Álvaro Morata, Ricky Rubio, Michael Phelps, Andrés Iniesta... y otros y otras deportistas que han manifestado públicamente sus problemas han ayudado a visibilizar y abordar la cuestión desde el debate público, reduciendo sin duda este miedo a la estigmatización. Estos casos representan ejemplos concretos de los datos epidemiológicos que los últimos estudios científicos han revelado, indicando que los deportistas en activo presentan una prevalencia significativa de trastornos mentales, concretamente de depresión entre el 17 y el 57%, de ansiedad entre el 21 y el 48% y trastornos alimentarios y/o abuso de alcohol del 19% (Armino et al., 2021).

Además, las mujeres manifiestan un porcentaje mayor de trastornos mentales respecto a los hombres, y más de la mitad de los deportistas informan una prevalencia de por vida de trastornos de salud mental, siendo la edad un factor relevante (Gwytter et al., 2024), ya que los síntomas se manifestaron precozmente y los episodios recurrentes fueron comunes (Åkesdotter et al., 2020). Es decir, al igual que en la población general, en el deporte existen problemas emocionales, malestar psicológico, y trastornos de salud mental. Los dioses son humanos.

Pero, debemos preguntarnos, ¿el deporte de alto rendimiento es un caldo de cultivo de problemas emocionales, psicológicos y mentales, que antes no "existían" y ahora afloran como parte definitoria de la práctica deportiva? Ni debemos, ni podemos (rigor en mano) demonizar la práctica deportiva, sea de élite, de rendimiento o simplemente competitiva. La práctica deportiva es beneficiosa para la salud mental y el bienestar psicológico, desde muchos puntos de vista. Existe abundante bibliografía, es decir, evidencia empírica, de los diversos beneficios de la práctica de ejercicio físico o deporte, para mejorar los síntomas de depresión (Dishman et al., 2021; Stanton, & Reaburn, 2014); ansiedad y angustia (Singh et al., 2023) en una amplia gama de poblaciones, incluida la general en todo el rango de edades, así como en personas con trastornos de salud mental diagnosticados, o personas con enfermedades físicas crónicas. De hecho, algunos autores (Pearce

et al., 2022; Singh et al., 2023) llegan hasta el punto de afirmar que la actividad física debería ser un enfoque fundamental en el tratamiento de la depresión, la ansiedad y el malestar psicológico, y que los diversos profesionales de la salud deberían estar suficientemente formados para tratar de fomentar cualquier aumento de la actividad física con el objetivo de facilitar el bienestar psicológico y -si es el caso- mejorar la salud mental.

En estos momentos la pelota está en nuestro tejado, y compromete a todo el colectivo de personas (deportistas, entrenadores, técnicos, psicólogos, médicos, etc.) y de instituciones (federaciones deportivas, gobiernos, consejerías, etc.) intervinientes en la práctica deportiva, sin olvidar los medios de comunicación, tanto los generales, los deportivos, como los divulgativos científicos.

Entonces, ¿se puede hacer algo? ¿qué podemos aportar para promocionar la Salud Mental y el Bienestar psicológico en el ámbito deportivo? Sin duda alguna, las respuestas a estas cuestiones deben inscribirse en un marco amplio y ecológico del hecho deportivo, donde además del deportista se tenga en cuenta todo su contexto y su interacción con él.

En este sentido, la *International Society of Sport Psychology (ISSP)* realizó propuestas y recomendaciones de trabajo derivadas de la discusión y consenso de expertos internacionales (Schinke et al., 2022) para la promoción de la salud mental y que han sido recientemente revisadas (Schinke et al., 2024), expresando la necesidad de una mayor comprensión clínica de la salud mental de los deportistas; conocer el papel del entorno deportivo; analizar el peso de la salud mental en relación con las carreras de los deportistas, y atender a las consideraciones culturales en relación a la práctica deportiva. Concretamente, sugiere (a) promover nuevos desarrollos conceptuales, teóricos y metodológicos, hallazgos de investigación sobre la salud mental de los atletas de élite y direcciones aplicadas a través de la educación, supervisión, publicaciones, grupos de expertos y otros debates públicos en psicología del deporte que involucren a profesionales científicos del deporte, atletas, entrenadores, gerentes, formuladores de políticas deportivas y medios de comunicación; (b) desarrollar aún más las líneas existentes de investigación sobre salud mental sobre la prevalencia de trastornos mentales entre varios grupos de deportistas; formas de tratamiento; sobre entornos deportivos saludables y no saludables; o analizar la existencia y el porqué de transiciones exitosas y de crisis; (c) promover líneas emergentes de investigación sobre los puntos anteriores pero desde una perspectiva transcultural, como por ejemplo ocurre con la estigmatización de los problemas psicológicos, especialmente en países no occidentales; (d) promover aún más la integración de los enfoques holísticos de desarrollo y ecológicos en la investigación y la práctica para comprender mejor la interacción entre los factores de riesgo y de protección para la salud mental de los atletas de élite y, en función de ello, realizar intervenciones basadas en evidencia; y (e) aumentar el papel de los profesionales de la psicología del deporte en los equipos de apoyo multidisciplinarios en relación con el seguimiento de la salud mental, el aumento del conocimiento en salud mental de los propios deportistas, y tratar por todos los medios de eliminar el estigma, y sobre todo, la barrera que ésta supone para facilitar el complejo paso de solicitar ayuda profesional.

Desde el punto de vista de este Editorial, todas estas recomendaciones son absolutamente relevantes para la promoción del bienestar psicológico y la prevención de problemas de salud mental en los deportistas de rendimiento. Si bien hoy ya podríamos decir que se trata de semidioses podemos pensar que el fuego de Prometeo, la victoria de los olímpicos nos ha permitido abrir una caja de Pandora que ya no debe cerrarse: trabajar clara y abiertamente para que la salud mental y el bienestar psicológico de los deportistas sea un acompañante indubitado y fiel, el Argos de Ulises, de la búsqueda del rendimiento, y de la práctica del deporte y del ejercicio, sea cual sea la exigencia a la que nos sometamos

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Attention Measurement in Basketball: A Brief Review

Medición de la Atención en el Baloncesto: Una Breve Revisión

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Abstract

Basketball is a team sport that demands the athlete's attention due to the situational demands present during its development. Attention is a mediating factor that, combined with cognition and activation, allows the athlete to achieve maximum performance. However, in the field of sports psychology, evidence on attention measurement is scarce. The present work aims to perform a brief review through an electronic search of the most commonly used instruments for the measurement of attention in basketball players. A total of 768 articles were reviewed in the open-access electronic databases: REDALYC, ProQuest, Scielo, and the ResearchGate network of researchers. Nine publications were relevant to this study, according to the inclusion and exclusion criteria. The results show that the Toulouse-Piéron test is the most widely used instrument to measure attention in basketball. However, it is important to highlight that the Assessment of Declarative Knowledge and Attentional Capacity is presented as the most specific tool to assess attention in this sport, as it focuses on the technique-tactics of basketball players.

Keywords: Sports psychology, psychometric test, training, concentration.

Resumen

El baloncesto es un deporte de conjunto que demanda la atención del deportista debido a las exigencias situacionales presentes durante su desarrollo. La atención es un factor mediador que, combinado con la cognición y la activación, permiten al atleta lograr su máximo rendimiento. No obstante, en el ámbito de la psicología del deporte la evidencia en medición de la atención en el baloncesto es escasa. El objetivo del presente trabajo consiste en realizar una breve revisión a través de una búsqueda electrónica de los instrumentos más utilizados en la medición de la atención en jugadores de baloncesto. Se revisaron un total de 768 artículos en las bases de datos electrónicas de acceso abierto: REDALYC, ProQuest, Scielo y la red de investigadores ResearchGate. Nueve publicaciones fueron relevantes para este estudio de acuerdo con los criterios de inclusión y exclusión. Los resultados muestran que el test Toulouse-Piéron es el instrumento más utilizado para medir la atención en el baloncesto. No obstante, es importante resaltar que la Evaluación del Conocimiento Declarativo y la Capacidad Atencional se presenta como la herramienta más específica para evaluar la atención en este deporte, al enfocarse en la técnica-táctica de los jugadores de baloncesto.

Palabras clave: Psicología deportiva, test psicométrico, entrenamiento, concentración.

Introduction

Attention is a necessary capacity to direct cognitive resources in the face of a relevant event in the environment, maintaining it for a certain period of time, which allows modifying the direction of the cognitive focus voluntarily depending on the needs of the environment and the goals that are set (Weinberg & Gould, 2019).

Sánchez and León (2012) define attention as the psychological process that allows the individual to establish contact with the most relevant stimuli in the situation at the present moment, discarding those that are not, except when the situation requires it. Atwi et al. (2018) consider that attention is a cognitive process that allows a person to perceive, understand, remember, and use information to solve problems and make decisions, essential for human functioning, and a priority in current scientific research.

Attention has been the subject of much research in sports sciences, evidencing its relevance for competitive performance in different disciplines and skills (Ducrocq et al., 2016).

Hernández (2007) states that the main component of concentration is the ability to focus attention on a task that is being performed and not to be distracted by irrelevant stimuli whether internal or external, that trigger cognitive and emotional change in the athlete, causing a loss of concentration on the objective.

Pérez and Crobu (2018) associate attention to selecting the relevant external stimuli resulting in successful sports performance, however, sometimes, it is affected by mood, tension, training loads, pain, fatigue, negative thoughts and self-worth; factors that contribute to the athletes' sports performance (Del Monte, 2017).

Sansone (2023) points out that, to obtain useful and efficient information about the athlete's conditions, tools such as questionnaires and scales are used, which are individually applied to athletes to obtain information on different perceptual factors, such as fatigue, recovery, pain, stress, sleep quality, mood, among others. These results provide information on the athlete's condition at different stages of their training and competition cycles. However, it is not possible to predict athletic performance by carefully designing training and recovery plans alone. This is especially relevant in team sports, where interindividual differences, group dynamics, contextual factors and opponents interact in complex ways.

Morillo (2014) comments that in a sport such as basketball, where the actions are very fast, the field is very small and the dynamics of the game very complex, attention span and concentration are skills that can determine who will be successful or not. Castelnau-Díaz and León (2013) indicate that two of the most frequent pressure situations that affect the focus of attention are, from an external point of view, exclamations and the presence of family members in the audience.

In recent years, there has been an increase in the number of tools used to evaluate various cognitive functions in basketball, as it is a team sport that demands the attention of the athlete due to the situational demands present throughout the game. Therefore, attention is fundamental in the sports scenario that allows the athlete to function properly (Monsma et al., 2017). Activity demands and physiological data vary based on playing position, level of play, and geographic location, however, players competing at the same level experience similar demands. During a match, basketball players run approximately 5-6 km at average physiological intensities above the lactate threshold and 85% of the maximum heart rate, at the end of the matches, a reduction in activity demands and a high dependence on the rapid glycolysis for energy supply, which can be attributed to the mechanisms associated with fatigue, which increase during periods of inactivity can be observed (Stojanović et al., 2018).

Some of the instruments used to measure attention contemplate various dimensions, including performance and concentration evaluation (Gimeno et al., 2001), spatial perception and intelligence (Thurstone & Yela, 2021), resistance to attentional fatigue and selective attention (Maureira et al., 2019). Attention is a key factor in sports performance, allowing athletes to focus on the task at hand and respond quickly and accurately to relevant stimuli in the court; its measurement provides the coaches with information about the players' level of attention, identifying their strengths and weaknesses in order to design specific training strategies.

The goal of the present study is to carry out a brief review through an electronic search of the most used instruments in measuring attention in basketball players.

Method

Selection of Studies

To meet the objective of this work, a search was conducted in English and Spanish, using the terms: attention/atención, basketball/baloncesto, "focus of attention" / "foco atencional" and concentration/concentración, with the Boolean descriptor AND in the electronic databases REDALYC, ProQuest, Scielo and the ResearchGate network of researchers. The search dates spanned from January 23 to March 15, 2023, the review of the information was completed using the bibliographic references found in the previous searches.

The guidelines of the PRISMA Statement (Sarkis-Onofre et al., 2021) were used.

The inclusion criteria for the bibliographic search were the following: a) original articles, b) open access, c) without date constrains, d) descriptive and/or experimental that mention the tests or assessments used, e) female and male basketball players over 11 years of age, f) from teams in competitive leagues.

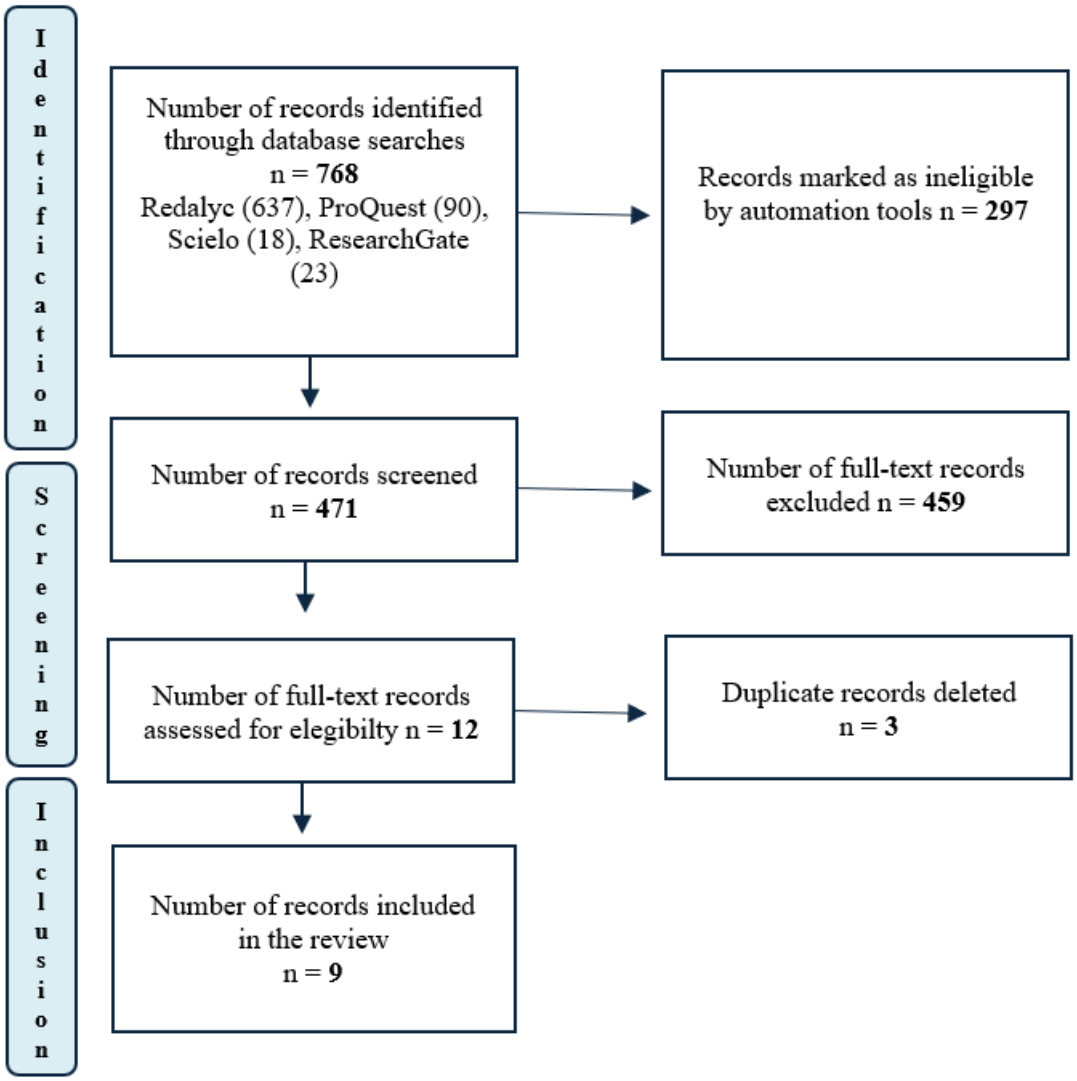
As exclusion criteria: a) doctoral theses, b) reviews, c) book chapters c) posters, d) presentations, e) studies of players with disabilities.

Results

The search parameters that were employed, a total of 768 articles were identified. After eliminating 297 by title and abstract, those that, although their title contained some of the key words, their content did not address the objective of this study, were also discarded, 471 articles were revised according to the inclusion criteria, (duplicates were identified) of which 459 were eliminated for not meeting search criteria, leaving 12 articles, subsequently three3 duplicate articles were eliminated, leaving nine publications selected for this study.

The selection process is specified in "Figure 1".

Figure 1
Flow chart of the studies obtained



"Table 1" summarizes the assessments instruments that were found in the revision of articles indicating the sample, age range, dimensions or factors, number of items, response format and reliability of the questionnaire, as well as the relationship with the variables and the type of study.

Table 1
Characteristics and psychometric properties of assessment instruments

Author and Year	n	Age	Instrument	Number of Items/ actions	Response form	Dimensions/ component	Reliability	Dimension-related variables	Study type
Alarcón López et al. (2010)	10	18 to 26	Instrument for the assessment of declarative knowledge and attentional capacity	40	Semi-structured interview 2 answers	NR	α = .95	Constructivist methodology	Unique case quasi-experimental, without control group. Cross-sectional and longitudinal comparison
Cong and Endozo (2022)	30	NR	Comparative mathematical statistics	NR	Qualitative and mathematical assessment	1. Mental training 2. Enhanced physical training 3. Ball sense 4. Shooting speed 5. Angle shooting	Significant change	Free-throw effectiveness and physical capabilities training methods	Comparative study
Enríquez-Molina et al. (2023)	1,038	20 to 29	Computerized numerical crossing out test	Per time	Crossed out number on 5X5 matrix.	1. Selective attention	NR	1. Individual sports 2. Collective and combat sports Measuring execution time and errors.	Research with associative, comparative and correlational strategy.
Fradejas and Espada (2016)	816	12 to 18	CPRD	55	Likert scale 6 options	1.Stress control 2. Influence of Performance Evaluation 3. Motivation, 4. Mental ability 5. Team Cohesion	α = .85 I.P.E. dimension α = .72	Sports modality. R. Gymnastics Handball Volleyball Basketball Football Soccer Swimming Athletics Judo Futsal Tennis	Test application
López-Roel and Dosil (2019)	327	11 to 54	CNPD-15	15	Likert scale	1. Activation 2. Concentration 3. Confidence 4. Motivation	α = .87	Instrument reduction and validation that evaluates psychological variables	Investigation research
Pinto et al. (2019)	18	18 to 34	Toulouse Pieron	460	Figure Identification	1. Concentration 2. Resistance to monotony 3. Visual perceptive concentration	NR	Free-throw effectiveness	Exploratory, descriptive and inferential
Ponce (2018)	15	18 to 27	Toulouse Pieron	460	Figure Identification	1. Concentration 2. Resistance to monotony 3. Visual perceptive concentration	NR	Free-throw effectiveness	Descriptive correlational, non-experimental

Rodríguez and Sáez (2009)	10	22 + / -	Excel Average	NR	NR	Attention	NR	Free-throw effectiveness	Explanatory
Rodríguez and Montoya (2006)	36	16 to 35	Caras	60	Determine differences	1.Perceptive and attentional skills.	α = .95	Sports Performance	Cuasi exp. Pre-test post-test
Rodríguez and Montoya (2006)	36	16 to 35	Toulouse Pieron	460	Figure Identification	1. Ability to concentrate 2. Attentional fatigue resistance 3. Perceptual speed and persistence	NR	Sports Performance	Cuasi exp. Pre-test post-test

In total, nine instruments applied to basketball players were located, and they are described below.

In the study by Fradejas and Espada (2016) it was observed that the researchers compared the attention of the players according to the different sports modalities in which each of them participate, using the test of Psychological Characteristics related to Sports Performance. It could be seen that there was greater control of attention-concentration among athletes who practiced rhythmic gymnastics and handball, despite having included basketball in this study, no differences were shown.

Rodríguez and Montoya (2006) used two instruments to measure attention: the "Caras" difference perception test and the Toulouse Piéron test. The authors found no differences; a slight increase in their level of attention was observed in the experimental group one, it is important to note that this is the group that received training with distractors in the applied intervention program.

Continuing with the Toulouse Piéron test, Ponce (2014) attempted to relate the effectiveness of free throws to the concentration of attention; it is relevant to mention that, to determine it, a scale of percentages was used, with 0-20% being very low, 21-40% low, 41-60% medium, 61-80% high and 81-100% very high level of attention; the team had an average effectiveness of 58.19% in free throws, which according to the scale used is considered a "low" percentage individually, only one player achieved a qualitative evaluation of "good" with a percentage of 76.47%, in contrast, eight players were evaluated as "bad" and the last six as "regular", when calculating the results of attention concentration, a general average of 41.47% was obtained, which indicates a "medium" qualitative value. At the individual level, only one player obtained a "high" level, while seven players achieved a "medium" level and the remaining seven obtained a "low" level.

Continuing with this instrument, Pinto et al. (2019) used it with the purpose of identifying the level of concentration in a female basketball team, in which the quality of visual perceptual concentration was established at 81.78%, resulting in good quality of attention in the athletes and demonstrating a moderate positive linear correlation between the level of concentration and the effectiveness of free throws. It is concluded that the time spent executing basketball free throws, attention and concentration, have a normally positive linear influence at a low and moderate level on the percentage effectiveness of the sports technique; regarding the "Caras" difference perception test, when performing the analysis, the improvement in attention was attributed to the training using distractors that was applied to experimental group one, however, there were no differences between the groups.

López-Roel and Dosil (2019) carried out the reduction and validation of the Athlete's Psychological Needs Questionnaire (APNQ-15), which evaluates psychological variables and consists of four factors: concentration, activation, confidence and motivation. Items 12 to 15 specifically measure the concentration factor, which allows us to focus on this variable more precisely: A correlational analysis was performed between the CNPD-15 scales and the Athletic Coping Skills Inventory (ACSI), finding a significant correlation of .526 ($p < .01$), which indicates a moderate positive relationship between both measures. In addition, a Cronbach's Alpha value of .809 was obtained, which indicates high reliability and internal consistency in the items that measure concentration.

These results suggest that the CNPD-15 scales and the ACSI test are consistent and reliable measures to evaluate concentration in sport.

Through a qualitative evaluation supported by statistics and throwing averages, both before and after the training program which the experimental groups underwent, it was possible to analyze the effectiveness of different training methods to improve the throwing percentage in basketball players, as was carried out in the study by Cong and Endozo

(2022), who used Comparative Mathematical Statistics to measure variables such as psychological attention, physical fitness, coordination, speed, launch angle and feel of the ball.

Enriquez Molina et al. (2022) determined the differences in selective attention between athletes who practiced individual, team and adversary sports, taking as reference the execution time and the errors presented in a Numerical Cross-Out Test (5x5 matrix), the interest of this review was focused on the measurement of basketball, differences were observed between the groups in terms of the time of execution of the test, those who they practice adversary and collective modalities performed the test more quickly and with fewer errors, the explanation that the authors provide of these results is that in basketball, due to the demands in technical-tactical training and selective attention, the decision making is more complex which helps the player develop this type of cognitive abilities.

Alarcón López et al. (2010) sought to test a methodology based on constructivist learning theories to improve the capacity for selective attention of Basic Collective Tactical Means (BCTM) and Declarative Knowledge in 10 basketball players. To assess attention, an instrument was designed based on the exhibition of a video of match sequences.

The program was divided into three phases for the improvement of MTCB. In the first part, the athletes were taught what the objectives of the game were in general; in the second, what the specific principles were, and in the last or improvement phase, emphasis was placed on the performance of the opponents, taking into account the previously established effectiveness criteria.

The results showed that, after the intervention program, all the athletes were able to improve attention towards the role of the defenders in 70.5% of the scenes, in relation to the pretest in which the players did not perceive what the defenders were doing; the post-test showed that they improved by 89.3% when it came to perceiving the defenders, while for the attackers the perception obtained was 96.5%.

Rodríguez and Sáez in 2009 wanted to evaluate if attention was reduced during games, to the point of being a key factor in the decrease in performance, which was measured in 30 free throws, ten alone, in maximum attention conditions ten during training with the entire team present and the first ten of the following games. The results showed higher percentages of success obtained during training than during matches. However, the minimal difference between training with the presence of other players or alone is due to the fact that they did not experience the tension, the nerves of the match and the level of distractions that must be greater than the simple presence of several people to affect the concentration of the players.

Discussion

In this review, the studies that have been published regarding the most widely used instruments in measuring attention in basketball players were analyzed, highlighting the scarcity of studies on this topic. Sansone et al. (2023) used different instruments to assess the well-being of young basketball players and found that those who have less recovery time on the court show a more constant intensity in the rhythm, which allows them to remain active throughout the training session or match, denoting that the players focus their attention on carrying out the activity, putting fatigue, muscle pain, stress or some other factor that could distract them from their objective.

As González Hernández (2007) mentions in his article to Guallar and Pons (1994), in order to help an athlete train his attention span, with the aim of improving his sports performance, it is necessary to start with an evaluation of the attentional level, thus the importance of the assessment of attention in basketball.

Among the most widely used instruments to measure attention in basketball players, the Toulouse Piéron test stands out (Pinto et al., 2019; Ponce, 2004; Rodríguez & Montoya, 2006), this test was mentioned in three of the nine selected articles. It focuses on evaluating both selective attention and sustained attention, with a duration of two and 10 minutes respectively, it can be applied both individually and collectively (Maureira et al., 2010); when analyzing the test, we agree with Yela (2009) that it would be beneficial to include the instrument's statistical values to provide greater clarity to the reader when choosing a measurement tool, since it has a certain reliability, it is important to use it appropriately in conjunction with other instruments and evaluation techniques, keeping in mind that the interpretation of the results must be carried out by a professional with training and experience in their use in order to guarantee a correct application and avoid possible interpretation errors.

There are some studies that have analyzed the reliability and validity of the Toulouse-Piéron test, each of these documents have addressed different aspects, establishing various methodologies, contexts and populations. In general, studies have found that the test has acceptable test-retest reliability, which means that the results obtained at different times are stable and consistent, also identifying some limitations and recommendations for its use (Fernandes Lopes et al., 2015; Gómez & Morales, 2006; Hilde, 2018).

The computerized Numerical Strikethrough test (5x5 matrix) by Hernández and Ramos (1995) is similar to the identification of images that measures selective attention. Its advantage is the remote application, it belongs to the Attentional Processes software on the MenPas 1.0 evaluation platform, this tool is recommended because of its easy access and for measuring six types of selective attention.

González-Guirval et al. (2020) report that specifically in the case of athletes, this type of software is interesting due to its versatility, its ability to create attractive tasks for the participating population and its potential to generate data that can later be used in the analysis and improvement of cognitive ability in this type of samples, in turn, González-Ruiz et al. (2018) comment that some advantages of technology in research are the speed of obtaining and analyzing results, ease of use, compatibility of various devices and lower margin of error; as disadvantages, it is mentioned that it could hinder the relationship between the researcher and the participants.

The reduction of the CNPD-15 test gave good results in terms of confidence, significant correlation and fulfilling the purpose of collecting data more quickly and efficiently on these 4 factors, reflecting positive psychometric data, however, the inconvenience of subtracting some items is that it also reduces each scale and that affects its reliability. These authors also observed that people who practiced open sports had better results in cognitive processes such as attention (Vestberg et al., 2017), understanding that the longer they practiced their sport, attentional functioning is positively affected.

The CPRD is considered a useful instrument, since it interacts with the information from other evaluation procedures, this helps the sports psychologist in detecting needs and resources, proposing explanatory hypotheses, carrying out functional analysis, making decisions. on the objectives of the intervention and the observation of the athletes' progress (Gimeno et al., 2001).

Conclusions

According to the analyzed literature and responding to the objective of this brief review, we can establish that the most widely used instrument is the Toulouse-Piéron test due to its effectiveness in measuring the athlete's attentional system; and although in the scientific literature there is no specific test to measure attention in basketball, this test can play a relevant role in the assessment of attention in this sport, however, by measuring only sustained and selective attention it is advisable to use the application of other batteries that complement the measurement of attention to obtain a complete and accurate evaluation.

Of the nine instruments that were analyzed in this systematic review for measuring attention, the psychometric quality of five of them is questioned, Toulouse Piéron (Pinto et al., 2019; Ponce, 2018; Rodríguez & Montoya, 2006), a computerized test of Numerical Crossing Out (Enríquez Molina et al., 2022) and the test to measure Free Throws by Rodríguez and Sáez (2009).

However, it is important to highlight that the Evaluation of Declarative Knowledge and Attentional Capacity is presented as the most specific tool to evaluate attention in this sport, by focusing on the technique-tactics of basketball players.

Evaluating attention with data-based methods from an early age allows for improvement of the quality of sports training, contributing efficiently and effectively to the training of basketball players (Xuexiang, 2024); it is advisable to investigate how different recovery methods influence the players' attention in order to identify how mental recovery impacts the improvement of concentration and decision-making within this sport (Calleja-González, 2021).

It should be noted that the field of attention evaluation in sports continues to evolve, it is recommended for future research the creation of a specific test in basketball focused on key aspects of attention during the game, measurement of the ability to concentrate in situations high pressure, selective attention to relevant stimuli in the field and shifting attention between different game actions to name a few.

Ethics Committee Statement

This study did not include research with human data.

Conflict of Interest

The authors declare no conflict of interest.

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Authors' Contribution

Conceptualization Q.G. & E.B.; Methodology M.O.; Software C.J.; Validation Q.G., V.B. & C.J.; Formal Analysis C.J.; Investigation Q.G. & E.B; Resources E.B.; Data Curation M.O.; Writing – Original Draft E.B.; Writing – Review & Editing Q.G. & E.B.; Visualization E.B.; Supervision C.J. & M.O.; Project Administration Q.G. & E.B.; Funding Acquisition Q.G., C.J. & M.O. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author (ebenavides@uach.mx).

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Medición de la Atención en el Baloncesto: Una Breve Revisión

Attention Measurement in Basketball: A Brief Review

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Resumen

El baloncesto es un deporte de conjunto que demanda la atención del deportista debido a las exigencias situacionales presentes durante su desarrollo. La atención es un factor mediador que, combinado con la cognición y la activación, permiten al atleta lograr su máximo rendimiento. No obstante, en el ámbito de la psicología del deporte la evidencia en medición de la atención en el baloncesto es escasa. El objetivo del presente trabajo consiste en realizar una breve revisión a través de una búsqueda electrónica de los instrumentos más utilizados en la medición de la atención en jugadores de baloncesto. Se revisaron un total de 768 artículos en las bases de datos electrónicas de acceso abierto: REDALYC, ProQuest, Scielo y la red de investigadores ResearchGate. Nueve publicaciones fueron relevantes para este estudio de acuerdo con los criterios de inclusión y exclusión. Los resultados muestran que el test Toulouse-Piéron es el instrumento más utilizado para medir la atención en el baloncesto. No obstante, es importante resaltar que la Evaluación del Conocimiento Declarativo y la Capacidad Atencional se presenta como la herramienta más específica para evaluar la atención en este deporte, al enfocarse en la técnica-táctica de los jugadores de baloncesto.

Palabras clave: Psicología deportiva, test psicométrico, entrenamiento, concentración.

Abstract

Basketball is a team sport that demands the athlete's attention due to the situational demands present during its development. attention is a mediating factor that, combined with cognition and activation, allows the athlete to achieve maximum performance. However, in the field of sports psychology, evidence on attention measurement is scarce. The present work aims to perform a brief review through an electronic search of the most commonly used instruments for the measurement of attention in basketball players. A total of 768 articles were reviewed in the open-access electronic databases: REDALYC, ProQuest, Scielo, and the ResearchGate network of researchers. Nine publications were relevant to this study, according to the inclusion and exclusion criteria. The results show that the Toulouse-Piéron test is the most widely used instrument to measure attention in basketball. However, it is important to highlight that the Assessment of Declarative Knowledge and Attentional Capacity is presented as the most specific tool to assess attention in this sport, as it focuses on the technique-tactics of basketball players.

Keywords: Sports psychology, psychometric test, training, concentration.

Introducción

La atención es una capacidad necesaria para dirigir los recursos cognitivos ante un evento relevante del entorno, manteniéndola durante un periodo de tiempo determinado, lo que permite modificar la dirección del enfoque cognitivo de manera voluntaria en función de las necesidades del ambiente y los objetivos que se pretendan (Weinberg & Gould, 2019).

Sánchez y León (2012) definen la atención como el proceso psicológico que permite al individuo establecer contacto con los estímulos más relevantes de la situación en el momento presente, descartando aquellos otros que no lo son, excepto cuando la situación así lo requiera. Atwi et al. (2018) consideran que es un proceso cognitivo que permite a una persona percibir, comprender, recordar y utilizar la información para resolver problemas y tomar decisiones, esencial para el funcionamiento humano, y una prioridad en la investigación científica actual.

La atención ha sido numerosas veces objeto de investigación en las ciencias del deporte, poniendo de manifiesto su relevancia para el rendimiento competitivo en diferentes disciplinas y destrezas (Ducrocq et al., 2016).

Hernández (2007) afirma que el componente principal de la concentración es la capacidad de focalizar la atención sobre una tarea que se está desarrollando y de no distraerse con estímulos internos o externos irrelevantes que desencadenan un cambio cognitivo y emocional en el deportista perdiendo la concentración en el objetivo.

Pérez y Crobu (2018) la relacionan al seleccionar los estímulos externos relevantes resultando un rendimiento deportivo exitoso, sin embargo, en ocasiones, es afectada por el estado de ánimo, la tensión, las cargas de entrenamiento, el dolor, la fatiga, los pensamientos negativos y la autovaloración; factores que contribuyen al rendimiento deportivo de los atletas (Del Monte, 2017).

Sansone (2023) puntualiza que, para obtener información útil y eficiente sobre las condiciones del atleta, se utilizan herramientas como cuestionarios y escalas, las cuales son aplicadas a los atletas de manera individual para conocer distintas medidas perceptivas, como, fatiga, recuperación, dolor, estrés, calidad del sueño, estado de ánimo, entre otros. Estos resultados nos brindan información sobre la condición del atleta en las distintas etapas de sus ciclos de entrenamiento y competencia. Sin embargo, no es posible predecir el rendimiento atlético solo diseñando cuidadosamente planes de entrenamiento y recuperación. Esto es especialmente relevante en deportes de equipo, donde las diferencias interindividuales, las dinámicas grupales, los factores contextuales y los oponentes interactúan de manera compleja.

Morillo (2014) comenta que en un deporte como el básquetbol las acciones son muy rápidas, el campo donde se desarrolla es muy pequeño y la dinámica del juego muy compleja, la capacidad atencional y la concentración son habilidades que pueden determinar quién será o no exitoso. Castelnau-Díaz y León (2013) indican que dos de las situaciones de presión más frecuentes que afectan la concentración de la atención son, desde el punto de vista externo, las exclamaciones y la presencia de familiares en el público.

En los últimos años se ha registrado un aumento del número de herramientas utilizadas para evaluar diversas funciones cognitivas en el baloncesto, ya que es un deporte de conjunto que demanda la atención del deportista debido a las exigencias situacionales presentes durante todo el partido. Por lo que esta habilidad es fundamental en el escenario deportivo que permite un funcionamiento adecuado del atleta (Monsma et al., 2017). Las demandas de la actividad y los datos fisiológicos varían en función de la posición de juego, el nivel de juego y la ubicación geográfica, no obstante, los jugadores que compiten al mismo nivel experimentan demandas similares. Durante un partido, los jugadores de baloncesto corren aproximadamente 5-6 km a intensidades fisiológicas medias superiores al umbral de lactato y al 85% de la frecuencia cardiaca máxima, al final de los partidos se observa una reducción de las demandas de actividad y una alta dependencia de la glucólisis rápida para el suministro de energía, pudiéndose atribuir a los mecanismos asociados con la fatiga, los cuales incrementan en los periodos de inactividad (Stojanović et al., 2018).

Algunos de los instrumentos que se utilizan para medir la atención, contemplan diversas dimensiones entre las que se encuentran la evaluación del rendimiento y concentración (Gimeno et al., 2001), percepción e inteligencia espacial (Thurstone & Yela, 2021) resistencia a la fatiga atencional y atención selectiva (Maureira et al., 2019). La atención es un factor clave en el rendimiento deportivo, permite a los atletas concentrarse en la tarea en cuestión y responder de manera rápida y precisa a los estímulos relevantes en el campo de juego; su medición indica a los entrenadores el nivel de atención de sus jugadores, identificando sus fortalezas y debilidades para así diseñar estrategias de entrenamiento específicas.

El objetivo de la presente revisión consiste en realizar una breve revisión a través de una búsqueda electrónica de los instrumentos más utilizados en la medición de la atención en jugadores de baloncesto.

Método

Selección de los Estudios

Para cumplir el objetivo de este trabajo, se realizó una búsqueda en inglés y español, utilizando los términos: attention/atención, basketball/baloncesto, “focus of attention” /” foco atencional” y concentration/concentración, con el descriptor

booleano AND en las bases de datos electrónicas REDALYC, ProQuest, Scielo y la red de investigadores ResearchGate. La fecha de búsqueda fue del 23 enero al 15 de marzo del 2023, se completó la revisión de la información utilizando las referencias bibliográficas encontradas en las búsquedas previas.

Se utilizaron los lineamientos de la declaración PRISMA (Sarkis-Onofre et al., 2021).

Los criterios de inclusión establecidos en la búsqueda bibliográfica fueron los siguientes: a) artículos originales, b) de acceso abierto, c) sin límite de fecha, d) descriptivos y/o experimentales que mencionan las pruebas utilizadas, e) jugadores de baloncesto femenino y masculino mayores de 11 años, f) de equipos en ligas de competencia.

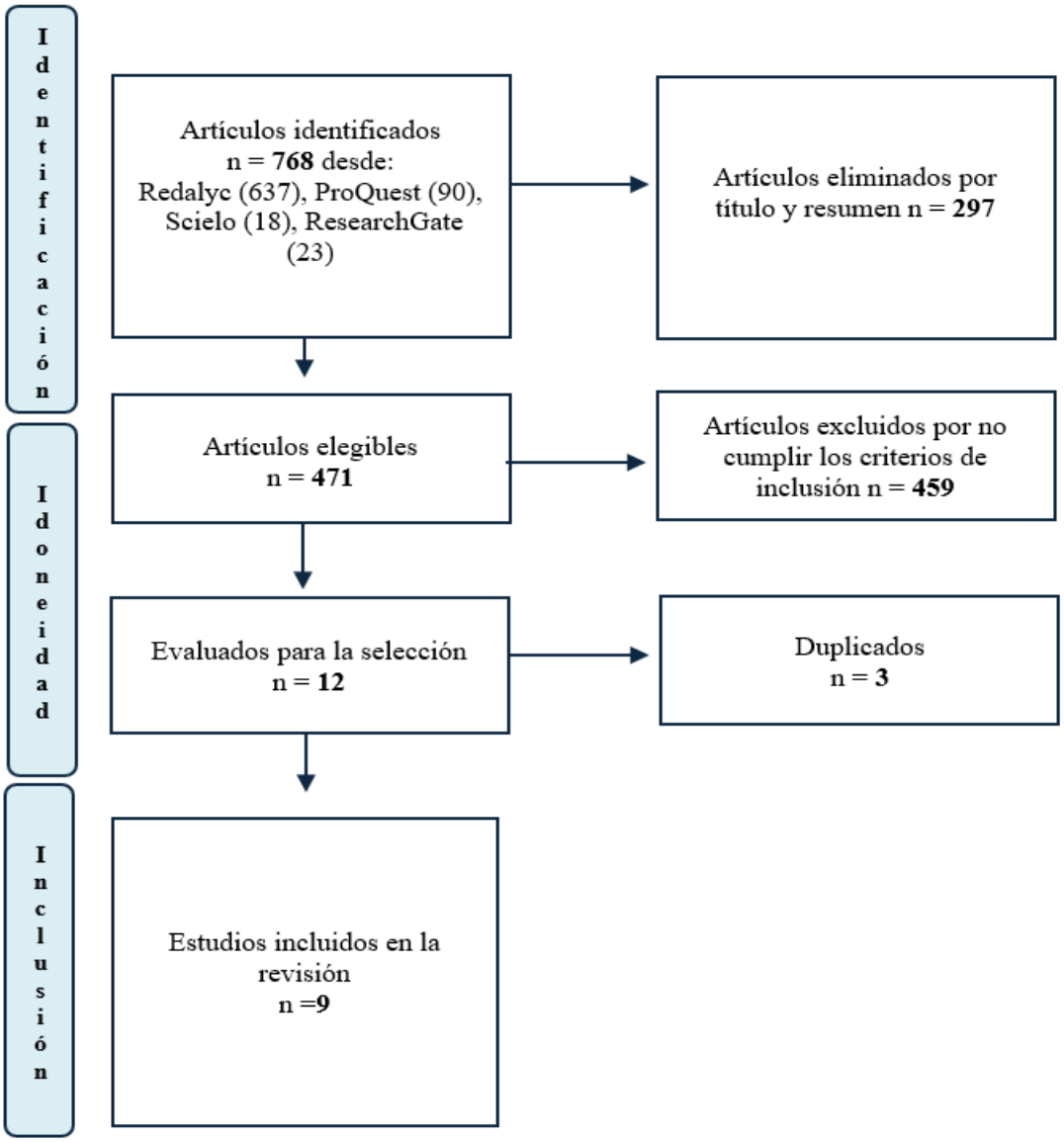
Como criterios de exclusión: a) tesis doctorales, b) revisiones, c) capítulos de libro c) carteles, d) ponencias, e) estudios de jugadores con discapacidad.

Resultados

Los parámetros de búsqueda utilizados identificaron un total de 768 artículos. Después de eliminar 297 por título y resumen, se desecharon también aquellos, que si bien, por su título contuvieran algunas de las palabras claves, su contenido no abordara la del objetivo planteado del presente estudio, 471 artículos fueron sometidos a los criterios de inclusión, (se identificaron los duplicados) de los cuales 459 fueron eliminados por no cumplir criterios de búsqueda, quedando 12, posteriormente se eliminaron tres artículos duplicados, quedando seleccionadas nueve publicaciones para este estudio.

El proceso de selección se especifica en la "Figura 1".

Figura 1
Proceso de selección de los artículos



La "Tabla 1" resume los instrumentos de evaluación localizados en la revisión de artículos indicando la muestra, el rango de edad, las dimensiones o factores, número de ítems, formato de respuesta y confiabilidad del cuestionario, así como la relación con las variables y el tipo de estudio.

Tabla 1
Características y propiedades psicométricas de los instrumentos de evaluación

Autor y año	n	Edad	Instrumento	Número de Ítems/ acciones	Formato de Respuesta	Dimensiones/ Factores	Confiabilidad	Variables relacionadas con las dimensiones	Tipo de estudio
Alarcón López et al. (2010)	10	18 a 26	Instrumento para la evaluación del conocimiento declarativo y la capacidad atencional	40	Entrevista semiestructurada 2 respuestas	NR	α=.95	Metodología constructivista	Cuasi-experimental de caso único, sin grupo control. Comparación Transversal y una longitudinal
Cong y Endozo (2022)	30	NR	Estadísticas matemáticas comparativas	NR	Evaluación cualitativa y matemática	1. Entrenamiento mental 2. Entrenamiento físico reforzado 3. Sentido de la pelota 4. Velocidad de disparo 5. Ángulos de disparo	Cambio significativo	Efectividad de los tiros libres y capacidades físicas Métodos de entrenamiento	Estudio Comparativo
Enríquez-Molina et. al. (2023)	1038	20 a 29	Test informatizado de tachado numérico	Por tiempo	Tachado numérico en matriz de 5X5	1. Atención selectiva	NR	1.Deportes individuales 2.Deportes colectivos y de adversario Midiendo tiempos de ejecución y errores.	Investigación con estrategia asociativa, comparativa y correlacional.
Fradejas y Espada (2016)	816	12 a 18	CPRD	55	Likert 6 opciones	1.Control del estrés 2. Influencia de la evaluación del rendimiento 3. Motivación, 4. Habilidad mental, 5. Cohesión de equipo	α=.85 Dimensión I.E.R. α=.72	Modalidad deportiva. G. Rítmica Balonmano Voleibol Baloncesto Fútbol Natación Atletismo Judo Fútbol Sal Tenis	Aplicación Test
López-Roel y Dosil (2019)	327	11 a 54	CNPD-15	15	Likert	1. Activación 2. Concentración 3. Confianza 4. Motivación	α=.87	Reducción y validación de un cuestionario que evalúa variables psicológicas	Investigación instrumental
Pinto et al. (2018)	18	18 a 34	Toulouse Pieron	460	Identificación de una figura	1. Concentración 2. Resistencia a la monotonía 3. Concentración perceptiva visual	NR	Efectividad de los tiros libres	Exploratorio, descriptivo e inferencial

Ponce (2014)	15	18 a 27	Toulouse Pieron	460	Identificación de una figura	1. Concentración 2. Resistencia a la monotonía 3. Concentración perceptiva visual	NR	Efectividad de los tiros libres	Descriptivo correlacional, no experimental
Rodríguez y Sáez (2009)	10	22 a +/-	Media en Excel	NR	NR	Atención	NR	Tiros libres	Explicativo
Rodríguez y Montoya (2006)	36	16 a 35	Caras	60	Determinar las diferencias	1.Aptitudes perceptivas y atencionales.	α=.95	Rendimiento deportivo	Cuasi exp. Pre-test post-test
Rodríguez y Montoya (2006)	36	16 a 35	Toulouse Pieron	460	Identificación de una figura	1. Capacidad de concentración 2. Resistencia a la fatiga atencional 3. Rapidez y persistencia perceptiva	NR	Rendimiento deportivo	Cuasi exp. Pre-test post-test

En total se localizaron nueve instrumentos aplicados a jugadores de baloncesto, y se describen a continuación.

En el estudio de Fradejas y Espada (2016) se observó que los investigadores compararon la atención de los jugadores de acuerdo a las diferentes modalidades deportivas en las que cada uno de ellos participan, mediante el test de Características Psicológicas relacionadas con el Rendimiento Deportivo, se pudo apreciar que hubo mayor control de la atención- concentración entre los deportistas que practican gimnasia rítmica y balonmano, a pesar de haber incluido el baloncesto en este estudio, no se mostraron diferencias.

Rodríguez y Montoya (2006), utilizaron dos instrumentos para medir la atención: el test de percepción de diferencias "Caras" y el de Toulouse Piéron, los autores no encontraron diferencias, se observó un leve incremento en su nivel de atención en el grupo experimental uno, es importante señalar que es el grupo que recibió entrenamiento con distractores en el programa de intervención aplicado.

Siguiendo con el test de Toulouse Piéron, Ponce (2018) pretendió relacionar la efectividad de los tiros libres con la concentración de la atención, resulta relevante mencionar que, para determinarla, se utilizó el baremo de porcentajes siendo 0-20% muy bajo, 21-40% bajo, 41-60% medio, 61-80% alto y 81-100% muy alto nivel de atención; el equipo tuvo una efectividad promedio del 58,19% en tiros libres, lo que según el baremo utilizado se considera un porcentaje "bajo" individualmente, solo una jugadora alcanzó una evaluación cualitativa de "bien" con un porcentaje del 76,47%, en contraste, ocho jugadoras fueron evaluadas como "mal" y las últimas seis como "regular", al obtener los resultados de la concentración de la atención se obtuvo un promedio general del 41.47%, lo que indica un valor cualitativo "medio". A nivel individual, solo un jugador obtuvo un nivel "alto", mientras que siete jugadores lograron un nivel "medio" y los restantes siete obtuvieron un nivel "bajo".

Continuando con este instrumento, Pinto et al. (2019), lo utilizaron con la finalidad de identificar el nivel de concentración en un equipo femenino de baloncesto, en el que se estableció la calidad de la concentración perceptiva visual en 81.78%, dando como resultado buena calidad de la atención en las deportistas y demostrando una correlación lineal positiva moderada entre el nivel de concentración y la efectividad de los tiros libres. Se concluye que el tiempo empleado en la ejecución de los tiros libres del baloncesto, la atención y la concentración, poseen una influencia lineal normalmente positiva a nivel bajo y moderado en la efectividad porcentual de la técnica deportiva; en cuanto al test de percepción de diferencias "Caras", al realizar el análisis, se atribuye que la mejora en la atención fue debido al entrenamiento con distractores que se aplicó en el grupo experimental uno, sin embargo, no hubo diferencias entre los grupos.

López-Roel y Dosil (2019) realizaron la reducción y validación del Cuestionario de Necesidades Psicológicas del Deportista (CNPD-15) el cual evalúa variables psicológicas y consta de cuatro factores: concentración, activación, confianza y motivación. Los ítems del 12 al 15 miden específicamente el factor de concentración, lo que nos permite enfocarnos en esta variable de manera más precisa: Se realizó un análisis de correlación entre las escalas CNPD-15 y el test Cuestionario de Habilidades Deportivas de Afrontamiento (ACSI), encontrando una correlación significativa de .526 ($p < .01$), lo que indica

una relación positiva moderada entre ambas medidas. Además, se obtuvo un valor de Alpha de Cronbach de .809, lo que indica una alta fiabilidad y consistencia interna en los ítems que miden la concentración.

Estos resultados sugieren que las escalas CNPD-15 y el test ACSI son medidas consistentes y fiables para evaluar la concentración en el deporte.

A través de una evaluación cualitativa respaldada por estadísticas y promedios de tiros, tanto antes como después del programa de entrenamiento al que se sometieron los grupos experimentales, se logró analizar la efectividad de distintos métodos de entrenamiento para mejorar el porcentaje de tiro en jugadores de baloncesto, tal como se realizó en el estudio de Cong y Endozo (2022), quienes utilizaron Estadísticas Matemáticas Comparativas para medir variables como la atención psicológica, aptitud física, coordinación, velocidad, ángulo de lanzamiento y sensación de la pelota.

Enríquez Molina et al. (2022) determinaron las diferencias en atención selectiva entre atletas que practicaban deportes individuales, colectivos y de adversario, tomando como referencia el tiempo de ejecución y los errores presentados en una Prueba de Tachado Numérico (matriz 5x5), el interés de esta revisión se centró en la medición del baloncesto, se observaron diferencias entre los grupos en cuanto al tiempo de ejecución de la prueba, quienes practican modalidades adversarias y colectivas realizaron el test de forma más rápida y con menos errores, la explicación que los autores dan a estos resultados es por las exigencias en el entrenamiento técnico-táctico y de atención selectiva, en el baloncesto se presenta la toma de decisiones de manera más compleja lo cual contribuye a que el jugador desarrolle este tipo de capacidades cognitivas.

Alarcón López et al. (2010) buscaron comprobar una metodología basada en las teorías constructivistas del aprendizaje para mejorar la capacidad de atención selectiva de los Medios Tácticos Colectivos Básicos (MTCB) y el Conocimiento Declarativo en 10 jugadores de baloncesto, para evaluar la atención se diseñó un instrumento basado en la exposición de un video de secuencias de partidos.

El programa se dividió en tres fases para la mejora de los MTCB. En la primera parte se les enseñó a los deportistas cuales eran los objetivos del juego de forma general; en la segunda, cuáles eran los principios específicos y en última fase o de perfeccionamiento se hizo énfasis en la actuación de los oponentes, atendiendo a los criterios de eficacia previamente establecidos.

Los resultados demostraron que, tras el programa de intervención, todos los deportistas fueron capaces de mejorar la atención hacia el papel de los defensores en el 70.5% de las escenas, en relación con el pretest en el que los jugadores no percibieron lo que realizaban los defensores; el post-test demostró que mejoraron un 89.3% a la hora de percibir a los defensores, mientras que para los atacantes la percepción obtenida fue de 96.5%.

Rodríguez y Sáez en el 2009, quisieron comprobar si la atención se reducía durante los partidos, hasta el punto de ser un factor clave en la disminución del rendimiento mismo que fue medido en 30 tiros libres, diez en solitario, en condiciones de máxima atención; diez durante el entrenamiento con todo el equipo presente y los diez primeros de los siguientes partidos. El resultado mostró porcentajes de acierto obtenidos más elevados durante los entrenamientos que durante los partidos. Sin embargo, la mínima diferencia entre el entrenamiento con presencia de otras jugadoras o en solitario se debe a que no experimentaron la tensión, los nervios del partido y el nivel de distractores que debe ser más grande que la simple presencia de varias personas para afectar la concentración de las jugadoras.

Discusión

En esta revisión se analizaron los estudios que se han realizado con respecto a los instrumentos más utilizados en la medición de la atención en jugadores de baloncesto, poniendo de manifiesto la escasez de estudios publicados sobre dicha temática. Sansone et al. (2023) utilizaron distintos instrumentos para evaluar el bienestar de jugadores jóvenes del baloncesto y encontraron que quienes presentan menor tiempo de recuperación en la cancha, manifiestan una intensidad en el ritmo más constante, lo que les permite mantenerse activos durante toda la sesión de entrenamiento o partido, denotando, que los jugadores enfocan su atención en la realización de la actividad, anteponiendo a la fatiga, dolor muscular, estrés o algún otro factor que pudiera distraerlos de su objetivo.

Por su parte, como menciona González Hernández (2007) en su artículo a Guallar y Pons (1994), para poder ayudar a un deportista a entrenar su capacidad de atención, con el objetivo de mejorar su rendimiento deportivo, es necesario partir de una evaluación del nivel atencional, residiendo ahí la importancia de la evaluación de la atención en el deporte de baloncesto.

Entre los instrumentos más empleados para medir la atención en jugadores de baloncesto, destaca la prueba Toulouse Piéron (Pinto et al., 2019; Ponce, 2018; Rodríguez & Montoya, 2006) misma que fue mencionada en tres de los nueve artículos seleccionados, se enfoca en evaluar tanto la atención selectiva como la atención sostenida, con una duración de dos y 10 minutos respectivamente, puede ser aplicada tanto en forma individual como colectiva (Maureira et al., 2010); al analizar

la prueba coincidimos con Yela (2009) en que sería beneficioso incluir valores estadísticos del instrumento para proporcionar mayor claridad al lector al momento de elegir una herramienta de medición, ya que posee cierta confiabilidad, es importante utilizarla adecuadamente en conjunto con otros instrumentos y técnicas de evaluación, tener en cuenta que la interpretación de los resultados debe ser llevada a cabo por un profesional capacitado y experimentado en su uso, para garantizar una correcta aplicación y evitar posibles errores de interpretación.

Existen algunos estudios que han analizado la fiabilidad y validez de la prueba Toulouse-Piéron, cada uno de estos documentos han abordado diferentes aspectos, estableciendo diversas metodologías, contextos y poblaciones. En general, los estudios han encontrado que el test tiene una fiabilidad test-retest aceptable, lo que significa que los resultados obtenidos en diferentes momentos son estables y consistentes, identificando también algunas limitaciones y recomendaciones para su uso (Fernandes Lopes et al., 2015; Gómez y Morales, 2006; Hilde, 2018).

La herramienta informatizada test Tachado Numérico (matriz 5x5) de Hernández y Ramos (1995) es una prueba similar en cuánto a la identificación de imágenes que mide la atención selectiva, su ventaja es la aplicación de forma remota, éste pertenece al software de Procesos Atencionales en la plataforma de evaluación MenPas 1.0, siendo una herramienta recomendada por su fácil acceso y por medir 6 tipos de atención selectiva.

González-Guirval et al. (2020) informan que específicamente en el caso de los deportistas, este tipo de software resulta interesante debido a su versatilidad, su capacidad para crear tareas atractivas a la población participante y su potencial para generar datos que puedan utilizarse posteriormente en el análisis y mejora de la capacidad cognitiva en este tipo de muestras, a su vez, González-Ruiz et al. (2018) comentan que algunas ventajas de la tecnología en la investigación son la rapidez de la obtención y análisis de resultados, la facilidad en el uso, compatibilidad de diversos dispositivos y menor margen de error; como desventajas se menciona que pudiera dificultar la relación entre el investigador y el investigado.

La reducción del test CNPD-15 dio buenos resultados en cuanto a confianza, correlación significativa y el cumplir con el propósito de recoger datos de forma más rápida y eficiente sobre estos 4 factores, reflejando datos psicométricos positivos, sin embargo, el inconveniente de sustraer algunos ítems es que también reduce cada escala y eso afecta su fiabilidad, estos autores también observaron que las personas que practicaban deportes de carácter abierto tenían mejores resultados en procesos cognitivos como la atención (Vestberg et al., 2017), entendiendo que a mayor tiempo de práctica en su deporte, se afecta positivamente el funcionamiento atencional.

El CPRD se considera un instrumento útil, ya que interactúa con la información procedente de otros procedimientos de evaluación, esto ayuda al psicólogo deportivo en la detección de necesidades y recursos, el planteamiento de hipótesis explicativas, la realización de análisis funcionales, la toma de decisión sobre los objetivos de la intervención y la observación del progreso de los deportistas (Gimeno et al., 2001).

Conclusiones

De acuerdo con la literatura analizada y respondiendo al objetivo de esta breve revisión, podemos establecer que el instrumento más utilizado es el test Toulouse-Piéron por su eficacia en la medición del sistema atencional del deportista; y aunque en la literatura científica no hay una prueba específica para medir la atención en el baloncesto; este test puede desempeñar un papel relevante en la evaluación de la atención en este deporte, sin embargo, al medir únicamente la atención sostenida y selectiva es conveniente utilizar la aplicación de otras baterías que complementen la medición de la atención para obtener una evaluación completa y precisa.

De los nueve instrumentos analizados en esta revisión sistemática para la medición de la atención, se cuestiona la calidad psicométrica de cinco de ellos, Toulouse Piéron (Pinto et al., 2019; Ponce, 2018; Rodríguez & Montoya, 2006), test informatizado de Tachado Numérico (Enríquez Molina et al., 2022) y la prueba para medir Tiros libres de Rodríguez y Sáez (2009).

No obstante, es importante resaltar que la Evaluación del Conocimiento Declarativo y la Capacidad Atencional se presenta como la herramienta más específica para evaluar la atención en este deporte, al enfocarse en la técnica-táctica de los jugadores de baloncesto.

Evaluar la atención con métodos basados en datos desde una edad temprana permite mejorar la calidad de la formación deportiva, contribuyendo de manera eficaz y efectiva en los entrenamientos de jugadores del baloncesto (Xuexiang, 2024); es recomendable investigar cómo distintos métodos de recuperación influyen en la atención de los jugadores para poder identificar cómo la recuperación mental impacta en la mejora de la concentración y en la toma de decisiones dentro de este deporte (Calleja-González, 2021).

Cabe destacar que el campo de la evaluación de la atención en el deporte sigue evolucionando, se recomienda para futuras investigaciones la creación de una prueba específica en el baloncesto centrada en aspectos clave de la atención

durante el juego, medición de la capacidad de concentración en situaciones de alta presión, atención selectiva a estímulos relevantes en el campo y el cambio de atención entre diferentes acciones del juego por nombrar algunos.

Declaración del Comité de Ética

Este estudio no incluyó investigación con datos humanos.

Conflicto de Intereses

Los autores no declaran conflicto de intereses.

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Contribución de los Autores

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Declaración de Disponibilidad de Datos

Los datos que respaldan los hallazgos de este estudio están disponibles previa solicitud al autor de correspondencia (ebenavides@uach.mx).

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Effects of Beet Juice on Performance in Competitive Swimmers

Efectos del Zumo de Remolacha Sobre el Rendimiento en Nadadores Competitivos

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Abstract

This study analysed the effect of beetroot juice supplementation (BRJ) in an intermittent swimming session with high glycolytic demands on performance, biomechanical variables (speed, stroke length, cycle frequency, stroke index), blood lactate concentrations (BLa) and rating of perceived exertion (RPE). This study design was randomized, double-blind, cross-over and placebo-controlled. Ten competitive adolescent swimmers (six females and four males, range of age from 13 to 16 years) executing a swimming test consisting of an 8 x 50 m swimming protocol after taking BRJ (~ 12.8 mmol of nitrate) or a placebo (PLA). Biomechanics parameters, RPE after each set, and BLa pre and post-exercise were assessed. BRJ enhanced the time in the swimming test (p = .004) with a best medium time (p = .004) and time in the slowest set (p = .041). No differences were reported between BRJ and PLA for biomechanical parameters, BLa or RPE. Based on the results of the present study, it is concluded that BRJ could enhance swimming performance and the relationship between work and RPE, without any effect on the biomechanics parameters. Therefore, the intake of BRJ could be beneficial for swimmers along the high-intensity intermittent sessions.

Keywords: Aquatic sport, swimmer, ergogenic aid, nitrate, nitrite, supplement.

Resumen

Este estudio analizó el efecto de la suplementación con zumo de remolacha (BRJ) en una sesión de natación intermitente con altas demandas glucolíticas sobre el rendimiento, variables biomecánicas (velocidad, longitud de brazada, frecuencia del ciclo, índice de brazada), concentraciones de lactato en sangre (BLa) y índice de esfuerzo percibido (RPE). El diseño de este estudio fue aleatorio, doble ciego, cruzado y controlado con placebo. Diez nadadores adolescentes competitivos (seis mujeres y cuatro hombres, rango de edad de 13 a 16 años) ejecutaron una prueba de natación consistente en un protocolo de nado de 8 x 50 m después de tomar BRJ (~ 12.8 mmol de nitrato) o un placebo (PLA). Se evaluaron los parámetros biomecánicos, RPE después de cada serie y BLa antes y después del ejercicio. BRJ mejoró el tiempo en la prueba de natación (p = .004) con un mejor tiempo medio (p = .004) y tiempo en la serie más lenta (p = .041). No se informaron diferencias entre BRJ y PLA para los parámetros biomecánicos, BLa o RPE. En base a los resultados del presente estudio, se concluye que el BRJ puede mejorar el rendimiento en natación y la relación entre trabajo y RPE, sin tener ningún efecto sobre los parámetros biomecánicos. Por tanto, la ingesta de BRJ podría ser beneficiosa para los nadadores durante las sesiones intermitentes de alta intensidad.

Palabras clave: Deporte acuático, nadador, ayuda ergogénica, nitrato, nitrito, suplemento.

Introduction

Swimming is one of the Olympic sports that has improved the most over the last years, with world records being broken regularly during the Olympic cycle. The biomechanical, energetic, and training methodology aspects are the main responsible for the evolution of this sport (Terzi et al., 2021). Parameters as stroke length (SL), cycle frequency (SF), stroke index (SI) and highest blood lactate (BLa) concentration in post-exercise condition are essential biomechanical and energetic factors for swimming performance (Marinho et al., 2020). In swimming season planning there are different training-intensity distribution models of periodization. Among the two most commonly used methodologies are traditional training (TT), characterized by high-volume, low-intensity training, and ultra-short race-pace training (USRPT) (Williamson et al., 2020). USRPT is a methodology used to increase a swimmer's performance through a large number of swimming sets at velocities similar to competitive velocities using short distances and short recovery periods. These two training methodologies are very different, but both methodologies have some similarities when comparing certain stages of their programming (Nugent et al., 2017). During various phases of TT, exercises resembling those in USRPT training are utilized to improve both oxidative and glycolytic capacity, to elicit and accumulate elevated BLa.

Increasing glycolytic capacity is essential for distances from 50 to 400 m. Various training tasks such as 4x50 m, 6x50 m, and 8x50 m, with several recovery periods are used to stimulate high BLa concentrations (Terzi et al., 2021) and to improve non oxidative capacity (Kabasakalis et al., 2019). These tasks promote ions of hydrogen (H+) accumulation, the development of fatigue, and a decrease in the intramuscular capacity of the muscle groups involved. When performing these tasks, the glycolytic capacity of the swimmer can be optimized. It can be checked by a reduction of BLa at a same swimming velocity, favoring the metabolic activity and the ability to produce force by the muscle groups involved, and thus increase their performance (Faghy et al., 2019). Also, the swimming velocity is dependent on the relationship between SF and SL. This relationship is affected by the energy cost of swimming (Cs) that increases when SF increases. SI is a swimming efficiency variable that at a certain speed, indicates that the swimmer who gets the greatest cycle distance per stroke also has the most efficient swimming technique. Also, higher levels of SI are correlated to low Cs (Lätt et al., 2010). Combining these metabolic and biomechanical adaptations using these tasks can result in higher performance for the swimmer.

In competitive swimming, differences of 1.6% distinguish a is conceivable between a gold medalist and a fourth- place in an Olympic Games (Mujika et al., 2002). In this context, 86.9% of a sample of national and international competitive level declared consuming at least one sport supplement with the main motivation for enhancing sport performance (Moreno et al., 2022). At the difference of caffeine supplements, sport drinks, or sport bars which are consumed by more than half of the competitive level swimmers, beetroot juice (BRJ) is not one of the sport supplements more consumed by swimmers (Moreno et al., 2022). However, it has been proposed as an ergogenic aid with a high level of scientific evidence (Maughan et al., 2018). BRJ is an enriched dietary source of inorganic nitrate (NO3-). Approximately 20% of NO3- dietary intake is reduced through the salivary glands to nitrite (NO2-) by commensal anaerobic bacteria on the dorsal surface of the tongue (Ahmed et al., 2017), whereas NO2- is partially reduced in the stomach into nitric oxide (NO). Thereby, NO3- supplementation increases systemic NO and NO2-, which could be further reduced into NO in hypoxia and acid conditions at the muscular level (Bailey et al., 2012), where it exists a reservoir of NO2- (Nyakayiru et al., 2020). Elevation of NO after NO3– supplements as BRJ increases capacity for muscular work and/or improves muscle contractile efficiency (San Juan et al., 2020). Nevertheless, the ergogenic properties of sport supplements depend on the mechanical and energy demands of each type of sports modality with possible ergogenic effects for some types of efforts and no effect for other types (Domínguez et al., 2018; Larrosa et al., 2024). Today, only four studies have analyzed the effect of BRJ on competitive swimmers (Esen et al., 2019; Lowings et al., 2017; Moreno et al., 2023; Pospieszna et al., 2016), but no studies have analyzed the effect of BRJ on biochemical parameters during swimming that influence in swimming performance as swimming velocity, SL, SF or SI. Therefore, the aim of this study was to analyze the effect of BRJ compared to placebo on the performance, biomechanics variables (swimming velocity, SL, SF and SI), BLa, and RPE during a session with high glycolytic demands (8x50 m) in competitive swimmers.

Methods

Design and Procedure

The study design was randomized, double-blind, cross-over, and placebo-controlled. Participants completed two experimental visits to the swimming pool. Randomly 50% of the participants (n = 5) were assigned to ingest 140 ml of BRJ enriched in NO3- (~12.8 mmol of NO3-) whereas the rest of the participants (n = 5) ingested as placebo (PLAC) 140 ml of BRJ depleted in NO3- (.08 mmol of NO3-) (Research Randomizer, www.randomizer.org). In the second session, participants who ingested BRJ enriched in NO3- during the first experimental session were supplemented with PLAC whereas participants who took PLAC in the first sessions ingested BRJ enriched in NO3-. Experimental visits were separated for 48 hours. Experimental sessions were performed in the evening at the same time of the day (± .25 hours) to avoid a possible interaction of the effects of BRJ based on the time of day. During each experimental session, after a standardized warm-up, participants executed 8 repetitions of 50 m at maximal speed with a passive recovery of two minutes. After each repetition,

RPE was administered. In addition, it was assessed blood lactate concentrations (BLa) before starting the warm-up (BLaPRE) and two minutes after the last 50 m repetition (BLaPOST).

Participants

The sample of this study was formed by 10 competitive adolescent swimmers (6 females and 4 males, range of age from 13 to 16 years). All the participants won a gold or silver medal in the regional competition the week before the start of the study. All the participants were normotensive, physically active, and summed an experience of systematically swimming training (> 5 sessions training per week) higher than three years. All the participants were familiarized with the test used because it was used frequently during the training session. Before the start of the study, participants and their parents were meeting with a researcher who informed about the characteristic of the study. After being fully informed of the experimental protocols, all the parents signed an informed consent for participating in this study. This study was in accordance with the Declaration of Helsinki, and it was approved by the Ethics Commission of the Polytechnic Institute of Setúbal (code: PI26/2022).

For the characterization of the sample, an anthropometric evaluation was assessed. Height was assessed using a stadiometer BSM170B Stadiometer (Inbody Co. Ltd, Cerritos, CA, USA) with participants barefoot and ensuring the frankfort plane. In addition, it was used a bioimpedance using an Inbody 270 body composition analyzer (Inbody Co. Ltd, Cerritos, CA, USA) for estimating body mass muscle mass, % body fat, and body mass index (BMI).

Supplementation and Dietary Control

One hundred fifty minutes before the warm-up participants arrived at the swimming pool and they ingested 140 mL of a BRJ supplement enriched in NO3- (~ 12.8 mmol NO3-) (Beet IT; James White Drinks Ltd, Ipswich, UK) or a PLAC attending to previous instructions (Domínguez et al., 2018). This timing was adjusted based on the plasma NO2- peaks (2-4 hours post-ingestion) after an intake of 140 ml of a BRJ supplement (Wylie et al., 2013). During the 24 hours preceding experimental sessions was standardized a diet to ensure a similar distribution of protein (10%), carbohydrates (60%) and lipids (30%). Also, it was restricted during this time NO3— rich foods (beetroot, turnip, celery, arugula, lettuce, spinach, leak, cabbage, endives, parsley) and caffeine dietary sources (energy drinks, coffee, mate, tea soft drinks, tea, cola drinks, chocolate drinks and chocolate). In addition, during 24 hours prior to each experimental session, participants were refrained for brushing their teeth or using a mouthwash, chewing gum, or eating any sweets that could contain bactericidal substances such as xylitol or chlorhexidine.

Swimming Test

The swimming test consisted of eight repetitions of 50 m freestyle performed at maximal speed with two minutes of passive recovery between repetitions. The test was performed in a swimming pool of 25 m. Before the test, participants performed a standardized warm-up consisting of four repetitions of 200 m freestyle with 45 seconds of rest between repetitions and four repetitions of 12.5 m at maximum intensity with 45 seconds of recovery between each repetition. For each repetition, it was measured the total time, SF, SL, and SI by two experienced researchers. Swimming velocity was obtained from the mean value of each lap (from 5 m to 20 m). SF was registered from the mean of three consecutive stroke cycles in the middle of the pool of each lap, using a chrono-frequency meter (Golfinho Sports MC 815, Aveiro, Portugal). Later, SF was converted to International System units (Hz). SL was calculated from the ratio of elapsed time to the SF. SI resulted from swimming velocity times SL (Marinho et al., 2020). All biomechanics values resulted from the mean of the two experienced researchers that were blinded to the swimmers. To confirm the accuracy of all measurements intraclass correlation coefficient was determined for the time, SF, SL, and SI.

Rating of Perceived Exertion

At the end of each 50 m repetition, a 10 point Borg scale was administered to record the ratings of perceived exertion (RPE).

Blood Lactate Concentrations

Previous to the warm-up and two minutes after the end of the swimming test, capillary blood samples (5 µL) were obtained from the pad of the left thumb for assessing BLa using a Lactate ProTM 2 LT-1710 blood analyzer (Arkray Factory Inc., KDK Corporation, Shiga, Japan).

Statistical Treatment

The normality distribution of the data was confirmed using a Shapiro-Wilk test whereas homoscedasticity was confirmed by the Levene test. Results are presented as mean (*M*) ± standard deviation (*SD*) values. An ANOVA-RM for the factors time (repetitions), supplementation (BRJ vs PLAC), and time·supplementation were performed for time, RPE, speed, SF, SL, and SI. In addition, an ANOVA-RM for the factors time (pre vs. post) supplementation and time·supplementation was performed for BLa. In addition, effect size (*ES*) was calculated using partial eta squared (η_p^2), with .25 considered as small; .26 - .63 considered as medium; and > .63 considered as large. In addition, it was performed a paired t-test for detecting

possible differences between BRJ and PLAC in speed, SF, SL, and SI registered in the best and the worst repetition for each participant under the two experimental conditions. Also, in the pairwise comparisons, *ES* was calculated using Cohen's d considering lower than .2 as trivial; .2 - .5 as small; .5 - .8 as moderate; and .8 as large. Statistical differences were set up $p < .05$. All the analyses were performed in the SPSS software (SPSS Inc., V.21, Chicago, IL, USA).

Results

Characteristics of the participants are presented in Table 1.

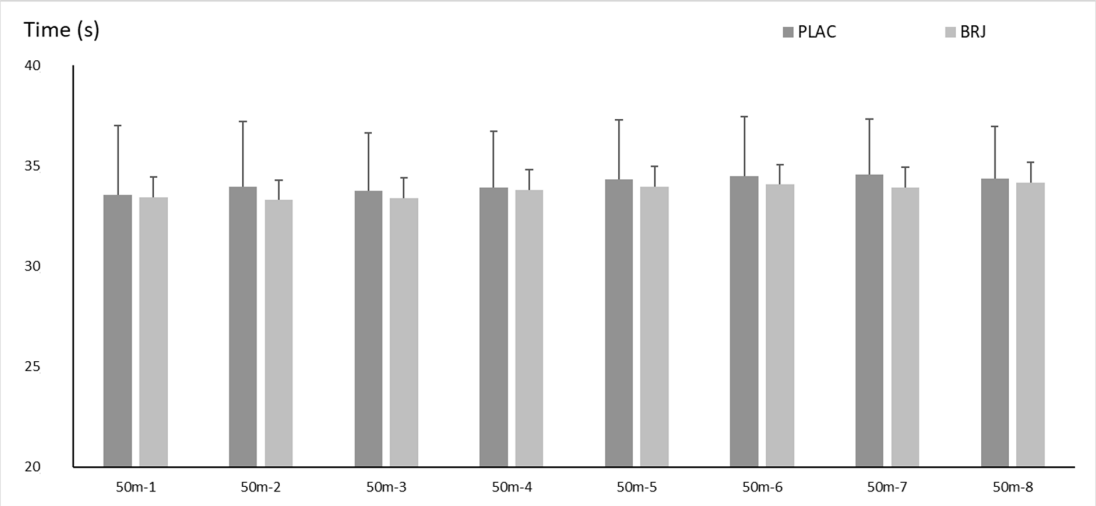
Table 1
Characteristics of the participants

VARIABLE	TOTAL	MALES	FEMALES
Height (cm)	162.7 ± 12.4	171.0 ± 17.0	158.0 ± 6.6
Weight (kg)	49.2 ± 10.7	54.2 ± 15.6	46.4 ± 6.4
Body mass index (kg/m^2)	18.4 ± 2.0	18.1 ± 2.4	18.5 ± 1.7
Body fat mass (%)	14.1 ± 6.1	8.7 ± 2.1	17.2 ± 5.1
Body muscle mass (kg)	22.8 ± 6.1	26.3 ± 9.3	20.8 ± 2.3

Note: Data expressed mean ± standard deviation (*SD*).

The ANOVA-RM reported statistical differences and a large ES for supplementation with a lower time for BRJ compared to PLAC ($F = 5.094$; $p = .004$; $\eta\_p^2 = .626$), but no statistical differences were reported for time ($F = 8.868$; $p = .055$; $\eta\_p^2 = .287$) nor time·supplementation ($F = .738$; $p = .512$; $\eta\_p^2 = .076$) (see Figure 1).

Figure 1
Time (s) of each 50 m repetition in the swimming test



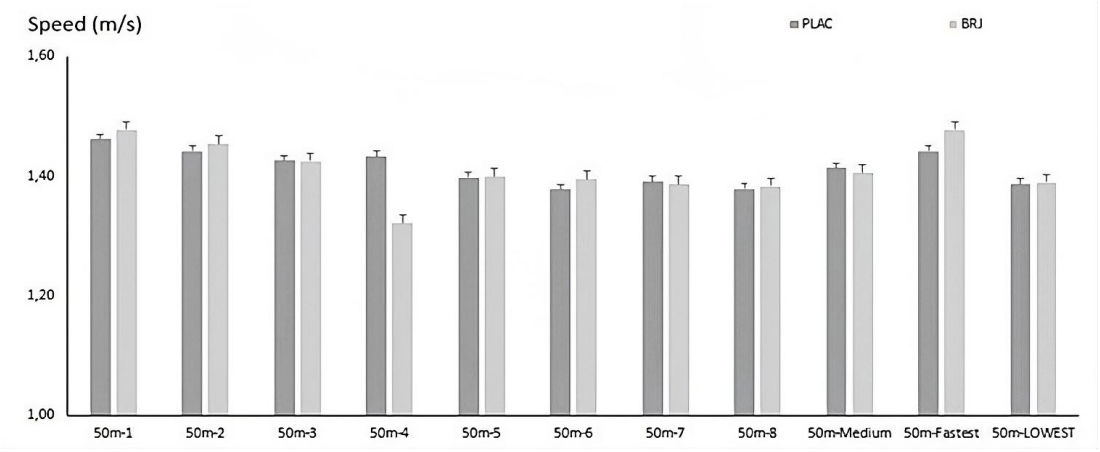
Note: Data presented as *M* ± *SD*.

Regarding the biomechanics variables, it was not reported differences in the speed for the factors time ($F = 3.287$; $p = .065$; $\eta\_p^2 = .267$), supplementation ($F = .406$; $p = .540$; $\eta\_p^2 = .043$) nor time·supplementation ($F = 1.379$; $p = .274$; $\eta\_p^2 = .133$) (see Figure 2a). For SF was reported differences for time ($F = 4.353$; $p = .014$; $\eta\_p^2 = .326$), but not for supplementation ($F = .666$; $p = .436$; $\eta\_p^2 = .666$) nor time·supplementation ($F = .484$; $p = .709$; $\eta\_p^2 = .051$) (Figure 2b) whereas for SL not differences were found nor time ($F = .801$; $p = .446$; $\eta\_p^2 = .082$), supplementation ($F = 2.056$; $p = .185$; $\eta\_p^2 = .186$) nor time·supplementation ($F = .324$; $p = .115$; $\eta\_p^2 = 1.670$) (see Figure 2c). The analysis of the SI didn´t report statistical differences for time ($F = 3.609$; $p = .054$; $\eta\_p^2 = .254$), supplementation ($F = 1.128$; $p = .316$; $\eta\_p^2 = .111$) nor time·supplementation ($F = 1.549$; $p = .243$; $\eta\_p^2 = .147$), but in the pairwise comparison was reflexed an enhanced SI for BRJ compared to PLAC only in the fastest 50 m (*BRJ*: 2.71 ± 0.48 *vs. PLAC*: 2.53 ± 0.47; $t = -2.447$; $p = .037$; $d = .40$) (see Figure 2d).

It was detected a progressively increase in RPE ($F = 12.707$; $p < .001$; $\eta\_p^2 = .585$), but no differences for supplementation (BRJ: 7.44 ± 0.31 vs. PLAC: 7.75 ± 0.25; $F = .001$; $p = .975$; $\eta\_p^2 < .001$) nor time·supplementation ($F = .552$; $p = .573$; $\eta\_p^2 = .058$). Similar results were found in BLa with differences based on time ($F = 275.945$; $p < .001$; $\eta\_p^2 = .968$), but not for supplementation (BRJ: 16.66 ± 2.50 vs. PLAC: 16.55 ± 2.81 mmol; $F = .119$; $p = .739$; $\eta\_p^2 = .013$) nor time·supplementation ($F = .026$; $p = .875$; $\eta\_p^2 = .003$).

Figure 2a

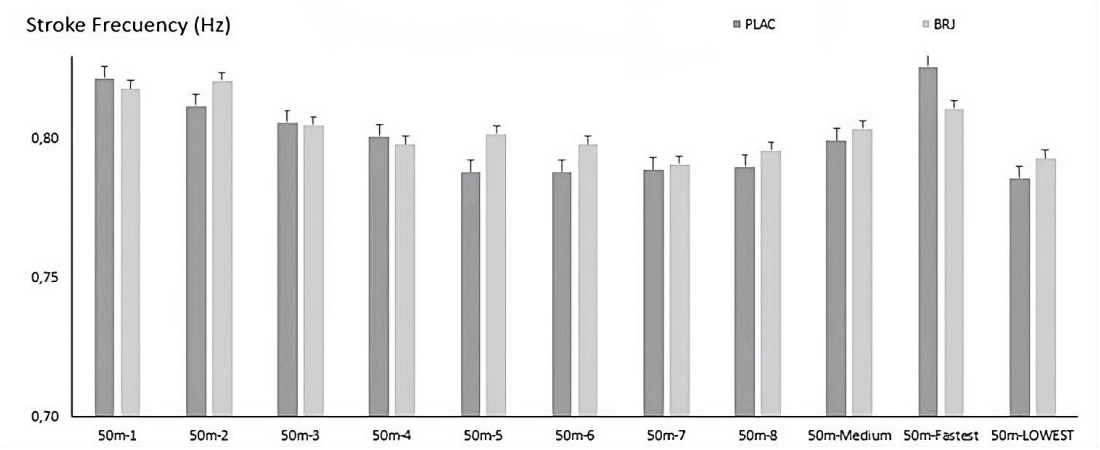
Speed (m/s) of each 50 m repetition, fastest, and lowest time in the swimming test



Note: Data presented as *M* ± *SD*.

Figure 2b

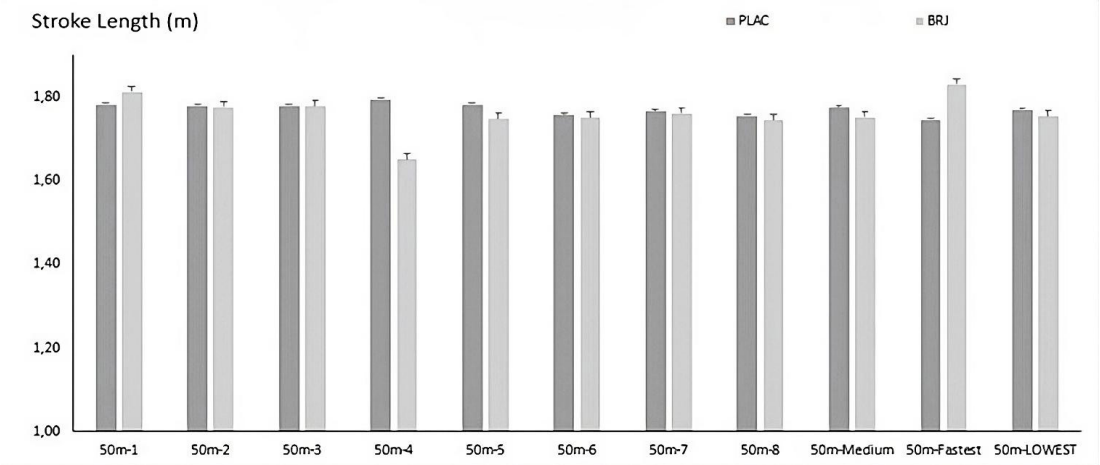
Stroke frequency (Hz) of each 50 m repetition, fastest, and lowest time in the swimming test



Note: Data presented as *M* ± *SD*.

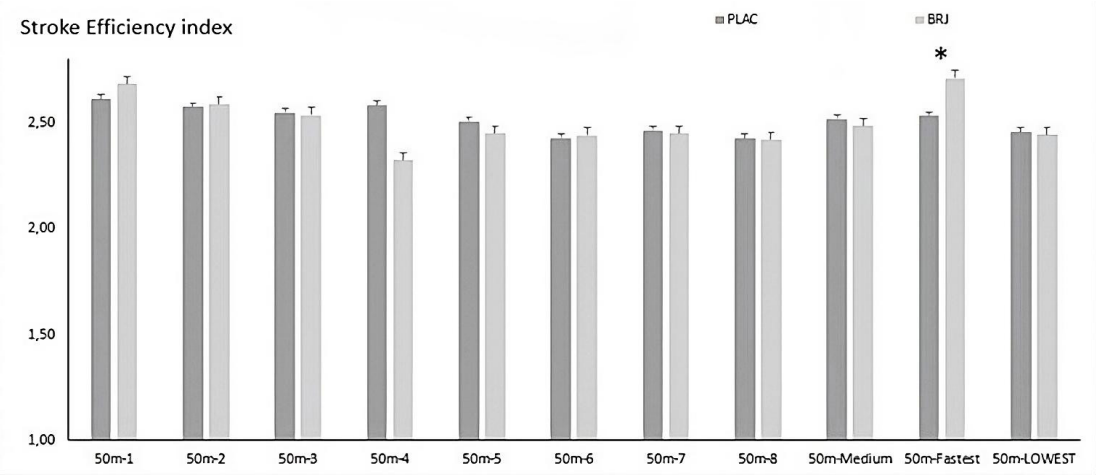
Figure 2c

Stroke length (m) of each 50 m repetition, fastest, and lowest time in the swimming test



Note: Data presented as *M* ± *SD*.

Figure 2d
Stroke efficiency index of each 50 m repetition, fastest, and lowest time in the swimming test



Note: Data presented as *M* ± *SD*. *: statistical differences ($p < 0.05$) between BRJ and PLAC.

Discussion

This study analyzed the effects of BRJ on the performance in an 8x50 m swimming test, a task commonly used for training glycolytic capacity in swimmers. The main results of this study were the next: i) exists a significant effect on SF, but there isn´t affectation of time and the rest of biomechanics variables analyzed along the intermittent swimming protocol; ii) BRJ resulted in a positive effect for factor supplementation in the 8x50 m swimming test; iii) RPE progressively increased during the swimming test without any effect of BRJ; iv) BRJ do not affect to BLa after a swimming protocol for enhancing glycolytic capacity in swimmers.

The analysis of BLa_{POST} concentrations (16.61 ± 0.75 mmol) shows an important contribution of glycolytic metabolism of the swimming test used which is suitable for stimulating the glycolytic capacity of swimmers during training. In fact, comparing with other studies with a same population the BLa_{POST} in this research is higher in comparison with other studies using the same swimming test (from 10.5 ± 2.9 in female to 14.2 ± 2.5 mmol in males to 15.3 ± 3.1 mmol in females) (Kabasakalis et al., 2020), a 4x50 m protocol (from 14.1 ± 3.1mmol in males to 15.3 ± 3.1 mmol in females) (Terzi et al., 2021), a 2x4x50 m or 8x50 m (~ 13 mmol) (Kabasakalis et al., 2019) or 20x25 m protocols (Williamson et al., 2020). The high BLa_{POST} could establish an affectation of muscle metabolic activity and force production during the propulsive phase of the stroke (Faghy et al., 2019). These fatigue mechanisms could establish a change in the swimming pattern with a progressive diminution of SF for the maintenance of Cs (Lätt et al., 2010). Therefore, it is possible that swimmers could benefit more meters the underwater wave, since under water hydrodynamic forces are less than on the surface (Born et al., 2022). This hydrodynamic advantage could explain a strategy for maintaining speed and performance along the high intensity intermittent swimming test used in this study in a very highly trained sample.

The main novelty of this study is that BRJ presents a statistical effect along the 8x50 m protocol. In the analysis of BLa, it was not detected any effect of BRJ on glycolytic capacity because there is not any difference in the comparison with PLA. In the laboratory has been registered a decreased oxidative energy cost in swimming after BRJ (Pinna et al., 2014), in agreement with the results reported in other types of exercises (i.e., knee extension) (Bailey et al., 2010). An in vitro study has reported an improved of the intramolecular mechanisms involved during the muscle contraction in the muscle II type fiber (Hernández et al., 2012), which are the more sensitive to fatigue. Therefore, BRJ could acts as ergogenic in a progressively reduction of the fatigue which is originated along the 8x50 m protocol. Thus, different meta-analyses have reported an enhanced economy after BRJ (Pawlak-Chaouch et al., 2016) and time-to-exhaustion tests (TTE), but not in time trial tests (TT) (Van De Walle & Vukovich, 2018).

Specific studies in swimming reflect discrepancies (Esen et al., 2019; Lowings et al., 2017; Moreno et al., 2023; Pospieszna et al., 2016). Essen et al. (2019) failed to enhance swimming performance in a 100 m and a 200 m TT while Lowings et al. (2017) reported a trend to increase performance ($p = .06$) in the second half of a 168 m backstroke TT. By contrast using an intermittent procedure, Pospieszna et al. (2016) reported an enhancement in the four last sets of an intermittent test consisting in 6x50 m in female university swimmers after BRJ (10.2 mmol NO3-). More recently, another study has reported a trend to enhance the time in a 6x100 m protocol (Moreno et al., 2023), however, the dosage used (6.4 mmol NO3-) could be insufficient for detecting statistical differences. In this way, the ergogenic effect of BRJ is mediated by its capacity to

increase NO levels versus baseline levels (Wylie et al., 2013). If NO is increased in a dosage relationship until 8.4 mmol NO3-, it is possible that the amount provided by Moreno et al. (2023) was insufficient for detecting statistical differences. Therefore, the results of the present studies and Pospieszna et al. (2016) suggest ergogenic properties of BRJ on high intensity intermittent protocol in swimming with dosages upper than 10 mmol NO3- in concordance with the results of meta-analysis focused on fatigue procedures (Van De Walle & Vukovich, 2018).

RPE is influenced by sensory feedback that includes the set of psychophysiological sensations integrating central and peripheral signals and is used as an indicator of different physiological parameters such as heart rate, BLa, or ventilatory response during exercise (Campos et al., 2021). Along the 8x50 m test, RPE was progressively increased in agreement with Barroso et al. (2015), who state that continuous exercise with constant intensity causes a linear increase in RPE, and that the volume of interval training affects the perception of effort and the swimmer's internal training load (Barroso et al., 2015). Similarly, with less distance but more repetitions than our study, Williamson et al. (2020) reported RPE increases after a 20x25 m protocol (18 ± 1.6). Nevertheless, however, the pattern of RPE along the swimming test is the normal answer to this type of exercise, the same RPE with a higher swimming performance after BRJ reflects ergogenic properties of BRJ on RPE. In this sense, the same RPE with a higher performance could be interpreted as a positive response because it enhances the relationship between work and RPE ratio (Jodra et al., 2020).

This study provides valuable insights into the potential benefits of BRJ on swimming performance and RPE during high-intensity intermittent sessions in swimming, several limitations should be considered. Firstly, it has been stablished a correlation between the increasement of NO2- as response to the supplementation and the ergogenic effects (Jones et al., 2018). Therefore, the absence of the assessment of NO2- concentrations is a limitation of this study. This study has recruited to a mixed sample formed by male and female swimmers based on the underrepresentation of women in studies focused on the analysis of the effect of sport supplements (Smith et al., 2022). Nevertheless, it has been suggested a specific effect of this supplement based on sex (Wickham & Spriet, 2019). Attending to the small sample size of this study, a second limitation is that this study does not analysed the interaction of the supplementation and sex effect for detecting a possible response mediated by sex. Lastly, this is a pioneer study analysing the effect of BRJ in biomechanics parameters, however, it is not studied the physiological mechanisms that are involved with the instauration of fatigue. Therefore, future studies should include the response of NO2- to the supplementation, analyse a possible interaction to the supplementation mediated by sex and combine kinematic swimming parameters with physiological mechanisms involved in the instauration of fatigue.

Conclusions

The results of this study reflect a positive effect of BRJ in an intermittent swimming protocol without affectation to biomechanics parameters or lactate production, but an increased work and RPE relationship. Also, responses to this protocol suggest that 8x50 m task could be effective for stimulating the glycolytic capacity of swimmers during training. In addition, it is possible that the increased performance during this task could favor adaptations to training and sport performance in highly trained swimmers.

Ethics Committee Statement

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee: POLYTECHNIC INSTITUTE OF SETÚBAL (code: PI26/2022).

Conflict of Interest Statement

The authors declare no conflict of interest associated with this article.

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Authors' Contribution

Conceptualization L.L. & R.D.; Methodology L.L. & R.D.; Formal Analysis R.D.; Investigation L.L., A.J.S.-O. & R.D.; Resources L.L.; Data Curation L.L., A.J.S.-O. & R.D.; Writing – Original Draft L.L., A.J.S.-O. & R.D.; Writing – Review & Editing L.L., A.J.S.-O. & R.D.; Visualization L.L., A.J.S.-O. & R.D.; Funding Acquisition L.L. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author (sanchezoliver@us.es).

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External Physical Load Control in Professional Soccer Referees During First Division Matches

Control de Carga Física Externa en Árbitros de Fútbol Profesional Durante Partidos de Primera División

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Abstract

Soccer, as a high-intensity and intermittence sport, also requires referees to be in good physical condition. The objective of this quantitative, explanatory, correlational, longitudinal study was to determine the external physical load on professional referees during official matches, using a global positioning system (GPS). Seventeen males participated (age: 36.19 ± 3.2 years; height: 1.79 ± 0.04 m; weight: 80.07 ± 4.32 kg); the physical load was recorded in 67 national first division matches. The results showed that, on average, the referees covered 11,202 ± 706 m; of which 1,139 ± 722 m were in high intensity and 85.19 ± 65.26 m in sprint; in addition, they performed 22 ± 10 accelerations and 23 ± 9 decelerations per match. When correlating age and external physical load, there was a correlation with the variables: total distance covered (-.231) and number of decelerations per game (-.205). However, the correlation value for both cases was less than .25. It was concluded that the external load control using of GPS in professional referees, makes it possible to objectify the workloads, in this case for national competition; highlighting that age would not be a determining factor in the physical performance of these athletes.

Keywords: Football, referee, physical load, GPS.

Resumen

El fútbol, como deporte de alta intensidad e intermitencia requiere que también los árbitros presenten una adecuada condición física. El estudio de tipo cuantitativo, explicativo, correlacional de corte longitudinal, tuvo por objetivo determinar la carga física externa en árbitros profesionales durante partidos oficiales, mediante sistema de posicionamiento global (GPS). Participaron 17 varones (edad: 36.19 ± 3.2 años; estatura; 1.79 ± 0.04 m; peso: 80,07 ± 4.32 kg); registrándose la carga física en 67 partidos de primera división nacional. Exponiéndose como resultados, que en promedio los árbitros recorrieron 11,202 ± 706 m; de los cuales 1,139 ± 722 m fueron en alta intensidad y 85.19 ± 65.26 m en sprint; además, ejecutaron 22 ± 10 aceleraciones y 23 ± 9 desaceleraciones por partido. Al correlacionarse edad y carga física externa, se presentó correlación con las variables: distancia total recorrida (-.231) y número de desaceleraciones por partido (-.205). No obstante, el valor de correlación para ambos casos fue menor a .25. Concluyéndose que el control de carga externa mediante GPS en árbitros profesionales, posibilita objetivar las cargas de trabajo, en este caso para competencia nacional; destacándose que la edad no sería un factor determinante en el rendimiento físico de estos deportistas.

Palabras clave: Fútbol, árbitro, carga física, GPS.

Introduction

Soccer is a collective sport of high physical demand, characterized by a constant alternation between low-intensity activities when standing, walking or jogging; high intensity when running or changing direction and very high intensity when performing sprints, accelerations and decelerations (Dalen et al., 2020; Gualtieri et al., 2023; Teixeira et al., 2021). These intermittent activity patterns generate important neuromuscular loads during motor actions of higher intensity and frequency, especially in high performance (Aloui et al., 2022; Djaoui et al., 2022). It is frequently associated with the moments of a match where there is a greater probability of scoring a goal (Calderon et al., 2022). For Chena et al. (2022), the latest research in this sport, has shown that the tactics used by the teams increased the physical demand, turning soccer into a faster, more intense and competitive activity. This requires more precise physical evaluations of soccer players' the internal and external loads, especially during matches (Strauss et al., 2019). This quantification of loads, according to Balaguer and Caparros (2021), is essential for the determination of individual responses and adaptations in relation to sports planning.

In response to this requirement, Sanchez et al. (2022) exposed that the Fédération Internationale de Football Association (FIFA), as well as many clubs, are investing time and resources in technologies to quantify the levels of physical demand in matches and training sessions. This has generated an exponential increase in the use of global positioning systems (GPS), due to the specific information they provide (Muñoz et al., 2022; Schulze et al., 2021), making it possible to record the external load of an athlete according to distances and speeds traveled on the field of play (Delves et al., 2021).

During soccer matches, Pavillon et al. (2021) indicated that more than 80% of the players' movements would be of low to medium intensity and between 10% to 20% would correspond to high-intensity actions. High-intensity running, called HSR (High-speed running) and sprints would have had an important increase in men's soccer, in the last 15 years, due to the intensity of the game that is being applied (Gualtieri et al., 2023).

Regarding the distance covered per match, Costa et al. (2013) indicated that elite players moved between 10 to 12 km. Currently, Barreira et al. (2022) stated that the distances would fluctuate between 10 to 14 km and they would perform 150 to 250 actions at high intensity, highlighting sprints, accelerations and decelerations. Sprints, according to Reinhardt et al. (2019), are established as a relevant factor in the physical demand of this sport, comprise no more than 5% of the total volume in a match and most of these displacements do not exceed 20 m. In addition, Aloui et al. (2022), indicated that sprints would fluctuate between 200 m to 1100 m per match, with a duration of 2 to 4 s, representing between 1% to 11% of the total distance covered in a match; where 96% of the sprints do not exceed 30 m, of which 49% would be under 10 m. For their part, González-Millán et al. (2014), determined that each player in a team would execute around 11 sprints per game with an average of 230 m covered in speed, depending on the playing position and 5% to 10% of the total game actions would be performed by running at high intensity.

In the case of horizontal accelerations and decelerations, these are classified as crucial locomotor skills in activities with intermittent multidirectional movements, allowing rapid changes in speed and direction by athletes (Harper et al., 2022). In soccer, accelerations would comprise 7% to 10% and decelerations 5% to 7% of the players' total physical load for all playing positions (Nobari et al., 2021). Zhang et al. (2021), reported that players would perform an approximate of 14 to 26 accelerations and 43 to 56 decelerations at high intensity per game. These advances in the physical fitness of players, have also had an impact on referees and assistant referees, who have had to face this increase in physical demand, taking into account that unlike players they do not have the possibility of substitution unless an injury occurs (Schmidt et al., 2019).

In soccer, the refereeing team is responsible for supervising and judging the actions that take place in a match, through the application of the rules of the game (Ozaeta et al., 2022; Yanci et al., 2016). However, Ozaeta et al. (2021), clarify that the functions of the referee and assistant referees are different; therefore, the movements vary, with the referee presenting multidirectional movements and the assistant referees presenting mainly linear movements. For Castillo et al. (2018), the role of the referee during a soccer match includes a very demanding task from the physical field, highlighting that the physical load can be similar to or higher than that of some players. This is because the referee must handle the different situations that occur on the field of play and, therefore, one of its main requirements is to always try to be as close as possible to the plays (González-Ortega et al., 2023).

During matches, referees move, according to Costa et al. (2013) and Moreno-Pérez et al. (2021) from 10 to 12 km. However, other authors propose that the range would fluctuate from 9 to 13 km (Coffi et al., 2018; Petri et al., 2020; Yanci et al., 2016). The fluctuation of these performances, by referees, would be mediated by the levels of competition in which they participate (Moreno-Pérez et al., 2021; Petri et al., 2020); especially, when comparing competitions at the national with regional level (Yanci et al., 2016). Of the total distance covered by referees, 18.6% would perform it at high intensity at speeds between 18 to 24.9 km/h during international matches (Fernández-Ruiz et al., 2021; Moreno-Pérez et al., 2021); with a variation between 21 to 38 sprints per game above 25 km/h (Fernández-Ruiz et al., 2021; Moreno-Pérez et al., 2021; Sánchez-García et al., 2018).

The purpose of this study was to analyze the external physical load in professional soccer referees and age as a possible influencing factor in physical performance during official matches of the national first division championship; using GPS devices to determine distances covered and speeds used by these athletes. Considering that at present, according to Sánchez et al. (2022), most of the studies referred to physical performance profiles are focused on soccer players, with a deficit in the case of referees.

Material and Methods

Intervention Design

A quantitative, explanatory, correlational and longitudinal study, consisting of describing the external physical load and analyzing age as a possible influential factor in the physical performance of professional soccer referees in first division matches during the first part of the Chilean national championship, using a GPS device on the field.

Participants

Population: It was constituted by first division referees belonging to the National Association of Professional Football of Chile (ANFP) (n = 20). Of this population, three were excluded, one due to injury and two due to a physical-technical situation. The final sample consisted of 17 referees in charge of directing first division matches in the national tournament, selected by convenience (non-probabilistic).

Sample: seventeen males (age: 36.19 ± 3.2 years; height: 1.79 ± .04 m; weight: 80.07 ± 4.32 kg), belonging to the ANFP of Chile, corresponding to professional soccer referees.

Inclusion criteria: To be an ANFP professional referee, to be qualified to referee in the first division of the national tournament after passing the official physical tests at the beginning of the season; to have the approval of the Technical Commission to referee in the first division.

Exclusion criteria: Not belonging to the ANFP professional referee staff, not having the physical or technical pass from the specific areas, having a clinical problem that would disqualify their participation during the first round of the national tournament.

Instruments

The Catapult Vector GPS monitoring system was used to monitor the physical load of the referees. It consists of a compact device attached to a Catapult vest, worn under the clothing during matches. The unit, through GPS, collected outdoor measurements at 18 HZ (soccer field). Data were processed through the platform and software of the brand, analyzing variables of total load, load index and session time, among others; the system has excellent intra- and inter-device accuracy and reliability (Lauck et al., 2022).

Procedure

The study was coordinated at the ANFP's Quilín Sports Center (Metropolitan Region, Santiago, Chile) and was applied in soccer stadiums throughout the country. Most of the professional first division soccer referees trained at the sports complex (nineteen of the referees and the remaining referee trained at the Concepción headquarters in southern Chile). The procedure was carried out during the Chilean first division championship season 2023; in the last nine dates of the first round, prior to the coordination and facilitation of the devices by the ANFP to carry out the study. The first round of the first division championship consisted of 15 dates, with eight games per date. The GPS devices were used in the last nine dates, of a total of 72 games, data were recorded for the study in 67 of these games, in the five missing games there were technical difficulties or difficulties in moving the equipment for the day of the game. Once the referees were designated for each game, by mid-week, coordination was made with the specific referee or the refereeing team (assistant referees, fourth official or VAR) if, for example, the assigned referee was not present at the regular weekly training sessions, because he/she had been designated internationally. The priority during the nine dates was to have a GPS device in each game for the referee to register his external physical load during the game.

In the match, the referee had to turn on the device and place the vest under his clothing before starting the warm-up, leaving it on until the end of the match. After the match, the GPS was turned off and handed over to the Physical Area at the next regular training session. Once all the devices were collected, at the beginning of each week, the data was downloaded and processed at the Quilín Sports Center until the end of the first round. The parameters established for data recording, for example, the speed bands, were in accordance with the ANFP's guidelines for external load control of the national U-20 men's soccer team, since this type of record was not available for professional referees at the national level.

From the ethical aspect of the study, it is noted that the use of GPS did not generate any type of physical overload or discomfort on the part of the referees. Furthermore, according to Reinhardt et al. (2019), this technology is in daily

use by most professional soccer teams and the information recorded by GPS enables valid data in the individualization of physical loads to determine performance and training planning. Therefore, the Physical Area of the professional referees of Chilean soccer, through the Referee Commission and in coordination with the Science Department of the ANFP, managed the provision of the necessary GPS for the use of the devices during the second part of the first round in the first division of the Chilean soccer championship; prior information, training and consent of the professional referees who participated in the study. In addition, the GPS devices used corresponded to the resources used by the ANFP for the national soccer teams. Therefore, the importance that Chile's major soccer body gave to this type of tool in improving the physical performance of athletes is noted, and therefore, it provided the necessary resources to be applied to professional referees.

Data Analysis

The data of the independent variable (age) and dependent variables were subjected to descriptive studies, estimating statistics such as minimum and maximum values, mean, standard error of the mean, standard deviation, skewness and kurtosis. Subsequently, the normality of the data distribution was estimated using the Shapiro-Wilk test. As the age variable is not normally distributed, the correlation between this (independent) variable was correlated with the dependent variables described above using Sperman's Rho test. The level of significance used was $\alpha < .5$.

Results

The results of the estimation of the minimum, maximum, mean, standard error of the mean, standard deviation, skewness and kurtosis of the variables studied are presented in Table 1.

Table 1
Results of the Estimation of the Descriptive Statistics of the Independent Variable (Age) and the Rest of the Dependent Variables Described Above

	n	*Mín*	*Máx*	*Med*	*SEM*	*DE*	*Asi*	*Kur*
Age	67	31	43	36.19	0.402	3.290	0.699	-0.670
Total meters traveled in the match	67	9206	13317	11202.42	86.372	706.983	0.090	1.327
Meters traveled at less than 6 km/h	67	3093	5197	4310.12	48.888	400.166	0.156	0.707
Meters traveled between 18 and 24 km/h (HSR)	67	609	6639	1139.09	88.233	722.221	6.891	52.726
Number of repetitions between 18 and 24 km/h	67	35	133	57.46	1.869	15.300	2.071	8.083
Meters traveled over 24 km/h (sprint)	67	0	298	85.19	7.973	65.260	1.126	1.409
Number of repetitions over 24 km/h	67	0	13	4.45	0.379	3.106	0.771	-0.062
Number of accelerations in the match	67	6	47	22.25	1.266	10.361	0.666	-0.311
Number of decelerations in the match	67	6	53	23.66	1.161	9.502	0.641	0.897

Note: n: sample, Min: minimum, Max: maximum, Med: average, SEM; standard error of the mean, SD: standard deviation, Asi: asymmetry, Kur: kurtosis.

It was observed that some variables have high values of skewness and kurtosis, which implies the possibility of absence of normal distribution.

Indeed, table 2 shows the results of the normality estimation and four of the dependent variables are not normally distributed, including age.

Table 2
Results of the Normality Estimation of the Age Variables (Independent) and the Rest of the Variables Studied (Dependent) in Professional Soccer Referees

	Statistical	Kolmogorov-Smirnov gl	significance
Age	0.225	67	0.000
Total meters traveled in the match	0.097	67	0.198
Meters traveled at less than 6 km/h	0.083	67	0.200*
Meters traveled between 18 and 24 km/h (HSR)	0.288	67	0.0001
Number of repetitions between 18 and 24 km/h	0.100	67	0.095
Meters traveled over 24 km/h (sprint)	0.104	67	0.072
Number of repetitions over 24 km/h	0.128	67	0.008
Number of accelerations in the match	0.145	67	0.001
Number of decelerations in the match	0.083	67	0.200*

Table 3 presents the results of the correlations observed.

Table 3
Results of the Correlation Between the Independent Variable Age and the Dependent Variables Studied in This Work

			Total meters traveled in the match	Meters traveled at less than 6 km/h	Meters traveled between 18 and 24 km/h (HSR)	Number of repetitions between 18 and 24 km/h
Rho de Spearman	Age	Correlation coefficient	-0.231*	0.092	0.095	0.110
		Sig. (unilateral)	0.030	0.230	0.223	0.188
		n	67	0.092	67	67
			Meters traveled over 24 km/h (sprint)	**Number of repetitions over 24 km/h**	**Number of accelerations in the match**	**Number of decelerations in the match**
Rho de Spearman	Age	Correlation coefficient	-0.022	-0.038	0.131	-0.205*
		Sig. (unilateral)	0.429	0.380	0.145	0.048
		n	67	67	67	67

Of all the estimates, only the correlation between age and total meters traveled in the match and age with the number of decelerations in the match was significant and with negative values of the estimates of these correlations, which shows that as age increases, the total meters traveled in the match and the number of decelerations in the match decrease. However, despite the significance found, the correlation values in both cases described are low (less than .25).

Discussion

High-performance soccer is a collective sport of great physical demand where players alternate actions of maximum intensity with periods of recovery; in the case of referees, although it presents a similar behavior, their movements are adjusted to the course of the game to be in the right place at the right time in order to make the best decisions, requiring

as one of the central axes to have an adequate physical condition (Fernández-Ruiz et al., 2021). According to the above, the main objective of the present study was to determine the external physical load in professional soccer referees during national first division matches and whether age could be considered an influential factor in the physical performance of these athletes.

Currently, Clemente et al. (2019), state that this level of physical demand merits quantifying the workloads in training sessions and matches, with the aim of adjusting the requirements of athletes.

The soccer referee, according to Viera et al. (2019), would have a displacement on the field similar to the midfield players. According to the results of the study, the referees on average traveled over 11 km presenting a value within the exposed in reference to the players with 10 to 12 km by Costa et al. (2013) and 10 to 14 km according to Barreira et al. (2022). As for values of distance covered by referees in matches, the results are also within those indicated in the scientific literature with 10 to 12 km by Moreno-Pérez et al. (2022) or 9 to 13 km according to Petri et al. (2020). Moreno-Perez et al. (2021) and Petri et al. (2020) emphasize that the performances are subject to the level of national or international competition in which they participate.

The GPS, according to Calderón-Pellegrino et al. (2022) has proven to be a valid and reliable technology for physical performance analysis. However, Harper et al. (2019), stated the importance of determining consensus or consistency in methodological procedures with these devices to quantify intensities during matches. For instance, Fernandez-Ruiz et al. (2021), indicated that in the total distance covered by referees during a match 18.6% was performed in HSR with speeds between 18 to 24.9 km/h; Moreno-Perez et al. (2021) also exposed 18.6% but at speeds of 15 to 25 km/h; Gonçalves et al. (2021) determined 17% of the total distance with speeds of 15 to 18 km/h. In the case of Castillo et al. (2018), they stated that, in the total distance traveled per match, 34% corresponded to HSR considering speeds above 13 km/h; Gabrilo et al. (2013) stated that the variation fluctuated between 4 to 18% depending on the competition, without indicating between which speed ranges were considered high intensity. For their part, Riiser et al. (2019), determined that the distance covered by the referees in HSR fluctuated between 600 to 1,200 m, without indicating speed parameters; finally, Sánchez-García et al. (2018), for the Spanish national tournament stated that the referees covered an average of 2,700 m at speeds above 18 km/h, without specifying whether the distance involved only HSR or also sprints. In the present study, the referees covered an average of 1,139 ± 722 m in HSR with speeds between 18 and 24 km/h, corresponding to 10.2% of the total distance covered per match and 57 ± 15 repetitions between these speeds. Results that in some studies would not be comparable due to the categorization of HSR according to speed ranges and the possible difference with respect to the level of competition where the study was applied. Similar condition for the analysis of sprints, with values between 38 ± 17 sprints over 25 km/h (Fernández-Ruiz et al., 2021), 40 sprints over 18 km/h (Moreno-Pérez et al., 2021), 21.3 to 30.5 sprints over 25.2 km/h (Sánchez-Gracía et al., 2018); compared to the 4 ± 3 sprints over 24 km/h consigned in the study with a distance of 85 ± 65 m covered over this speed. Regarding accelerations and decelerations, the study determined that referees on average performed 22 ± 10 accelerations and 23 ± 9 decelerations, which could not be compared with any antecedents of this type of motor actions by referees in the scientific literature reviewed.

The background exposes that, in recent years, soccer has increased the intensity of the game due to the change of tactics of the teams; making it faster, more intense and competitive (Chena et al., 2022). The type of national, regional or global competition is a relevant factor in the analysis of the external physical load of soccer referees (Moreno-Pérez et al., 2021; Petri et al., 2020; Yanci et al., 2016).

Another factor to consider in the external physical load with respect to movements on the field of play between players and referees and even between the referees themselves would be age. The age difference between players and referees on average corresponds to 15 years (Da Silva et al., 2012; Gabrilo et al., 2013; Viera et al., 2019) and in reference to elite referees, they would have their best physical performances between 30 to 45 years (Mazaheri et al., 2016; Mascherini et al., 2020). In the study, the average age for the group of referees was 36.19 ± 3.2 years and in the correlation of age with the variables of external physical load in matches there was a correlation with the total distance covered (-.231) and number of decelerations per match (-.205), resulting significant with negative values. It was determined that as age increases, the total distance traveled and the number of decelerations per game decrease. However, despite the significance found, the correlation values for both cases were less than .25. In addition, Gonçalves et al. (2021) noted that referees with greater experience would present better anticipation strategies and greater speed of intervention due to better positioning on the court owing to a more efficient reading of the game. A condition that according to Da Silva et al. (2012) would explain, in part, the difference in age and distance traveled between referees because the years of experience would allow a shorter total distance traveled but better quality in refereeing movements. Therefore, the total distance covered would be a variable to be considered in physical performance, but not a determining factor in terms of refereeing, as would the number of decelerations, since having a better anticipation and reading of the game, the movements on the field of play would be more calculated and regulated by referees with more experience. A faculty that FIFA states as essential in elite refereeing (Da Silva et al., 2012).

The comparative analysis of the results with the scientific evidence allows establishing a reference in terms of physical performance standards, in this case in professional referees. However, the specific use of GPS is related to the acquisition of valid and useful data to analyze performance, such as in sprints; with the aim of achieving differentiations in the specific physical work of each athlete (Reinhardt et al., 2019); allowing to obtain physiological adaptations that improve performance in competition, based on proper training planning and efficient recovery periods (Costa et al., 2013). Therefore, according to Delves et al. (2021), GPS information allows the creation of activity profiles in different sports disciplines. The background of the present study contributes to the creation of a physical performance profile according to external load in national first division matches for professional referees, being considered the first intervention of this type for this group of athletes in the country; allowing the establishment of work values based on the reality observed in the national tournament. Simultaneously, integrate international information in terms of professional referees who, in addition to their participation in national tournaments, also compete at a continental or world level.

Limitations and Future Research

Although the primary objective of the study was to determine the external physical load in professional referees during official national first division matches using GPS, the concrete determination of a workload should also take into account the internal load of the individual, a fact that should be considered in future interventions. Another limitation could be implicit in the number of matches recorded. However, as a preliminary study, the number of parties for the study was considered adequate. Finally, more than a limitation, the alternative of applying the GPS in international matches by FIFA referees, in addition to national matches, is presented as an alternative for future intervention approaches. Finally, by establishing that the use of GPS in referees is an objective contribution to the planning of physical training, questions arise as to the behavior in this matter by referees in categories other than the first division, as well as the performance in the external physical load by the assistant referees because they have different movements and functions to the referees and internalize in female referees with these same objectives; generating new instances of research.

Conclusions

The application of GPS as an external load control for professional soccer referees is proposed as a valid instrument to objectify training plans according to the referee's function. The results of the study are referred to a national competition level, highlighting for this instance that age would not be a determining factor in the physical performance of the referees.

Ethics Committee Statement

For the present research the Ethics Committee declaration does not apply, because the study, although it considered the Declaration of Helsinki to intervene in professional soccer referees, was conducted through the approval of the National Association of Professional Soccer (ANFP) of Chile and ANFP Referees Commission; as part of the regular activities of the planning of the Physical Area of professional referees, in the control of the physical performance of this group of athletes; as part of the improvement of the controls and monitoring of physical performance during the official season 2023.

Conflict of Interest Statement

The authors declare that they have no conflicts of interest in this study.

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Authors' Contribution

Individual contributions for the present study were: Cristian Díaz Escobar: conceptualization, methodology, research, formal analysis, original draft, revision and editing. Juan Pablo Araya Astudillo: methodology, research, resources, supervision, writing and revision. Felipe Cabezas Caballero: methodology, research, resources, writing. Víctor Díaz Narváez: methodology, formal analysis, writing original draft, revising and editing. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

Data available upon request to the author of correspondence [email] as it is specific information regarding the physical performance of professional soccer referees.

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Control de Carga Física Externa en Árbitros de Fútbol Profesional Durante Partidos de Primera División

External Physical Load Control in Professional Soccer Referees During First Division Matches

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Resumen

El fútbol, como deporte de alta intensidad e intermitencia requiere que también los árbitros presenten una adecuada condición física. El estudio de tipo cuantitativo, explicativo, correlacional de corte longitudinal, tuvo por objetivo determinar la carga física externa en árbitros profesionales durante partidos oficiales, mediante sistema de posicionamiento global (GPS). Participaron 17 varones (edad: 36.19 ± 3.2 años; estatura: 1.79 ± 0.04 m; peso: 80.07 ± 4.32 kg); registrándose la carga física en 67 partidos de primera división nacional. Exponiéndose como resultados, que en promedio los árbitros recorrieron 11,202 ± 706 m; de los cuales 1,139 ± 722 m fueron en alta intensidad y 85.19 ± 65.26 m en sprint; además, ejecutaron 22 ± 10 aceleraciones y 23 ± 9 desaceleraciones por partido. Al correlacionarse edad y carga física externa, se presentó correlación con las variables: distancia total recorrida (-.231) y número de desaceleraciones por partido (-.205). No obstante, el valor de correlación para ambos casos fue menor a .25. Concluyéndose que el control de carga externa mediante GPS en árbitros profesionales, posibilita objetivar las cargas de trabajo, en este caso para competencia nacional; destacándose que la edad no sería un factor determinante en el rendimiento físico de estos deportistas.

Palabras clave: Fútbol, árbitro, carga física, GPS.

Abstract

Soccer, as a high-intensity and intermittence sport, also requires referees to be in good physical condition. The objective of this quantitative, explanatory, correlational, longitudinal study was to determine the external physical load on professional referees during official matches, using a global positioning system (GPS). Seventeen males participated (age: 36.19 ± 3.2 years; height: 1.79 ± 0.04 m; weight: 80.07 ± 4.32 kg); the physical load was recorded in 67 national first division matches. The results showed that, on average, the referees covered 11,202 ± 706 m; of which 1,139 ± 722 m were in high intensity and 85.19 ± 65.26 m in sprint; in addition, they performed 22 ± 10 accelerations and 23 ± 9 decelerations per match. When correlating age and external physical load, there was a correlation with the variables: total distance covered (-.231) and number of decelerations per game (-.205). However, the correlation value for both cases was less than .25. It was concluded that the external load control using of GPS in professional referees, makes it possible to objectify the workloads, in this case for national competition; highlighting that age would not be a determining factor in the physical performance of these athletes.

Keywords: Football, referee, physical load, GPS.

Introducción

El fútbol es un deporte colectivo de alta exigencia física, caracterizado por una alternancia constante entre actividades de baja intensidad al estar de pie, caminar o trotar; de alta intensidad al correr o cambiar de dirección y de muy alta intensidad al realizar sprints, aceleraciones y desaceleraciones (Dalen et al., 2020; Gualtieri et al., 2023; Teixeira et al., 2021). Estos patrones de actividad intermitente generan importantes cargas neuromusculares durante las acciones motoras de mayor intensidad y frecuencia, especialmente en el alto rendimiento (Aloui et al., 2022; Djaoui et al., 2022). Asociándose frecuentemente a los momentos de un partido donde existe mayor probabilidad de concretar una anotación (Calderon et al., 2022). Para Chena et al. (2022), las últimas investigaciones, en este deporte, han demostrado que las tácticas utilizadas por los equipos aumentaron la exigencia física, convirtiendo el fútbol en una actividad más rápida, intensa y competitiva. Lo que requiere de evaluaciones físicas más precisas, respecto a las cargas internas y externas de los futbolistas, especialmente durante los partidos (Strauss et al., 2019). Esta cuantificación de las cargas, según Balaguer y Caparros (2021), resulta esencial para la determinación de respuestas y adaptaciones individuales en relación a la planificación deportiva.

Frente a este requerimiento, Sánchez et al. (2022), expusieron que la Federación Internacional de Fútbol Asociación (FIFA) al igual que muchos clubes, están invirtiendo tiempo y recursos en tecnologías que permitan cuantificar los niveles de exigencia física en partidos como entrenamientos. Generándose un aumento exponencial en el uso de sistemas de posicionamiento global (GPS), por la información específica que entregan (Muñoz et al., 2022; Schulze et al., 2021), permitiendo registrar la carga externa de un deportista de acuerdo a distancias y velocidades recorridas en el terreno de juego (Delves et al., 2021).

Durante los partidos de fútbol, Pavillon et al. (2021) indicaron que más del 80% de los desplazamientos de los jugadores serían de baja a mediana intensidad y entre el 10% a 20% correspondería a acciones en alta intensidad. Las carreras a alta intensidad, denominadas HSR (High speed running) y los sprints habrían tenido un incremento importante en el fútbol masculino, en los últimos 15 años, por la intensidad de juego que se está aplicando (Gualtieri et al., 2023).

En cuanto a distancia recorrida por partido, Costa et al. (2013) indicaron que los jugadores de elite se desplazaban entre 10 a 12 km. Actualmente, Barreira et al. (2022) expusieron que las distancias fluctuarían entre 10 a 14 km y realizarían de 150 a 250 acciones a alta intensidad, destacándose los sprints, aceleraciones y desaceleraciones. Los sprints, de acuerdo a Reinhardt et al. (2019), se establecen como un factor relevante en la exigencia física de este deporte, comprenden no más del 5% del volumen total de recorrido en un partido y la mayoría de estos desplazamientos no superan los 20 m. Además, Aloui et al. (2022), indicaron que los sprints fluctuarían entre 200 m a 1100 m por partido, con una duración de 2 a 4 s., representando entre 1% al 11% de la distancia total recorrida en un partido; donde el 96% de los sprints no superan los 30 m, de los cuales el 49% estarían bajo los 10 m. Por su parte, González-Millán et al. (2014), determinaron que cada jugador en un equipo ejecutaría alrededor de 11 sprints por partido con un promedio de 230 m recorridos en velocidad, dependiendo del puesto de juego y del 5% a 10% de las acciones totales de juego se realizarían mediante carreras en alta intensidad.

En el caso de las aceleraciones y desaceleraciones horizontales, se clasifican como habilidades locomotoras cruciales en actividades con movimientos multidireccionales intermitentes, permitiendo cambios rápidos de velocidad y dirección por parte de los deportistas (Harper et al., 2022). En el fútbol, las aceleraciones comprenderían de un 7% a 10% y las desaceleraciones de un 5% a 7% de la carga física total de los jugadores para todas las posiciones de juego (Nobari et al., 2021). Zhang et al. (2021), informaron que los jugadores realizarían un aproximado de 14 a 26 aceleraciones y de 43 a 56 desaceleraciones a alta intensidad por partido.

Estos avances en la forma física de los jugadores, también ha repercutido en los árbitros y árbitros asistentes, quienes han debido afrontar este aumento en la exigencia física, teniendo en cuenta que a diferencia de los jugadores no tienen la posibilidad de sustitución a menos que se produzca una lesión (Schmidt et al., 2019). En el fútbol, el cuerpo arbitral es el responsable de supervisar y juzgar las acciones que se van produciendo en un partido, mediante la aplicación de las reglas de juego (Ozaeta et al., 2022; Yanci et al., 2016). No obstante, Ozaeta et al. (2021), clarifican que las funciones del árbitro y los árbitros asistentes son diferentes; por lo tanto, los desplazamientos varían presentando el árbitro movimientos multidireccionales y los árbitros asistentes movimientos principalmente lineales. Para Castillo et al. (2018), la función del árbitro durante un partido de fútbol comprende una tarea muy exigente desde el ámbito físico, destacándose que la carga física puede ser similar o superior a la de algunos jugadores. Dado, porque el árbitro debe manejar las distintas situaciones que se van dando en el terreno de juego y, por tanto, uno de sus principales requerimientos es procurar estar siempre lo más cerca de las jugadas (González-Ortega et al., 2023).

Durante los partidos los árbitros recorren, según Costa et al. (2013) y Moreno-Pérez et al. (2021) de 10 a 12 km. Sin embargo, otros autores plantean que el rango fluctuaría de 9 a 13 km (Coffi et al., 2018; Petri et al., 2020; Yanci et al., 2016). La fluctuación de estos rendimientos, por parte de los árbitros, estaría mediado por los niveles de competición en los que participan (Moreno-Pérez et al., 2021; Petri et al., 2020); especialmente, cuando se comparan competencias a nivel nacional con regional (Yanci et al., 2016). Del total de la distancia recorrida por los árbitros, el 18,6% lo realizarían en alta intensidad a

velocidades entre 18 a 24.9 km/h durante partidos internacionales (Fernández-Ruiz et al., 2021; Moreno-Pérez et al., 2021); con una variación entre 21 a 38 sprints por juego por sobre 25 km/h (Fernández-Ruiz et al., 2021; Moreno-Pérez et al., 2021; Sánchez-García et al., 2018).

El propósito del presente estudio fue analizar la carga física externa en árbitros profesionales de fútbol y la edad como posible factor influyente en el rendimiento físico durante partidos oficiales del campeonato de primera división nacional; mediante la utilización de dispositivos GPS para determinar distancias recorridas y velocidades utilizadas por estos deportistas. Considerando qué en la actualidad, según Sánchez et al. (2022), la mayoría de los estudios referidos a perfiles de rendimientos físico se concentran en los futbolistas, existiendo un déficit en el caso de los árbitros.

Material y Métodos

Diseño de Intervención

Estudio de tipo cuantitativo, explicativo, correlacional de corte longitudinal; consistente en describir la carga física externa y analizar la edad como posible factor influyente en el rendimiento físico de árbitros profesionales de fútbol en partidos de primera división durante la primera rueda del campeonato nacional chileno, utilizando dispositivo GPS en cancha.

Participantes

Población: Estuvo constituida por árbitros de primera división pertenecientes a la Asociación Nacional de Fútbol Profesional de Chile (ANFP) (n = 20). De esta población, tres quedaron excluidos, uno por lesión y dos por situación físico-técnica. La muestra final correspondió a 17 árbitros encargados de dirigir partidos de primera división torneo nacional, seleccionados por conveniencia (no probabilística)

Muestra: Constituida por 17 varones (edad: 36.19 ± 3.2 años; estatura; 1.79 ± .04 m; peso: 80.07 ± 4.32 kg), pertenecientes a la ANFP de Chile, correspondientes a árbitros profesionales de fútbol.

Criterio de inclusión: Ser árbitro profesional ANFP, estar habilitado para dirigir en primera división del torneo nacional previa aprobación de las pruebas físicas oficiales a principio de temporada; tener la aprobación de la Comisión técnica para dirigir en primera división.

Criterio de exclusión: No pertenecer al staff de árbitros profesionales ANFP, no tener el pase físico o técnico por parte de las áreas específicas, cursar con una problemática de carácter clínico que inhabilitara su participación durante la primera rueda del torneo nacional.

Instrumentos

Para el control de la carga física de los árbitros se utilizó el sistema de monitorización GPS Catapult Vector. Compuesto de un dispositivo compacto acoplado a un chaleco Catapult, utilizado bajo la vestimenta durante los partidos. La unidad, a través del GPS, recogió las mediciones en exteriores a 18 HZ (cancha de fútbol). Datos que se procesaron mediante la plataforma y software de la marca, analizando variables de carga total, índice de carga, tiempo de sesión, entre otros; el sistema cuenta con excelente precisión intra e interdispositivos y fiabiliad (Lauck et al., 2022).

Procedimiento

El estudio se coordinó en el Centro Deportivo Quilín de la ANFP (Región Metropolitana, Santiago, Chile) y se aplicó en estadios de fútbol del país. En el complejo deportivo entrenaba la mayoría de los árbitros profesionales de fútbol de primera división (diecinueve de los árbitros, el árbitro restante entrenaba en la sede de Concepción, en el sur de Chile). El procedimiento se llevó a cabo durante el Campeonato de primera división chileno temporada 2023; en las últimas nueve fechas de la primera rueda, previo a la coordinación y facilitación de los dispositivos por parte de la ANFP para llevar a cabo el estudio.

La primera rueda del campeonato de primera división se constituyó de 15 fechas, con ocho partidos por fecha. Los dispositivos GPS se utilizaron en las últimas nueve fechas, de un total de 72 juegos, se registraron los datos para el estudio en 67 de estos partidos, en los cinco faltantes se presentaron dificultades técnicas o de traslado del equipo para el día del partido. Una vez designados los árbitros para cada juego, ha mediado de semana, se coordinó con el árbitro en específico o el equipo arbitral (árbitros asistentes, cuarto árbitro o VAR) si por ejemplo el árbitro asignado no estaba presente en los entrenamientos regulares semanales, por haber sido designado internacionalmente. La prioridad en las nueve fechas, fue contar con un dispositivo GPS en cada partido para que el árbitro registrara su carga física externa durante el juego.

En el partido, el árbitro debía encender el dispositivo y colocarse el chaleco bajo su vestimenta antes de comenzar el calentamiento, dejándolo encendido hasta el final del encuentro. Terminado el partido, se apagaba el GPS y se entregaba al Área Física en el siguiente entrenamiento regular. Una vez reunidos todos los dispositivos, a inicio de cada semana, se procedía a la descarga y procesamiento de los datos en el Centro deportivo Quilín, hasta el término de la primera rueda.

Los parámetros establecidos para el registro de datos, por ejemplo, las bandas de velocidad; fueron de acuerdo a lo determinado en la ANFP para el control de carga externa de la selección nacional de fútbol Sub-20 masculina, debido a que no se tenía este tipo de registro en árbitros profesionales a nivel nacional.

Desde el aspecto ético del estudio, se consigna que el uso de GPS no generó ningún tipo de sobrecarga física o incomodidad por parte de los árbitros. Además, según Reinhardt et al. (2019), esta tecnología es de uso diario por parte de la mayoría de los equipos de fútbol profesional y la información registrada por GPS posibilita datos válidos en la individualización de cargas físicas para determinar rendimientos y planificación de entrenamientos. Por lo anterior, el Área Física de los árbitros profesionales del fútbol chileno, a través de la Comisión Arbitral y en coordinación con el Departamento de Ciencias de la ANFP gestionó la facilitación de los GPS necesarios para la utilización de los dispositivos durante la segunda mitad de la primera rueda en el Campeonato de primera división del fútbol chileno; previa información, capacitación y consentimiento por parte de los árbitros profesionales que participaron en el estudio. Además, los dispositivos GPS utilizados correspondían a los recursos utilizados por la ANFP para las selecciones nacionales de fútbol. Por lo tanto, se consigna la importancia que el ente mayor del fútbol de Chile le daba a este tipo de herramienta en la mejora de los rendimientos físicos de los deportistas y por ello, facilitó los recursos necesarios para ser aplicados en los árbitros profesionales.

Análisis de Datos

Los datos de la variable independiente (edad) y dependientes fueron sometidos a estudios descriptivos estimándose los estadísticos como valores mínimos y máximos, media, error estándar de la media, desviación estándar, asimetría y curtosis. Posteriormente, se estimó la normalidad de la distribución de los datos mediante la prueba de Shapiro-Wilk. Como la variable edad no se distribuye normalmente, la correlación entre esta variable (independiente) fue correlacionada con las variables dependientes descritas anteriormente mediante la prueba Rho de Sperman. El nivel de significación empleado fue de $\alpha < .05$.

Resultados

Los resultados de la estimación de los valores mínimos, máximos, media, error estándar de la media, desviación estándar, asimetría y curtosis de las variables estudiadas se presentan en Tabla 1.

Tabla 1
Resultados de la Estimación de los Estadísticos Descriptivos de la Variable Independiente (Edad) y del Resto de la Variables Dependientes Antes Descritas

	n	*Mín*	*Máx*	*Med*	*EEM*	*DE*	*Asi*	*Cur*
Edad	67	31	43	36.19	0.402	3.290	0.699	-0.670
Total de metros recorridos en el partido	67	9206	13317	11202.42	86.372	706.983	0.090	1.327
Metros recorridos a menos de 6 km/h	67	3093	5197	4310.12	48.888	400.166	0.156	0.707
Metros recorridos entre 18 y 24 km/h (*HSR*)	67	609	6639	1139.09	88.233	722.221	6.891	52.726
Número de repeticiones entre 18 y 24 km/h	67	35	133	57.46	1.869	15.300	2.071	8.083
Metros recorridos sobre 24 km/h (sprint)	67	0	298	85.19	7.973	65.260	1.126	1.409
Número de repeticiones sobre 24 km/h	67	0	13	4.45	0.379	3.106	0.771	-0.062
Número de aceleraciones en el partido	67	6	47	22.25	1.266	10.361	0.666	-0.311
Número de desaceleraciones en el partido	67	6	53	23.66	1.161	9.502	0.641	0.897

Nota: n: muestra, Mín: mínimo, Máx: máximo, Med: media, EEM; error estándar de la media, DE: desviación estándar, Asi: asimetría, Cur: curtosis.

Se observó que algunas variables tienen valores altos de asimetría y curtosis lo que implica la posibilidad de ausencia de distribución normal.

En efecto, en la tabla 2 se muestran los resultados de la estimación de la normalidad y cuatro de las variables dependientes no se distribuyen normalmente, incluyendo la edad.

Tabla 2
Resultados de la Estimación de Normalidad de las Variables Edad (Independiente) y el Resto de las Variables Estudiadas (Dependientes) en Árbitros Profesionales de Fútbol

	Estadístico	Kolmogorov-Smirnov gl	Significación
Edad	0.225	67	0.000
Total de metros recorridos en el partido	0.097	67	0.198
Metros recorridos a menos de 6 km/h	0.083	67	0.200*
Metros recorridos entre 18 y 24 km/h (*HSR*)	0.288	67	0.0001
Número de repeticiones entre 18 y 24 km/h	0.100	67	0.095
Metros recorridos sobre 24 km/h (sprint)	0.104	67	0.072
Número de repeticiones sobre 24 km/h	0.128	67	0.008
Número de aceleraciones en el partido	0.145	67	0.001
Número de desaceleraciones en el partido	0.083	67	0.200*

En la tabla 3 se presentan los resultados de las correlaciones observadas.

Tabla 3
Resultados de la Correlación Entre la Variable Independiente Edad y las Variables Dependientes Estudiadas en el Presente Trabajo

			Total de metros recorridos en el partido	Metros recorridos a menos de 6 km/h	Metros recorridos entre 18 y 24 km/h (HSR)	Número de repeticiones entre 18 y 24 km/h
Rho de Spearman	Edad	Coeficiente de correlación	-0.231*	0.092	0.095	0.110
		Sig. (unilateral)	0.030	0.230	0.223	0.188
		n	67	0.092	67	67
			Metros recorridos sobre 24 km/h (sprint)	**Número de repeticiones sobre 24 km/h**	**Número de aceleraciones en el partido**	**Número de desacelera-ciones en el partido**
Rho de Spearman	Edad	Coeficiente de correlación	-0.022	-0.038	0.131	-0.205*
		Sig. (unilateral)	0.429	0.380	0.145	0.048
		n	67	67	67	67

De todas las estimaciones, sólo la correlación entre la edad y el total de metros recorridos en el partido y la edad con el número de desaceleraciones en el partido resultaron significativos y con valores negativos de las estimaciones de estas correlaciones, todo lo cual muestra que en la medida que la edad aumenta, disminuye el total de metros recorridos en el partido y número de desaceleraciones en el partido. Sin embargo, a pesar de la significación encontrada, los valores de correlación en ambos casos descritos son bajos (menores a .25)

Discusión

El fútbol de alto rendimiento es un deporte colectivo de gran exigencia física donde los jugadores alternan acciones de máxima intensidad con periodos de recuperación; en el caso de los árbitros, si bien presenta un comportamiento similar, sus desplazamientos se ajustan al curso del juego para estar en el lugar correcto y momento preciso con el propósito de tomar las mejores decisiones, requiriéndose como uno de los ejes centrales tener una adecuada condición física (Fernández-Ruiz et al., 2021). De acuerdo a lo anterior, el objetivo principal del presente estudio fue determinar la carga física externa en árbitros profesionales de fútbol durante partidos de primera división nacional y si la edad se podía considerar como un factor influyente en el rendimiento físico de estos deportistas.

Actualmente, Clemente et al. (2019), plantean que este nivel de exigencia física amerita cuantificar las cargas de trabajo en entrenamientos como partidos, con el objetivo de ajustar los requerimientos de los deportistas.

El árbitro de fútbol, según Viera et al. (2019), tendría un desplazamiento en cancha similar a los jugadores volantes. De acuerdo con los resultados del estudio, los árbitros en promedio recorrieron sobre 11 km presentando un valor dentro de lo expuesto en referencia a los jugadores con 10 a 12 km por parte de Costa et al. (2013) y 10 a 14 km según Barreira et al. (2022). En cuanto a valores de distancia recorrida por árbitros en partidos, también los resultados estarían dentro de los indicados en la literatura científica con 10 a 12 km por parte de Moreno-Pérez et al. (2022) o 9 a 13 km según Petri et al. (2020). Destacándose por parte de Moreno-Pérez et al. (2021) y Petri et al. (2020) que los rendimientos están supeditados al nivel de competencia nacional o internacional en el que se participa.

Los GPS, según Calderón-Pellegrino et al. (2022) han demostrado ser una tecnología válida y fiable para el análisis de rendimiento físico. Sin embargo, Harper et al. (2019), manifestaron la importancia de determinar consenso o coherencia en los procedimientos metodológicos con estos dispositivos para cuantificar intensidades durante los partidos. Como ejemplos, Fernández-Ruiz et al. (2021), indicaron que en la distancia total recorrida por árbitros durante un partido el 18,6% se realizaba en HSR con velocidades entre 18 a 24.9 km/h; Moreno-Pérez et al. (2021) también expusieron un 18,6% pero en velocidades de 15 a 25 km/h; Gonçalves et al. (2021) determinaron un 17% respecto a la distancia total con velocidades de 15 a 18 km/h. En el caso de Castillo et al. (2018) manifestaron que, en la distancia total recorrida por partido, el 34% correspondía a HSR considerando velocidades por sobre los 13 km/h; Gabrilo et al. (2013) plantearon que la variación fluctuaba entre 4 a 18% según competencia, sin indicar entre qué rangos de velocidad se consideraba alta intensidad. Por su parte, Riiser et al. (2019), determinaron que la distancia recorrida por los árbitros en HSR fluctuaba entre 600 a 1,200 m, sin indicar parámetros de velocidad; finalmente, Sánchez-García et al. (2018), para el torneo nacional español expusieron que los árbitros recorrían en promedio 2,700 m en velocidades superiores a 18 km/h, no especificando si la distancia involucraba sólo HSR o también los sprints. En el presente estudio, los árbitros recorrieron en HSR con velocidades entre 18 y 24 km/h un promedio de 1,139 ± 722 m, correspondiente a un 10,2% de la distancia total recorrida por partido y 57 ± 15 repeticiones entre estas velocidades. Resultados que en algunos estudios no serían comparables por la categorización del HSR según rangos de velocidad y por la posible diferencia respecto al nivel de competencia donde el estudio fue aplicado. Condición similar para el análisis de los sprints, con valores entre 38 ± 17 sprints sobre 25 km/h (Fernández-Ruiz et al., 2021), 40 sprints sobre 18 km/h (Moreno-Pérez et al., 2021), 21,3 a 30,5 sprints sobre 25,2 km/h (Sánchez-Gracía et al., 2018); en comparación a los 4 ± 3 sprints por sobre 24 km/h consignados en el estudio con una distancia de 85 ± 65 m recorridos por sobre esta velocidad. En cuanto a las aceleraciones y desaceleraciones el estudio determinó que los árbitros en promedio realizaron 22 ± 10 aceleraciones y 23 ± 9 desaceleraciones, lo cual no se pudo comparar con algún antecedente sobre este tipo de acciones motoras por parte de los réferis en la literatura científica revisada.

Los antecedentes exponen que, si bien en los últimos años, el fútbol ha incrementado la intensidad de juego producto del cambio de tácticas de los equipos; haciéndolo más rápido, intenso y competitivo (Chena et al., 2022). El tipo de competencia de carácter nacional, regional o mundial comprende un factor relevante en el análisis de la carga física externa de los árbitros de fútbol (Moreno-Pérez et al., 2021; Petri et al., 2020; Yanci et al., 2016).

Otro factor para considerar en la carga física externa respecto a los desplazamientos en el terreno de juego entre jugadores y árbitros e incluso entre los mismos árbitros sería la edad. La diferencia de edad entre jugadores y árbitros en promedio corresponde a 15 años (Da Silva et al., 2012; Gabrilo et al., 2013; Viera et al., 2019) y en referencia a los árbitros de elite, tendrían sus mejores rendimientos físicos entre los 30 a 45 años (Mazaheri et al., 2016; Mascherini et al., 2020). En el estudio, el promedio de edad para el grupo de árbitros fue de 36.19 ± 3.2 años y en la correlación de la edad con las variables de carga física externa en partidos se presentó correlación con distancia total requerida (-.231) y número de desaceleraciones por partido (-.205), resultando significativo con valores negativos. Determinándose que a medida que aumenta la edad disminuye el total de distancia recorrida y número de desaceleraciones por partido. Sin embargo, pese a la significación encontrada, los valores de correlación para ambos casos fueron menores a .25. Además, Gonçalves et al. (2021), destacaron que los árbitros con mayor experticia presentarían mejores estrategias de anticipación y mayor celeridad de intervención debido a un mejor posicionamiento en la cancha dado por una lectura del juego más eficiente.

Condición que según Da Silva et al. (2012) explicaría, en parte, la diferencia para edad y distancia recorrida entre árbitros debido a que los años de experiencia permitirían una menor distancia total recorrida pero mejor calidad en los desplazamientos arbitrales. Por lo tanto, la distancia total recorrida sería una variable por considerar en el rendimiento físico, pero no determinante en cuanto a la conducción arbitral, lo mismo el número de desaceleraciones ya que al tener una mejor anticipación y lectura de juego, los desplazamientos en el terreno de juego serían más calculados y regulados por parte de los árbitros con mayor experiencia. Facultad que la FIFA expone como esencial en el arbitraje de elite (Da Silva et al., 2012).

El análisis comparativo de los resultados con la evidencia científica permite establecer una referencia en cuanto a estándares de rendimiento físico, para este caso en árbitros profesionales. No obstante, el uso concreto de GPS tiene relación con la adquisición de datos válidos y útiles para analizar rendimientos, como por ejemplo en sprints; con el objetivo de lograr diferenciaciones en el trabajo físico específico de cada deportista (Reinhardt et al., 2019); permitiendo obtener adaptaciones fisiológicas que mejoren el rendimiento en competencia, con base en una adecuada planificación de entrenamiento y eficientes periodos de recuperación (Costa et al., 2013). Por lo tanto, según Delves et al. (2021), la información de los GPS permite crear perfiles de actividad en distintas disciplinas deportivas. Los antecedentes del presente estudio contribuyen en la creación de un perfil de rendimiento físico según carga externa en partidos de primera división nacional para árbitros profesionales, considerándose que es la primera intervención de este tipo para este grupo de deportistas en el país; permitiendo establecer valores de trabajo en función a la realidad observada en el torneo nacional. Pero a su vez, integrando la información internacional en función a los árbitros profesionales que además de la participación en los torneos nacionales se les suma la competencia a nivel continental o mundial.

Limitaciones y Futuras Investigaciones

Si bien, el objetivo primordial del estudio fue determinar la carga física externa en árbitros profesionales durante partidos oficiales de primera división nacional con utilización de GPS; la determinación concreta de una carga de trabajo debe contemplar también la carga interna de la persona; antecedente que en futuras intervenciones debiese considerarse. Otra limitación podría estar implícita en el número de partidos registrados. No obstante, como estudio preliminar se consideró como adecuada la cantidad de partidos para el estudio. Por último, más que limitación se expone dentro de futuros planteamientos de intervención la alternativa de aplicar los GPS en partidos internacionales, por parte de los árbitros FIFA, además de los encuentros nacionales. Finalmente, al establecer que el uso de GPS en los árbitros es un aporte objetivo para la planificación del entrenamiento físico, se generan interrogantes en cuanto al comportamiento, en esta materia, por parte de árbitros en categorías diferentes a la primera división, también el rendimiento en la carga física externa por parte de los árbitros asistentes debido a que tienen desplazamientos y funciones distintas a los árbitros e internalizarse en el arbitraje femenino con estos mismos objetivos; generándose nuevas instancias de investigación.

Conclusiones

La aplicación de GPS como control de carga externa para árbitros de fútbol profesional se plantea como un instrumento válido para objetivar planes de entrenamiento de acuerdo con la función arbitral. Los resultados del estudio están referidos a un nivel de competencia nacional, destacándose para esta instancia que la edad no sería un factor determinante en el rendimiento físico de los árbitros.

Declaración del Comité de Ética

Para la presente investigación no aplica la declaración de Comité de ética, debido a que el estudio, si bien consideró la Declaración de Helsinki para intervenir en árbitros profesionales de fútbol, se realizó a través de la aprobación de la Asociación Nacional de Fútbol Profesional (ANFP) de Chile y Comisión de Árbitros de la ANFP; como parte de las actividades regulares de la planificación del Área Física de los árbitros profesionales, en el control del rendimiento físico de este grupo de deportistas; como parte de la mejora de los controles y seguimiento del rendimiento físico durante la temporada oficial 2023.

Conflicto de Intereses

Los autores declaran no tener conflictos de interés en el presente estudio.

Financiación

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Contribución de los Autores

Las contribuciones individuales para el presente estudio fueron: Cristian Díaz Escobar: conceptualización, metodología, investigación, análisis formal, redacción borrador original, revisión y edición. Juan Pablo Araya Astudillo: metodología, investigación, recursos, supervisión, redacción y revisión. Felipe Cabezas Caballero: metodología, investigación, recursos, redacción. Víctor Díaz Narváez: metodología, análisis formal, redacción borrador original, revisión y edición. Todos los autores han leído y están de acuerdo con la versión publicada del manuscrito.

Declaración de Disponibilidad de Datos

Datos disponibles bajo demanda al autor de correspondencia [email] por ser información específica en cuanto al rendimiento físico de árbitros profesionales de fútbol.

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Effects of 12-Week Combined Circuit Tabata Training (Ctt): Empower the Fitness and Passion of Young Squash Athletes

Efectos del Entrenamiento en Circuito Tabata (Ctt) Combinado de 12 Semanas: Potencia la Forma Física y la Pasión de los Atletas Jóvenes de Squash

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Abstract

The present study aims to investigate the effects of combined circuit tabata training (CTT) on physical fitness and passion of young squash athletes. This experiment randomized control trial (RCT) research was carried out three times a week for 12 weeks. A total of 50 young squash athletes were divided into CTT (n = 25, 18.7 ± 1.06 year, 161 ± 3.74 cm, 58.0 ± 3.03 kg, 22.0 ± 1.06 kg/m2) and control group (CG, n = 25, 18.9 ± 1.04 year, 162 ± 3.50 cm, 59.0 ± 3.49 kg, 22.2 ± 1.04 kg/m2). Pre and post measurements were carried out using the handgrip dynamometer test (HDT), 5m sprint test (5mST), 5-0-5 COD test (505CODT), medicine ball throw test (MBTT), sit and reach test (SRT), yo-yo intermittent recovery test level 1 (YYIRTL1). We observed Time (T) effects for physical fitness on components HDT (p < .001), 5mST (p

Resumen

El presente estudio tiene como objetivo investigar los efectos del entrenamiento tabata en circuito combinado (CTT) sobre la condición física y la pasión de los jóvenes atletas de squash. Esta verdadera investigación experiment de control aleatorio (ECA) se llevó a cabo tres veces por semana durante 12 semanas. Un total de 50 jóvenes atletas de squash se dividieron en CTT (n = 25, 18.7 ± 1.06 años, 161 ± 3.74 cm, 58.0 ± 3.03 kg, 22.0 ± 1.06 kg/m2) y grupo de control (CG, n = 25, 18.9 ± 1.04 años, 162 ± 3.50 cm, 59.0 ± 3.49 kg, 22.2 ± 1.04 kg/m2). Las mediciones previas y posteriores se llevaron a cabo mediante la prueba de dinamómetro de agarre manual (HDT), la prueba de sprint de 5 m (5mST), la prueba de COD 5-0-5 (505CODT), la prueba de lanzamiento de balón medicinal (MBTT), la prueba de sentarse y alcanzar (SRT),

< .001), 505CODT (p < .001), MBTT (p < .001), SRT (p = .006), and YYIRTL1 (p < .001). There were significant differences in group (G), including HDT (p < .001), 5mST (p = .048), 505CODT (p = 0.018), MBTT (p = .005), SRT (p = .004), and YYIRTL1 (p = .001). There was an interaction (I) on the components HDT (p < .001), 5mST (p < .001), 505CODT (p < .001), MBTT (p < .001), YYIRTL1 (p < .001). However, no interaction was reported on SRT (p = .687). In addition, based on %Δ and ES, it shows that CTT group has greater changes in physical fitness and passion from pre-test to post-test compared to CG group. Among young squash athletes, the study revealed that CTT was the key factor in the improvement of physical fitness and passion.

Keywords: Circuit tabata training, Fitness, Passion, Squash.

Prueba de recuperación intermitente yo-yo nivel 1 (YYIRTL1). Observamos efectos del tiempo (T) para la aptitud física en los componentes HDT (p < .001), 5mST (p < .001), 505CODT (p < .001), MBTT (p < .001), SRT (p = .006) y YYIRTL1 (p < .001). Hubo diferencias significativas en el grupo (G), incluyendo HDT (p < .001), 5mST (p = .048), 505CODT (p = .018), MBTT (p = .005), SRT (p = .004) y YYIRTL1 (p = .001). Hubo interacción (I) sobre los componentes HDT (p < .001), 5mST (p < .001), 505CODT (p < .001), MBTT (p < .001), YYIRTL1 (p < .001). Sin embargo, no se informó ninguna interacción con la SRT (p = .687). Además, con base en %Δ y ES, muestra que el grupo CTT tiene mayores cambios en la aptitud física y la pasión desde la prueba previa hasta la prueba posterior en comparación con el grupo CG. Entre los jóvenes atletas de squash, el estudio reveló que el CTT era el factor clave en la mejora de la condición física y la pasión.

Palabras clave: Circuito tabata entrenamiento, Fitness, Pasión, Squash.

Introduction

Squash is a type of competitive sport that has the characteristics of high intensity game, because athletes are required to perform several types of movement skills (e.g., running, accelerations, decelerations, hitting the ball, changing direction) (James et al., 2022). In addition, Squash is considered a racket sport that has a fast level and requires an energy expenditure of 4.933 ± 620 kJ.h−1 (Turner et al., 2021), and the average oxygen consumption during the game is 86-92% from maximum oxygen consumption (VO^{2max}) (Ventura-Comes et al., 2019), therefore athletes need well-developed physical fitness (Ma & Kabala, 2024). Physical fitness consists of many factors (motor abilities) for example: strength, speed, agility, power, flexibility and endurance. Data from previous studies reported that physical fitness is an important factor in competitive sports (Lambrich & Muehlbaue, 2023; Wang et al., 2023), athletes with high physical fitness can maintain good performance during competition (Deng et al., 2023; Eraslan et al., 2021). Likewise in tennis, components of physical fitness such as strength can generates strong shots (Xiao et al., 2022), in badminton it helps athletes change direction quickly (Guo et al., 2021). Meanwhile, poor physical fitness is a major factor that causes fatigue and difficulty to achieve high performance (Gani et al., 2023). In addition, it has been proven based on previous studies that physical fitness is an important aspect for athletes to achieve success in competitive sports (Gonzalez Ortega, 2023; Marin et al., 2023; Rios et al., 2023).

Over the last several decades, passion has also been identified as a factor that is important for athletes (Ogallar-Blanco et al., 2024). Basically, passion can be interpreted as an athlete's ability in gaining strong passion for participating in multiple activities for long term periode (St-Cyr et al., 2021; Uğraş et al., 2024). Based on the literature, "the Dualistic Model of Passion (DMP)" has two dimensions, namely harmonious passion (HP) which is the result of the internalization of autonomous activities into one's identity (Vankakova et al., 2021), HP stimulates a behavior to carry out activities voluntarily or without pressure internal or external (St-Cyr et al., 2023). Meanwhile, obsessive passion (OP) is generated from the internalization of controlled activities into one's identity (Mahdavi-Jafari, 2019), OP creates a certain behavior to engage in activities because of the internal possibilities that control them. Data from previous studies reported that passion provides many positive benefits, for example have an important role in triggering motivation to exercise (Yukhymenko-Lescroart, 2021). Chen et al. (2019), reported that the development of passion in athletes will have a positive impact on reducing burnout. In addition, based on other studies, OP has been shown to be positively related to satisfaction and concentration (Chamorro et al., 2020). Considering the benefits which can be obtained by increasing physical fitness and passion, many studies have documented various types of training to improve physical fitness (Deng et al., 2023), and passion (Castillo et al., 2020).

A combination of circuit tabata training (CTT) becomes a solution and recommendation by researchers (Murawska-Cialowicz et al., 2020). Basically, CTT is an exercise that involves stations (Pieczyńska et al., 2021), each station has a different type of activity (Stojanović et al., 2023). In addition, CTT adopts the concept of high-intensity training carried out for 20-seconds and alternated by 10-second rest periods (Gutiérrez-Arroyo et al., 2023). Based on previous studies, CTT has been proven can be used as a training tool to improve several aspects of athletes, for example it was reported that CTT could be ideal training to induce significant changes in obesity indices and physical fitness (Lee et al., 2021). In addition, other facts reported that CTT induces greater cardiorespiratory and metabolic responses in soccer players (Marín-Pagán et al., 2020). Meanwhile, Mehmood et al. (2022), reported other benefits from the effects of the CTT program for six weeks,

which can reduce body mass index (BMI), body fat (BF) and waist-to-hip ratio (WHR). Research on CTT has been studied previously by several researchers (Andreassen et al., 2019; Ballesta-García et al., 2019; Ho et al., 2024; Marinho et al., 2022; Sperlich et al., 2017; Turri-Silva et al., 2021). However, to the best of our current knowledge there was a lack of previous research on the effects of CTT which was implemented for 12 weeks to improve physical fitness and passion among young squash athletes. Thus, the purpose of the study was to evaluate the effect of CTT training on the physical fitness and passion of young squash players.

Materials and Methods

Participants

There were 60 young male squash athletes from the Department of Physical Education at Makasar State University (Indonesia) were selected based on inclusion criteria: (i) beginner-level athletes, (ii) aged 17-20 years, (iii) not injured. Meanwhile, the exclusion criteria are: (i) got injury in the last 1 month, (ii) more than 21 years old, (iii) elite level athlete, and (iv) currently taking part in a national or international competitive event. Initially, there were 60 athletes involved in this research, but 5 athletes were injured and 5 others took part in national competition.

As a result, only 50 athletes were involved in this research (see Fig.1). When referring to sample (participant) requirements based on G*power analysis (version 3.1.9.4, Kiel University, Germany), with effect size = .25, α err prob = .05, and power (1-β err prob) = .90 (power actual = 0.91%), the result showed that the minimum sample required is 46 athletes, thus the number of 50 athletes involved in this research met the requirement. Participants were allocated into experimental (CTT, *n* = 25, 18.7 ± 1.06 year, 161 ± 3.74 cm, 58.0 ± 3.03 kg, 22.0 ± 1.06 kg/m2), and control (CG, *n* = 25, 18.9 ± 1.04 year, 162 ± 3.50 cm, 59.0 ± 3.49 kg, 22.2 ± 1.04 kg/m2) groups using the Random Group Generator (RGG) application. After participants fully grasp the rules of the study, they are required to sign a consent letter regarding their involvement in the study. This study was approved by the local Ethics Committee of Makasar State University, Indonesia (approval date: UNM-503/LPPM/01/01/2024). All procedures were in accordance with the the latest amendement of the Declaration of Helsinki (Human Studies). Information regarding age, height, weight, and body mass index is presented in Table 1.

Figure 1
CONSORT flow

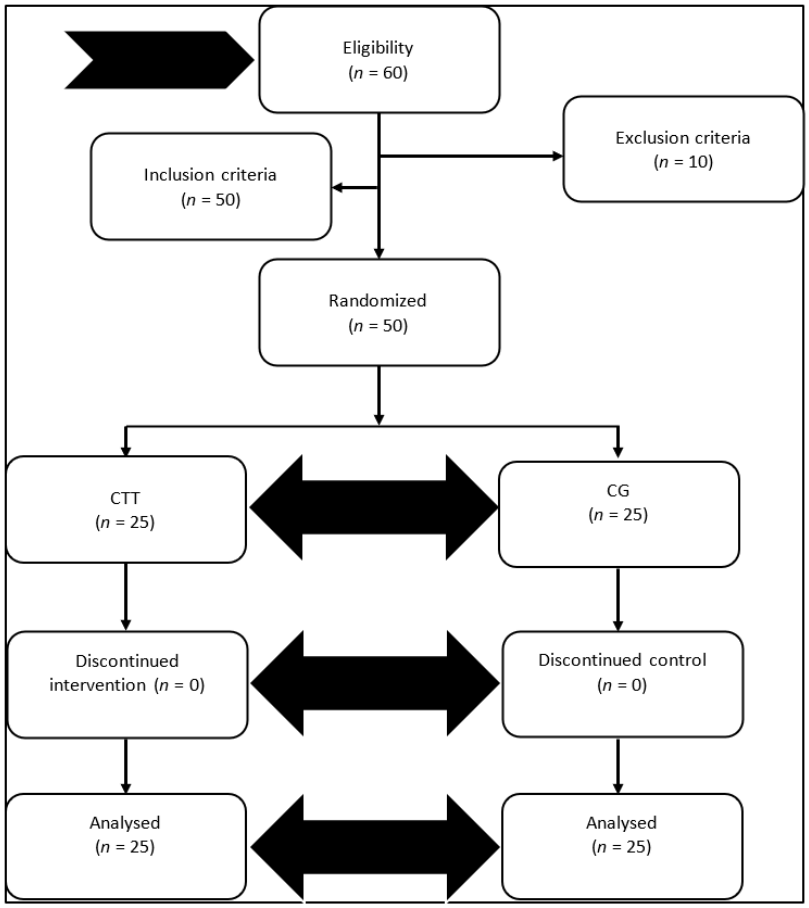


Table 1
Participant Characteristics (mean ± SD)

Group	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m²)
CTT (*n* = 25)	18.7 ± 1.06	161 ± 3.74	58.0 ± 3.03	22.0 ± 1.06
p	.232	.158	.189	.131
CG (*n* = 25)	18.9 ± 1.04	162 ± 3.50	59.0 ± 3.49	22.2 ± 1.04
p	.311	.243	.269	.144

Note: CTT = Circuit tabata training, CG = Control group, *SD* = Standard deviation, BMI = Body mass index.

Instruments

Physical Fitness

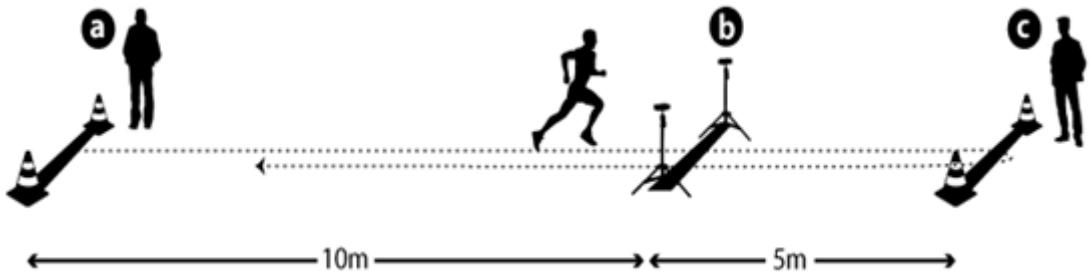
The instrument for measuring the level of physical fitness among athletes consists of several tests:

Strength: Handgrip Dynamometer Test (HDT). The HDT device (Takei Kiki Kogyo, Tokyo, Japan) was used to measure hand grip strength (kg) (Sánchez-Muñoz et al., 2020). Participants stood upright holding the handgrip dynamometer in their right or left hand. On the "Go" signal, participants grip the dynamometer handgrip as tightly as possible. Each participant got three opportunities to carry out this test. The highest score was recorded for statistical analysis.

Speed: 5m Sprint Test (5mST). This instrument was adopted from a previous study to measure running speed levels (James et al., 2022). Participants stood on the start line. On the "Go" signal, participants must run maximally towards the finish line. The distance from the start line to the finish line is 5 m. Each participant got three opportunities and the assessment was carried out by calculating the fastest time (seconds) from these three opportunities.

Agility: 5-0-5 COD Test (505CODT). The 505CODT instrument has been recognized as a valid test for measuring the agility abilities of athletes in several sports that require short-distance acceleration (Guo et al., 2021). Participants stood on the star line. On the "Go" signal, participants ran to cone A then to cone B. From cone B, participants quickly ran to cone C, then turned around and ran back to cone A (see Fig. 2). Participants were given three opportunities. The assessment was carried out by calculating the fastest time (seconds) from these three opportunities.

Figure 2
5-0-5 COD test



Power: Medicine Ball Throw Test (MBTT). MBTT is an accurate instrument for measuring arm power levels (Nuhmani, 2022). Participants stand on a mat holding a medicine ball weighing 6 kg at their chest. On the "Go" signal, participants bend their knees and then threw the medicine ball horizontally using both hands (chest pass) (Belli et al., 2022). Participants were given three opportunities to throw. The farthest throwing was used for the final score (cm) in the analysis result.

Flexibility: Sit and Reach Test (SRT). SRT is an instrument that can be used to measure flexibility of the trunk and hip joints (cm) (Sánchez-Muñoz et al., 2020). Participants removed their shoes and sat on the floor with their legs straight against the box of a sit-and-reach table (Novel Products, Inc., Rockton, Illinois, USA). With their hands on the table, after the "Go" instruction, participants stretched their hands forward as far as possible while pushing the ruler along the measurement scale on the box. Participants were given 3 opportunities. The assessment was carried out by recording the furthest distance.

Endurance: Yo-Yo Intermittent Recovery Test Level 1 (YYIRTL1). YYIRTL1 was used to evaluate the endurance capacity of athletes in meters. This test was conducted as follows: After the audio sounded "beep", participants ran from cone A towards cone B with a distance of 20 m (must be reached before the next beep signal), after reaching cone B, the participants had a recovery period of 10 seconds and run again from cone B to cone A. This activity was carried out continuously until the participant could not run or could not follow the "beep" sound. The running distance (YYIRL1) was recorded for statistical analysis (Villaseca-Vicuña et al., 2021).

Passion

In this study, the Spanish version of the passion measurement tool (Chamarro et al., 2015) was used and translated into the English language, following the International Test Commission's guidelines for cross-cultural-test adaptation of the Hambleton (1993) method to improve its comprehension by the participants. The translated scale evolved from a set of focus-group meetings with university professors. Four male and female academic educators/researchers formed the focus group. The focus group held a discussion and administered a pre-test to a group of students (n = 20) to gauge their understanding of the items in order to identify potential issues relating to issues with the cultural context. This questionnaire has six question items from the harmonious passion (HP) dimension and 6 question items from the obsessive passion (OP) dimension which were adapted to the squash sport. For example, question for HP = "This squash is carried out aligns with my other activities". Meanwhile OP = "I can't live without squash". The 12 question items were scored using a Likert scale from 1 = strongly disagree to 7 = very strongly agree (Vankakova et al., 2021). A high score reflects a great level of passion in squash athletes.

Procedures

This research was carried out between January-March 2024. We adopted a experiment method with a random control trial (RCT) design for 12 weeks. At the first meeting, participants in CTT and CG carried out a physical fitness pre-test (HDT, 5mST, 505CODT, MBTT, SRT, YYIRTL1), and filled out a passion questionnaire (HP, OP). This pre-test activity was directly supervised by five research team members, who were expert in sports training. The second meeting, CTT and CG groups implemented an intervention program for 12 weeks with three meetings a week, namely: Monday, Wednesday, and Saturday. At the last meeting, CTT and CG carried out a physical fitness post-test (HDT, 5mST, 505CODT, MBTT, SRT, YYIRTL1), and filled out a passion questionnaire (HP, OP).

CTT and CG program

Before the CTT and CG intervention program begins, all participants should warm-up for 5 minutes. The duration of CTT was 5 minutes with details of one station work: 20 seconds and rest: 10 seconds, while CG has a training duration of 15 minutes and 1 minute rest for each type of exercise. After the CTT and CG activities were completed, all participants were instructed to cool down for 5 minutes. The CTT and CG programs are presented in Table 2.

Statistic Analysis

Data normality testing was checked using Shapiro-Wilk analysis and homogeneity with Levene's test. Descriptive data was presented as mean ± *SD*. The delta percentage (%Δ) was calculated as follows: %Δ = (posttest–pretest/pretest) × 100. In addition, differences in physical fitness (HDT, 5mST, 505CODT, MBTT, SRT, YYIRTL1), and passion (HP, OP) intervention effects (time [pre-test vs post-test] × group [CTT vs. CG] and interaction [time vs group]) were analyzed with repeated-measures two-way analysis of variance (Menz et al., 2021). Paired student's t tests were chosen to investigate changes in physical fitness and passion variables from the pre-test to post-test. Cohen's (d) was chosen to investigate the effect size (*ES*) selected with the criteria: < 0.2 (trivial), 0.2 – 0.6 (small), 0.6 – 1.2 (moderate), 1.2 – 2.0 (large), and > 2.0 (very large) (Stojanović et al., 2023). Meanwhile, η2p with the criteria: .01 (small), .06 (medium), and .14 (large). All data were analyzed using the Jamovi statistical tool (version 2.3.28). The determined p-value was .05. The reliability of all dependent variables was assessed by calculating intra-class correlation coefficients (ICC).

Table 2
CTT and CG program for 12 weeks

Weeks	CTT Day: Monday, Wednesday, and Friday Circuit Station	Tabata Work:Rest	Music	CG Day: Monday, Wednesday, and Friday	Duration
1-2	Station 1: Jumping Jacks Station 2: Plank Station 3: Push-up Station 4: Dumbbell lateral raise	20 s :10 s perstation	Shape of You (Tabata)	Exercise 1: Sprinting Drills Exercise 2: Push-up Exercise 3: Sit-up Exercise 4: Fartleks	15 minutes
3-4	Station 1: Down-dog toe touch Station 2: Plank Station 3: Shuttle run 10m Station 4: Plank jacks Station 5: Dumbbell lateral raise	20 s :10 s perstation	Poker Face (Tabata)	Exercise 1: Sprinting Drills Exercise 2: Push-up Exercise 3: Sit-up Exercise 4: Fartleks	15 minutes
5-6	Station 1: Side plank Station 2: Plank to push Station 3: Throwing tires Station 4: Mt. climbers Station 5: Dumbbell lateral raise Station 6: Shuttle run 10m	20 s :10 s perstation	Just Dance (Tabata)	Exercise 1: Sprinting Drills Exercise 2: Push-up Exercise 3: Sit-up Exercise 4: Fartleks	15 minutes
7-8	Station 1: Russian twist Station 2: Side plank Station 3: Throwing tires Station 4: Dumbbell lateral raise Station 5: Shuttle run 10m Station 6: Push-ups Station 7: Down-dog toe touch	20 s :10 s perstation	Mi Gente (Tabata)	Exercise 1: Sprinting Drills Exercise 2: Push-up Exercise 3: Sit-up Exercise 4: Fartleks	15 minutes
9-10	Station 1: Side plank Station 2: Plank to push Station 3: Dumbbell lateral raise Station 4: Plank jacks Station 5: Throwing tires	20 s :10 s perstation	Loco Contigo (Tabata)	Exercise 1: Sprinting Drills Exercise 2: Push-up Exercise 3: Sit-up Exercise 4: Fartleks	15 minutes
11-12	Station 1: Russian twist Station 2: Plank Station 3: Down-dog toe touch Station 4: Dumbbell lateral raise Station 5: Throwing tires Station 6: Push-ups Station 7: Shuttle run 10m Station 8: Side plank	20 s :10 s perstation	Despacito (Tabata)	Exercise 1: Sprinting Drills Exercise 2: Push-up Exercise 3: Sit-up Exercise 4: Fartleks	15 minutes

Results

In table 3 presents the reliability and variability on physical fitness and passion variables are in the range of .80 - .94. In addition, the Shapiro-Wilk and Levene's test on all variables in this study had a normal distribution (see Table 4).

Table 3
Reliability and variability of physical fitness and passion

Measures	ICC	95% CI
Physical fitness		
HDT (kg)	.91	.96 to .99
5mST (s)	.80	.70 to .93
505CODT (s)	.94	.83 to .92
MBTT (cm)	.86	.79 to .97
SRT (cm)	.90	.85 to .94
YYIRTL1 (m)	.87	.88 to .97
Passion		
HP (score)	.92	.75 to .97
OP (score)	.88	.84 to .86

Note: HDT = handgrip dynamometer test, 5mST =5m sprint test, 505CODT =5-0-5 COD test, MBTT = medicine ball throw test, SRT = sit and reach test, YYIRTL1= yo-yo intermittent recovery test level 1, HP = harmonious passion, OP = obsessive passion, ICC = intraclass correlation coefficient; CI = confidence intervals, SW = Shapiro-Wilk, LT = Levene's test.

Table 4
Shapiro-Wilk and Levene's test of physical fitness and passion

		SW	LT
		p	p
Physical fitness			
HDT (kg)	Pre	.162	.407
	Post	.200	.380
5mST (s)	Pre	.387	.230
	Post	.120	.345
505CODT (s)	Pre	.066	.149
	Post	.176	.281
MBTT (cm)	Pre	.148	.313
	Post	.422	.360
SRT (cm)	Pre	.491	.252
	Post	.344	.169
YYIRTL1 (m)	Pre	.357	.312
	Post	.450	.289
Passion			
HP (score)	Pre	.330	.124
	Post	.316	.344
OP (score)	Pre	.095	.381
	Post	.135	.430

Note: HDT = handgrip dynamometer test, 5mST =5m sprint test, 505CODT =5-0-5 COD test, MBTT = medicine ball throw test, SRT = sit and reach test, YYIRTL1= yo-yo intermittent recovery test level 1, HP = harmonious passion, OP = obsessive passion, SW = Shapiro-Wilk, LT = Levene's test.

Changes in Physical Fitness in CTT and CG

Based on the results of the repeated-measures two-way analysis of variance in table 5, it shows that there is a main effect of time (T) on the physical fitness variable with the HDT component ($F_{1\text{-}48}$ = 162.8, p < .001, η2p = .772), 5mST ($F_{1\text{-}48}$ = 100.0, p < .001, η2p = .676), 505CODT ($F_{1\text{-}48}$ = 26.0, p < .001, η2p = .351), MBTT ($F_{1\text{-}48}$ = 57.8, p < .001, η2p = .546), SRT ($F_{1\text{-}48}$ = 8.35, p = .006, η2p = .148), and YYIRTL1 ($F_{1\text{-}48}$ = 248, p < .001, η2p = .838). We also observed that there was a significant group (G) effect on HDT ($F_{1\text{-}48}$ = 13.6, p < .001, η2p = .221), 5mST ($F_{1\text{-}48}$ = 4.13, p = .048, η2p = .079), 505CODT ($F_{1\text{-}48}$ = 6.03, p = .018, η2p = .112), MBTT ($F_{1\text{-}48}$ = 8.85, p = .005, η2p = .156), SRT ($F_{1\text{-}48}$ = 9.13, p = .004, η2p = .160), and YYIRTL1 ($F_{1\text{-}48}$ = 11.8, p = .001, η2p = .197). In addition, we found that there was an interaction (I) between time (T) x group (G) on the HDT component ($F_{1\text{-}48}$ = 49.5, p < .001, η2p = .508), 5mST ($F_{1\text{-}48}$ = 84.0 p < .001, η2p = .636), 505CODT ($F_{1\text{-}48}$ = 21.9, p < .001, η2p = .313), MBTT ($F_{1\text{-}48}$ = 34.3, p < .001, η2p = .416), YYIRTL1 ($F_{1\text{-}48}$ = 217, p < .001, η2p = .819), but there was no significant interaction for SRT ($F_{1\text{-}48}$ = 0.164, p = .687, η2p = .003).

Based on the results of Paired student's t tests (see Fig. 3) and delta percentage (%Δ), we observed changes in physical fitness (HDT [%Δ = + 33.6, ES = -2.21], 5mST [%Δ = - 16.7, ES = 1.92], 505CODT [%Δ= - 13.1, ES = 0.97], MBTT [%Δ = + 13.8, ES = - 1.35], SRT [%Δ = +1.4, ES = - 0.88], and YYIRTL1 [%Δ = + 27.7, ES = - 3.06]) which was greater in CTT than CG (HDT [%Δ = + 9.4, ES = - 1.28], 5mST [%Δ = - 0.9, ES = 1.28], 505CODT [%Δ = - 0.4, ES = 1.56], MBTT [%Δ= + 2.0, ES = - 1.26], SRT [%Δ = - 0.0, ES = - 0.01], and YYIRTL1 [%Δ = + 0.9, ES = - 1.14]) , as presented in table 5.

Changes in Passion in CTT and CG

Based on the results of the repeated-measures two-way analysis of variance in table 6, it shows that there is a main effect of time (T) on the passion variable with components HP ($F_{1\text{-}48}$ = 676.00, p < .001, η2p = .827), and OP ($F_{1\text{-}48}$ = 248.5, p < .001, η2p = .838). We also observed that there was a significant group (G) effect on HP ($F_{1\text{-}48}$ = 7.29, p = .010, η2p = .132), and OP ($F_{1\text{-}48}$ = 5.36, p = .025, η2p = .100). In addition, we found that there was an interaction (I) between time (T) x group (G) on the HP ($F_{1\text{-}48}$ = 9.21, p = .004, η2p = .161), and OP ($F_{1\text{-}48}$ = 12.8, p < .001, η2p = .210).

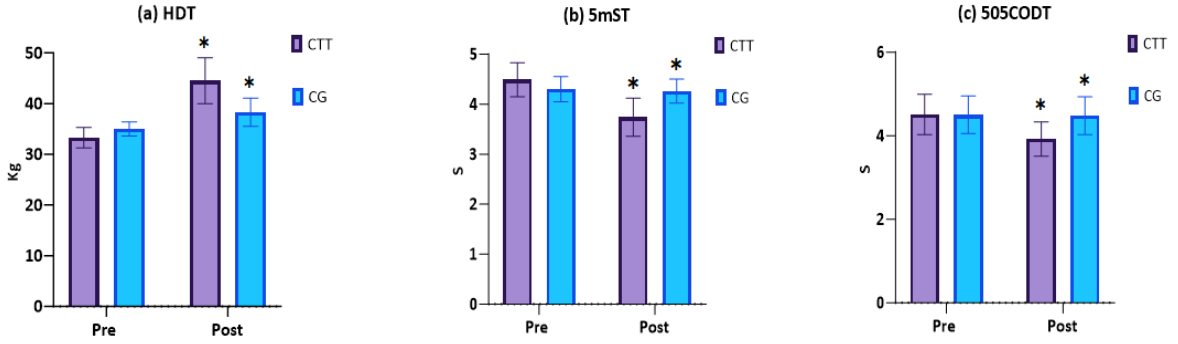
Based on the results of Paired student's t tests (see Fig. 4) and delta percentage (%Δ), we observed changes in passion (HP [%Δ = + 29.0, ES = - 2.24], and OP [%Δ = + 28.4, ES = - 2.69]), which is greater in CTT than CG (HP [%Δ = + 20.4, ES = - 2.09], and OP [%Δ = + 18.1, ES = - 1.76]), as presented in table 6.

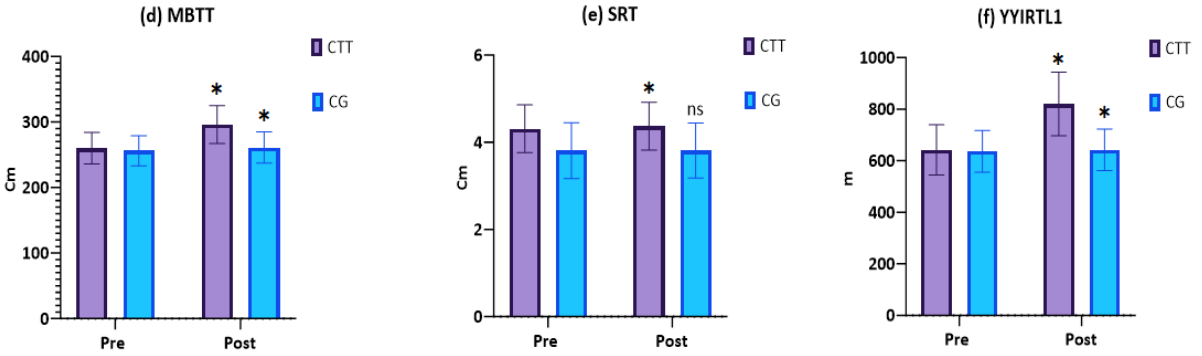
Table 5
Changes in physical fitness between CTT and CG

Outcome measures	CTT (*n* = 25)		%Δ	*ES*	CG (*n* = 25)		%Δ	*ES*	Time (T). Group (G), Interaction (I)
	Pre Mean ± *SD*	Post Mean ± *SD*			Pre Mean ± *SD*	Post Mean ± *SD*			
Physical Fitness									
HDT (kg)	33.3 ± 2.01	44.5 ± 4.52	+33.6	-2.21	35.0 ± 1.40	38.3 ± 2.78	+9.4	-1.28	*T:[F_{1-48} = 162.8, p < .001, η2p = .772] *G:[F_{1-48} = 13.6, p < .001, η2p = .221] *I:[F_{1-48} = 49.5, p < .001, η2p = .508]
5mST (s)	4.49 ± 0.34	3.74 ± 0.38	-16.7	1.92	4.30 ± 0.25	4.26 ± 0.24	-0.9	1.28	*T:[F_{1-48} = 100.0, p < .001, η2p = .676] *G:[F_{1-48} = 4.13, p = .048, η2p = .079] *I:[F_{1-48} = 84.0 p < .001, η2p = .636]
505CODT (s)	4.51 ± 0.48	3.92 ± 0.41	-13.1	0.97	4.50 ± 0.45	4.48 ± 0.45	-0.4	1.56	*T:[F_{1-48} = 26.0, p < .001, η2p = .351] *G:[F_{1-48} = 6.03, p = .018, η2p = .112] *I:[F_{1-48} = 21.9, p < .001, η2p = .313]
MBTT (cm)	260 ± 24.2	296 ± 28.8	+13.8	-1.35	256 ± 22.9	261 ± 23.9	+2.0	-1.26	*T:[F_{1-48} = 57.8, p < .001, η2p = .546] *G:[F_{1-48} = 8.85, p = .005, η2p = .156] *I:[F_{1-48} = 34.3, p < .001, η2p = .416]
SRT (cm)	4.31 ± 0.55	4.37 ± 0.55	+1.4	-0.88	3.81 ± 0.64	3.81 ± 0.63	-0.0	-0.01	*T [F_{1-48} = 8.35, p = .006, η2p = .148] *G:[F_{1-48} = 9.13, p = .004, η2p = .160] I:[F_{1-48} = 0.164, p = .687, η2p = .003]
YYIRTL1 (m)	642 ± 97.4	820 ± 123.1	+27.7	-3.06	636 ± 81.1	642 ± 80.8	+0.9	-1.14	*T:[F_{1-48} = 248, p < .001, η2p = .838] *G:[F_{1-48} = 11.8, p = .001, η2p = .197] *I:[F_{1-48} = 217, p < .001, η2p = .819]

Note: CTT = circuit tabata training, CG = control group, HDT = handgrip dynamometer test, 5mST =5m sprint test, 505CODT =5-0-5 COD test, MBTT = medicine ball throw test, SRT = sit and reach test, YYIRTL1= yo-yo intermittent recovery test level 1, %Δ = change, ES = effect size, η2p = partial eta-square; *****significant values obtained by the two-way ANOVA (p < 0.05).

Figure 3
Changes mean and SD in (a) HDT, (b) 5mST, (c) M505CODT, (d) MBTT, (e) SRT (f) YYIRTL1





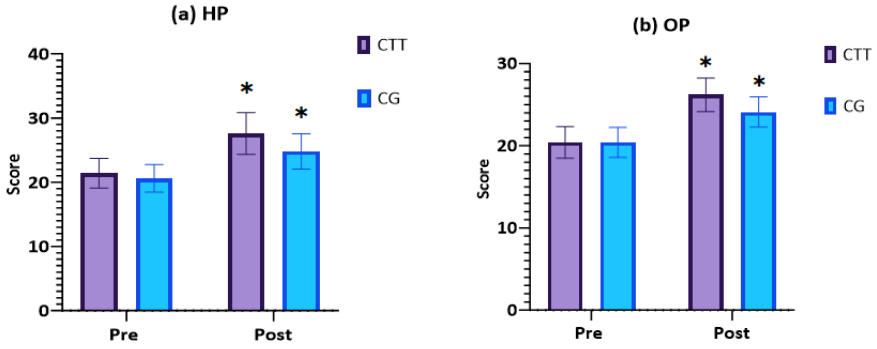
Note: ns = no significance, *significantly different from pre-post at $p < 0.05$.

Table 6
Changes in passion between CTT and CG

Outcome measures	CTT (n = 25)		%Δ	*ES*	CG (n = 25)		%Δ	*ES*	Time (T). Group (G), Interaction (I)
	Pre Mean ± *SD*	Post Mean ± *SD*			Pre Mean ± *SD*	Post Mean ± *SD*			
Passion									
HP (score)	21.4 ± 2.29	27.6 ± 3.25	+29.0	-2.24	20.6 ± 2.16	24.8 ± 2.76	+20.4	-2.09	*T:[$F_{1\text{-}48}$ = 676.00, p < .001, η2p = .827] *G: [$F_{1\text{-}48}$ = 7.29, p = .010, η2p = .132] *I: [$F_{1\text{-}48}$ = 9.21, p = .004, η2p = .161]
OP (score)	20.4 ± 1.93	26.2 ± 2.04	+28.4	-2.69	20.4 ± 1.83	24.1 ± 1.85	+18.1	-1.76	*T:[$F_{1\text{-}48}$ = 248.5, p < .001, η2p = .838] *G:[$F_{1\text{-}48}$ = 5.36, p = .025, η2p = .100] *I:[$F_{1\text{-}48}$ = 12.8, p < .001, η2p = .210]

Note: CTT = circuit tabata training, CG = control group, HP = harmonious passion, OP = obsessive passion, %Δ = change, ES = effect size, η2p = partial eta-square; *significant values obtained by the two-way ANOVA ($p < 0.05$).

Figure 4
Changes mean and SD in (a) HP, (b) OP



Note: *significantly different from pre-post at $p < 0.05$.

Discussion

This present study investigated the effects of CTT on improving the physical fitness and passion of young squash athletes through a 12-week experiment study.

This study has identified several findings. First, CTT is more effective than CG for inducing positive changes in physical fitness related to HDT, 5mST, 505CODT, MBTT, SRT, and YYIRTL1 components in young squash athletes. These results

highlight that the use of a CTT program designed by combining circuits with the tabata protocol has several advantages over CG in cultivating aspects of physical fitness. These results are consistent with previous study which reported that circuit training in combination with the tabata protocol was an ideal exercise to encourage positive changes in physical fitness among students aged 20-23 years at university level (Lee et al., 2021). Another study described similar results, athletes with low physical fitness experienced gradual improvement after following the CTT program for 8 weeks (Gutiérrez-Arroyo et al., 2023). On the other hand, Ho et al. (2024), reported that CTT consistently improved muscle performance in a short time. Similar findings have also been reported by Yunus et al. (2024), in their latest study, which used a true experimental design and 20 teenagers to administer the CTT intervention program, the findings showed that CTT could be an effective alternative training in improving the quality of low physical fitness to a higher level. In addition, other findings have acknowledged that carried out CTT repeatedly with stationary training tasks and high intensity (20:10) was an important tool in developing physical fitness to a higher level (Megahed et al., 2023). Likewise, Ajjimaporn et al. (2019), proved that a high-intensity circuit-based program for 4-weeks was sufficient to improve physical fitness components related to cardiorespiratory endurance. Marinho et al. (2022), supported the results of this study, CTT provided a significant increase in physical performance in men. Finally, in line with our results, Ballesta-García et al. (2019), showed that 12-weeks of CTT training generated a high impact on increasing strength, cardiorespiratory fitness, and gait/dynamic balance compared to CG. Furthermore, to our modeste knowledge, this is the initial study to find out whether CTT is more effective in encouraging positive changes in passion related to HP and OP in athletes than CG. These findings are in line with previous studies which reported that CTT used to increase exercise motivation levels (Wilke et al., 2018). In this research, CTT was proven to be able to influence the level of passion in athletes, this is because CTT has a program with various types of movement tasks which is accompanied with energetic music, so this is the main factor that causes athletes' passion to experience positive changes. Meanwhile, Putri et al. (2020), reported that another benefit provided by the CTT program is an improvement in attention function aspect.

The strength of our research is the positive effect of CTT on increasing physical fitness and passion in young squash athletes. The implications of this research related to the importance of CTT as an effective training method to encourage positive and major changes in physical fitness and passion. Apart from that, the feasibility of CTT causes it simple to implement, and without need to pay expensive costs. Although this research shows that 12 weeks of CTT produced improvements in physical fitness (HDT, 5mST, 505CODT, MBTT, SRT, YYIRTL1) and passion (HP, OP), it still has limitations. First, this study only involved male participants at one university in Indonesia. Therefore, we suggest the future research to involve male and female participants from several universities in Indonesia or other countries, to measure changes more accurately using this CTT for both genders. Moreover, it would be more interesting if future research could compare the effectiveness of CTT against other types of exercise.

Conclusions

We confirm and highlight that CTT can be the main factor causing positive changes in physical fitness (HDT, 5mST, 505CODT, MBTT, SRT, YYIRTL1), and passion (HP, OP) among young squash athletes. Although there are several limitations in this research, the positive results of our research prove that CTT can be used as an appropriate strategy, to provide more empirical evidence about the importance of continuing to investigate the effects of this training program. Moreover, it is expected that CTT can be implemented intensely by athletes and coaches around the world. This research contributes to the development of innovative training methods in squash, so that coaches can apply CTT to athletes continuously and ultimately achieve a high level of physical fitness and passion.

Ethics Committee Statement

This study was approved by the local Ethics Committee of Makasar State University, Indonesia (approval date: UNM-503/LPPM/01/01/2024). All procedures were in accordance with the latest amendment of the Declaration of Helsinki (Human Studies).

Conflict of Interest Statement

All authors confirm there is no conflict of interest.

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Authors' Contribution

Conceptualization I.I., E.S., A.T; Methodology E.S., Z.K., A.K; Software H.H., E.S; Validation E.S., I.I., B.B; Formal Analysis E.S., B.B; Investigation I.I., H.H., E.S; Resources I.I., H.H., S.S; Data Curation E.S; Writing – Original Draft I.I., E.S., Z.K; Writing – Review & Editing E.S., A.T., A.K., Z.K; Visualization I.I., B.B; Supervision E.S; Project Administration I.I., H.H., S.S; Funding Acquisition I.I., H.H., S.S. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

Data supporting the findings of this study are available on request from the corresponding author (info@unm.ac.id); Data supporting the findings of this study are available at (Makassar State University repository).

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Assessing the Aerodynamics of an Able-Bodied Cyclist and Shoulder-Amputee Cyclist by Computer Fluid Dynamics

Evaluando la Aerodinámica de un Ciclista sin Discapacidad y un Ciclista con Amputación de Hombro Mediante Dinámica de Fluidos

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Abstract

This study aimed to analyse the aerodynamics by numerical simulations with computer fluid dynamics of an able-bodied cyclist and a shoulder-amputee cyclist. An elite cyclist volunteered for this research; the cyclist was scanned with his competition gear and bicycle and the able-bodied and shoulder amputee 3D cyclists models were created. Numerical simulations were conducted between 1 m/s and 13 m/s (with increments of 1 m/s) with the fluent code. The effective surface area (ACd) varied between 0.38 and 0.59 m^2 for the able-bodied cyclist; whereas, for the shoulder-amputee, it varied between 0.29 m^2 and 0.62 m^2. The ACd

Resumen

Este estudio tuvo como objetivo analizar la aerodinámica mediante simulaciones numéricas con dinámica de fluidos computacional de un ciclista sin discapacidad y un ciclista con amputación de hombro. Un ciclista de élite se ofreció como voluntario para esta investigación; el ciclista fue escaneado con su equipo de competición y bicicleta, y se crearon modelos tridimensionales de ciclistas con y sin discapacidad de hombro. Se realizaron simulaciones numéricas entre 1 m/s y 13 m/s (con incrementos de 1 m/s) con el código Fluent. El área efectiva de superficie (ACd) varió entre 0.38 y 0.59 m^2 para el ciclista sin discapacidad, mientras

difference between the able-bodied and the amputee ranged from 3% to 28% and the drag differed between 2% and 19%. The drag coefficient ranged between 0.55 and 0.84 for the able-bodied and from 0.45 and 0.92 for the shoulder-amputee. The drag ranged across the different velocities (1-13 m/s) from 0.36 N – 39.25 N for the able-bodied cyclist and for the shoulder-amputee between 0.38 N – 31.69 N. The two cyclist models presented significant differences and small effect sizes ($t = 2.720$; $p = 0.019$; $d = 0.18$). The linear regression models computed the drag differences between the able-bodied and the disabled cyclist; a significant relationship and very high effect sizes for drag ($R^2 = 0.997$; $R^2a = 0.995$; $SEE = 0.996$; $p < 0.001$) were observed. This study allowed us to conclude that the shoulder-amputee cyclist presents a lower drag compared to the able-bodied one.

***Keywords*:** Cycling, CFD, able-bodied, drag, paralympic.

que para el ciclista con amputación de hombro varió entre 0.29 m^2 y 0.62 m^2. La diferencia de ACd entre el ciclista sin discapacidad y el amputado de hombro osciló entre el 3% y el 28%, y la resistencia varió entre el 2% y el 19%. El coeficiente de resistencia varió entre 0.55 y 0.84 para el ciclista sin discapacidad y entre 0.45 y 0.92 para el ciclista con amputación de hombro. La resistencia varió en las diferentes velocidades (1-13 m/s) desde 0.36 N hasta 39.25 N para el ciclista sin discapacidad y desde 0.38 N hasta 31.69 N para el ciclista con amputación de hombro. Los dos modelos de ciclistas presentaron diferencias significativas y tamaños de efecto pequeños ($t = 2.720$; $p = 0.019$; $d = 0.18$). Los modelos de regresión lineal calcularon las diferencias de resistencia entre el ciclista sin discapacidad y el ciclista discapacitado; se observó una relación significativa y tamaños de efecto muy altos para la resistencia ($R^2 = 0.997$; $R^2a = 0.995$; $SEE = 0.996$; $p < 0.001$). Este estudio nos permitió concluir que el ciclista con amputación de hombro presenta una resistencia menor en comparación con el ciclista sin discapacidad.

Palabras clave: Ciclismo, CFD, sin discapacidad, resistencia, paralímpico.

Introduction

The literature is scarce in para-cyclists biomechanics analysis (Fletcher et al., 2021; Goodlin et al., 2022; Liljedahl et al., 2021a; Nooijen et al., 2021). Little is known about the differences between cyclists with disabilities and able-bodied (Connick et al., 2018; Keogh, 2011) and the majority of methodologies, training assessment protocols, and Paralympics testing are conceived on evidence-based research with able-bodied subjects (Andrews et al., 2011; Forte et al., 2015). Regrettably, a notable challenge arises in the potential introduction of bias when extending conclusions drawn from able-bodied subjects to cyclists with disabilities (Borg et al., 2022; Cawthorne-Nugent, 2021; Inckle, 2019; Liljedahl et al., 2023; Tasiemski et al., 2018). This discrepancy in biomechanical understanding underscores the imperative need for tailored research to ensure accurate and relevant insights for the para-cyclists staff, athletes, and researchers (Dyer, 2020; Dyer, Glithro, et al., 2022; Dyer, Gumowski, et al., 2022; Lima et al., 2021; Mannion, Toparlar, Clifford, et al., 2019; Mannion et al., 2021; Menaspà et al., 2012).

This Paralympic cycling classification is divided into five classes based on the athlete's condition (WCi, i.e., I = 1, 2, 3, 4, or 5 with limitations and/or amputations in the lower and upper limbs). Amputees who have had bilateral knee amputations and have severe athetosis or ataxia compete in C1, while those who have had unilateral knee amputations and have moderate athetosis or ataxia compete in C2. C3 are the cyclists with lower limbs disfuction or amputation. C4 cyclists have hemiplegic or diplegic spasticity and/or mild athetosis or ataxia, whereas C5 cyclists have unilateral arm amputation and mild monoplegic spasticity (Keogh, 2011; Liljedahl et al., 2021b). Cyclist's aerodynamics is influenced by their body posture (Blocken, van Druenen, Toparlar, & Andrianne, 2018; T. Crouch et al., 2012; Defraeye et al., 2010) and physical impairments such as amputations (Forte, Marinho, Nikolaidis, et al., 2020; Forte, Marinho, Silveira, et al., 2020; Forte, Morais, et al., 2021). Few studies have been conducted assessing the Paralympics cyclists aerodynamics. In handbike it is possible to find comparisons between wind tunnel and experimental procedures (Belloli et al., 2014). Also, in tandem cycling is possible to find a study assessing aerodynamics with wind tunnel testing and numerical simulations by computational fluid dynamics (Mannion, Toparlar, Blocken, Hajdukiewicz, et al., 2018). In Para-cycling there's also a published research article about the stroker effect in aerodynamics, evaluated by computer fluid dynamics (Mannion, Toparlar, Blocken, et al., 2019). Finally, another study assessed by experimental procedures, the using prosthesis in cyclists aerodynamics (Dyer & Disley, 2020). Comparisons with amputee cyclists are possible to find in literature (Forte, Marinho, Nikolaidis, et al., 2020; Forte, Marinho, Silveira, et al., 2020; Forte, Morais, et al., 2021; Forte et al., 2023), especially with trans-radial and trans-tibial amputations. However, no research has been conducted to compare the able-bodied to shoulder amputee cyclists.

The cyclist's performance is given by the Estimated Time of Arrival (ETA: equation 1), and is based on velocity (Forte, Marinho, Barbosa, et al., 2020; Forte, Marinho, et al., 2021):

$$ETA = \frac{d}{v} \quad (1)$$

in which ETA is the estimated time of arrival, d is the distance, v is the velocity; however, to accelerate (equation 2) there must be a positive balance between propulsion (F_{prop}) and resistance (F_{resist}) (Forte, Marinho, Barbosa, et al., 2020; Forte, Marinho, et al., 2021).

$$a = \frac{(F_{prop} - F_{resist})}{m} \quad (2)$$

Some studies have analysed cyclists performance and the drag and rolling resistance as the main contributors of total resistance (equation 3), in which drag (F_d) represents about 90% (in cases where the cyclists typically ride at high speeds and on flat terrain) and rolling resistance (F_{RR}) 10% (Forte, Marinho, Barbosa, et al., 2020; Forte, Marinho, et al., 2021; Malizia & Blocken, 2021). Under these assumptions, the total resistance can be written as the sum of the rolling resistance and aerodynamic drag. The first term, the rolling resistance, is given by the multiplication of the coefficient of rolling resistance, the mass and gravity, and the second term, aerodynamic drag, is given in equation 4.

$$F_{resist} = F_d + F_{RR} \quad (3)$$

$$F_d = 0.5\rho A C_d v^2 \quad (4)$$

in which ρ is the air density, A is the surface area and C_d is the coefficient of drag.

The drag has mostly the higher contribution to the total resistance and for that reason, most of the studies focused on assessing the cyclists aerodynamics considering the flat terrain and high velocities, neglecting bearing friction and crosswinds and other confounding factors for the simulations (Blocken et al., 2023; Mannion, Toparlar, Blocken, Clifford, et al., 2018; van Druenen & Blocken, 2023). The cycling community has focused its research on drag (Blocken, van Druenen, Toparlar, Malizia, et al., 2018; Forte, Morais, Neiva, et al., 2020; Scarano et al., 2019; Terra et al., 2020a). Typically, a higher A represents greater drag (disregarding the drag coefficient), and the bicycle dimensions and cyclist anthropometry are of great importance (Candau et al., 1999; Debraux et al., 2011b). Moreover, the drag coefficient is sensitive to the shape or shape of the object, fluid flow behaviour, and velocity (equation 5) (Forte, Morais, Neiva, et al., 2020; Schlichting, 1979).

$$C_d = \frac{0.5\rho A v^2}{F_d} \quad (5)$$

The cyclists' drag coefficient has been assessed based on Computer Fluid Dynamics (CFD) (Forte, Morais, Neiva, et al., 2020). Most studies assessed aerodynamics by total drag or effective surface area (AC_d), which is the multiplication of A with C_d, given in m^2 (Blocken, van Druenen, Toparlar, & Andrianne, 2018; Forte et al., 2018). The AC_d (equation 6) depends on the area of the bicycle-cyclist system and its drag coefficient.

$$ACd = A.C_d \quad (6)$$

The literature presents few studies assessing amputees aerodynamics, and specially comparing with able-bodied cyclists through CFD (Dyer, 2015; Dyer & Disley, 2018; Forte, Marinho, Silveira, et al., 2020; Forte, Morais, et al., 2021). In a previous study, CFD presented agreement when compared to wind tunnel testing, with differences between 3 and 13% (Defraeye et al., 2010). This methodology allows to reduce confounding factors such as inter-subjects variability and weather conditions (Forte, Marinho, Nikolaidis, et al., 2020; Forte, Morais, et al., 2021). Regarding the above information, cyclists' performance depends on aerodynamics, therefore understanding drag variations has been considered an important topic in cycling research (Blocken et al., 2013; Defraeye et al., 2010; Forte, Marinho, Nikolaidis, et al., 2020). However, there is no study comparing the aerodynamics of an able-bodied cyclist with a shoulder-amputee cyclist. Hence, this study aimed to compare the aerodynamics of an able-bodied cyclist model with a shoulder-amputee cyclist model by CFD. It was hypothesised that the shoulder-amputee cyclist may present lower drag compared to the non-disable cyclist.

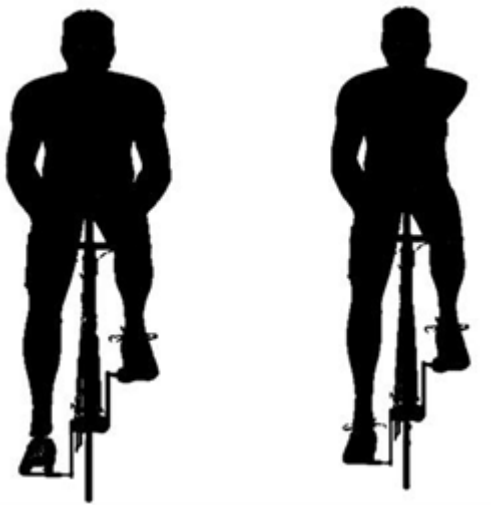
Methods

Subject, Model Scanning and 3d Models

An elite male cyclist aged 32 years old, with 65.0 kg of body mass, 1.72 m of height, and 12 years of experience in elite competitions was recruited for the research. The participant wore his competition gear (jersey: 100% polyester; shorts: polyamide, polypropylene, and elastane fibres) and time-trial helmet (LAS, Cronometro), and rode a road bicycle (KTM, Revelator Master 2017). All the procedures were in accordance with the Declaration of Helsinki, and informed written consent was obtained beforehand.

The bicycle and the non-disable cyclist geometry was collected using a Sense 3D scanner (3D Systems, Inc., Canada) and commercially available software (Sense, 3D Systems, Inc., Canada). The cyclist was in the upright position on the bicycle (Blocken, van Druenen, Toparlar, & Andrianne, 2018) . The scans were performed with the participant in a static position. The geometry was edited and converted to CAD models on Geomagic Studio (3D Systems, United States) CAD models (Forte et al., 2018). Two CAD models were created based on the single scanned participant (Figure 1): able-bodied (Figure 1 on the left: scanned geometry); and shoulder-amputee (Figure 1 on the right: edited geometry).

Figure 1
Able-bodied (left picture) and shoulder-disarticulation (right picture) three-dimensional models



Boundary Conditions and Numerical Simulations

The 3D boundaries around the bicycle-cyclist system were defined at 7 m in length, 2.5 m in width, and 2.5 m in height on Ansys Workbench software (Ansys Fluent 16.0, Ansys Inc., Canonsburg, PA, United States) as reported elsewhere (Forte, Morais, et al., 2021). A grid with more than 42 million elements (for the two geometry domains) was created around the geometry, placed 2.5 m away from the fluid flow inlet portion (Blocken et al., 2013). The automatic mesh options to generate the mesh were made as selected options to create the mesh and the mesh quality (Marinho et al., 2021). The functionality of 'proximity and curvature', 'proximity', and 'curvature' options underwent testing, revealing that the "proximity and curvature" option delivered the highest quality. Additionally, mesh generation incorporated high levels of 'smoothing' with the program-controlled 'inflation' setting. The mesh quality was controlled based on skewness, orthogonal quality, the number of elements, and Y+ wall turbulence values (Peters, 2009). The polyhedral mesh, tetrahedron assembly mesh, and CutCell assembly mesh with a fine relevance center were tested in this study. The CutCell method was used to generate the mesh. A previous study also had the best mesh with the CutCell method (Marinho et al., 2021). The smaller cell size (finer mesh) was close to 15.74 μm for the height of the first cell around the geometry. Similar cell sizes were founded in the literature (Forte et al., 2023); the final mesh of the present study showed the smallest Y+ value of 11.58 at 6 m/s simulation. Some cases recommend to get Y+ values below 3 (Tominaga et al., 2008), but it is acceptable to find analysis with values below 5 (Blocken et al., 2019). It is important to note that in the majority of cyclists analysis, the authors seek for values below 5 (Spalart, 2000). However, values below 12 are also founded in literature (Malizia et al., 2019; Suvanjumrat, 2017) and in some cases are expected due the fluid turbulence and turbulence model (Ariff et al., 2009). In the present study, the Y+ values were above 11, that can be explained by the used scalable wall functions. The number of prism layers was defined as 20 and the final Y+ values on the cyclist was 4.8. The steady simulations with the different meshes were run at 11.11 m/s, a velocity that elite cyclists typically reach during a race as presented in other studies (Forte, Marinho, Barbosa, et al., 2020). Finally, for the different meshes the residuals of the flow velocity components in the x-, y- and z-directions were monitored; when not stable after 1500 interactions, the simulation was concluded and the mesh refined; When the simulations concluded due "reverse flow" convergence, the mesh was refined. These procedures were repeated until reaching the mesh of the current study. When residual and drag values remained close to constant, showing only small fluctuations, the simulation was considered convergent (around 1500 iterations needed). In the inlet portion of the domain, the velocities were set between 1 and 13 m/s with increments of 1 m/s and in the opposite direction (−z direction) of the geometry. For the numerical simulations, the turbulence intensity was assumed as 1×10^{-6}%. The bicycle-cyclist system was assumed to have a non-slip wall with zero roughness and scalable wall functions were assigned. All CFD simulations were run with 3D double-precision settings. For the near-wall treatment, non-equilibrium wall functions were selected (Forte et al., 2018). These give improved predictions for fluid flows in the case of strong separation and large adverse pressure gradients compared to the standard wall-functions (Marinho et al., 2021). For the turbulence modelling, the viscous realizable k-epsilon model was selected. The k-epsilon turbulence model is a two-equation model with good predictions for turbulent flows. The model has been successfully and extensively used for industrial applications (Raiesi et al., 2011), cycling simulations (Forte et al., 2023; Forte, Marinho, Silveira, et al., 2020) and showed good accuracy in cycling tests compared to literature (Blocken et al., 2013, 2016; Blocken, van Druenen, Toparlar, Malizia, et al., 2018; Blocken & Toparlar, 2015; T. N. Crouch et al., 2017; Defraeye et al., 2011, 2014).

At the velocity inlet and pressure outlet, the turbulence intensity and length scale were set to 5% and 0.1 m. The incompressible fluid in the CFD domain was given the characteristics of air (density of 1.225 kg/m^3 and dynamic viscosity of 1.81×10^{-5} kg/m·s^{-1}). Turbulent kinetic energy and turbulent dissipation rate were set to second-order upwind and the residual convergence criteria of the flow parameters were set to 10x10^{-6} for the most accurate results (Blocken, van Druenen, Toparlar, Malizia, et al., 2018; Forte, Morais, et al., 2021; Marinho et al., 2021).

Outcomes

CFD allows the assessment of total drag, coefficient of drag, and surface area (Ansys Fluent 15.0.7, Ansys Inc., Pennsylvania, USA). Through this, it is possible to retrieve equation 6 of the effective surface area:

In the current study, the able-bodied model presented an A of 0.69 m^2 and the shoulder-amputee an A of 0.66 m^2. The numerical simulations allowed to ouput C_d. The product between A and Cd resulted in effective surface area (AC_d).

Statistical Analysis

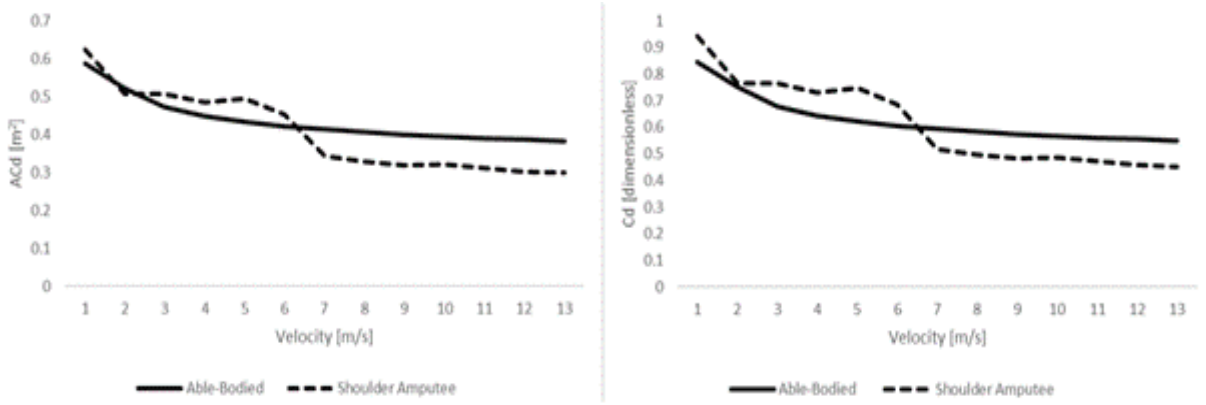
Descriptive statistics, Kolmogorov–Smirnov and Levene's tests were selected to assess normality and homogeneity. The drag value distributions for the 13 velocities for each model were tested by the Kolmogorov–Smirnov test. The paired sample t-test was used to compare the two models (able-bodied vs. shoulder-amputee) as in similar studies (Forte, Marinho, Silveira, et al., 2020). Cohen's d effect size was interpreted as null effect if $d < 0.2$, moderate if $0.2 \leq d < 0.5$, strong if $0.5 \leq d < 0.8$, and large effect if $d \geq 0.8$ (Barbosa et al., 2018; Forte, Marinho, Nikolaidis, et al., 2020). Simple linear regression models using CFD and analytical procedures were computed for the dataset in SI units and for logarithmic (Log-Log) transformations. The determination coefficient was computed (R^2). Effect sizes were set as very weak if $R^2 < 0.04$, weak if $0.04 \leq R^2 < 0.16$, moderate if $0.16 \leq R^2 < 0.49$, high if $0.49 \leq R^2 < 0.81$, and very high if $0.81 \leq R^2 < 1.0$ (Barbosa et al., 2018; Forte, Marinho, Nikolaidis, et al., 2020).

Results

Effective Surface Area

The AC_d varied between 0.38 and 0.59 m^2 for the able-bodied cyclist, while for the shoulder-amputee it ranged between 0.30 m^2 and 0.62 m^2 (Figure 2). The non-disable cyclist's AC_d decreased between 1 and 2 m/s and between 5 and 7 m/s; however, between 2 and 5 m/s and between 8 and 13 m/s, the AC_d tended to maintain. For the amputee cyclist, the AC_d tended to decrease from 1 m/s to 13 m/s; however, between 3 m/s and 13 m/s the decrease was smaller. The differences between cyclists varied between 3% and 24%.

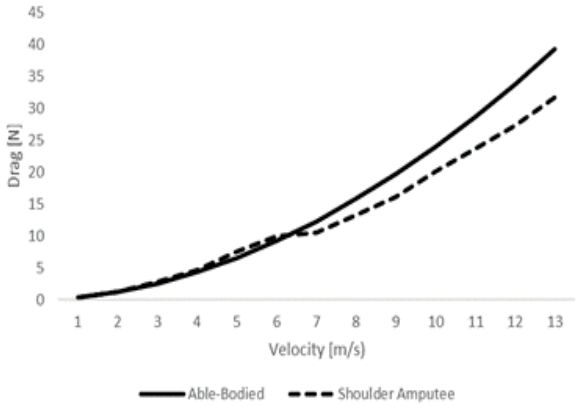
Figure 2
ACd (left picture) and Cd variations (right picture) variations from 1 m/s to 13 m/s with increments of 1 m/s for able-bodied (solid line) and shoulder amputee cyclist (dash line)



Drag

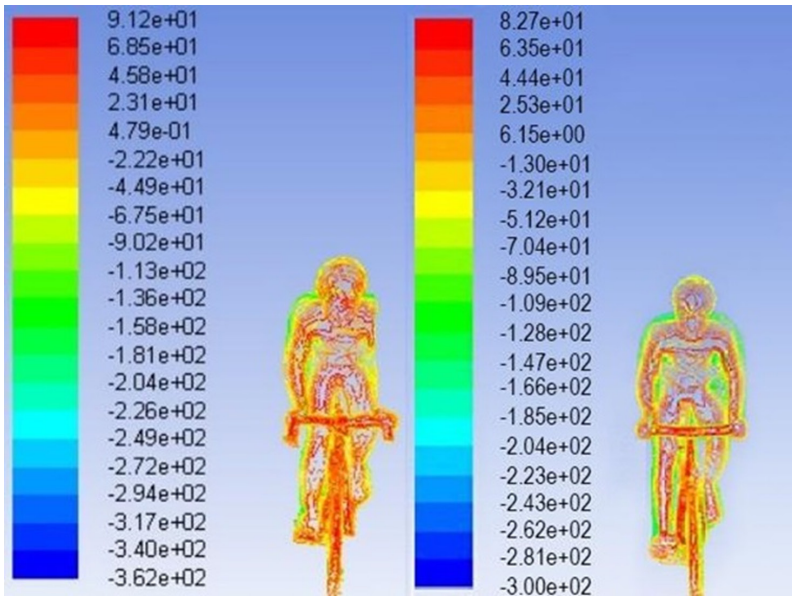
The drag increased with velocity (1-13 m/s) for the able-bodied cyclist (0.36 N – 39.25 N) and the shoulder-amputee (0.38 N – 31.69 N). The shoulder-amputee cyclist had a small tendency to maintain the drag between 6 and 7 m/s and to increase it between 1 and 6 m/s and 7 and 13 m/s. It ranged between 2% and 19% (Figure 3).

Figure 3
Drag variations between 1 m/s to 13 m/s with increments of 1 m/s for able-bodied (solid line) and shoulder amputee cyclist (dash line)



The figure 4 presents the pressure maps for 11.11 m/s (40 km/h) between the able bodied and shoulder-amputee. The shoulder-amputee cyclist presented the higher pressure 9.12×10^1 Pa above the able-bodied 8.12×10^1. The lower pressure for shoulder-amputee was -3.12×10^2 Pa below the -2.81×10^2 Pa for the able-bodied. Thus, the shoulder-amputee model presented high variance between high- and low-pressure zones in comparison to the able-bodied cyclist.

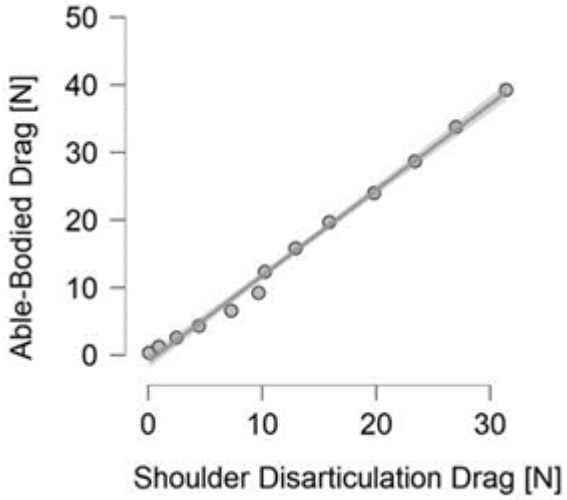
Figure 4
Pressure maps for able for the shoulder-amputee (left) and able-bodied (right), at 11.11 m/s



Comparisons Between Able-Bodied Cyclist and Shoulder-Amputee Cyclist

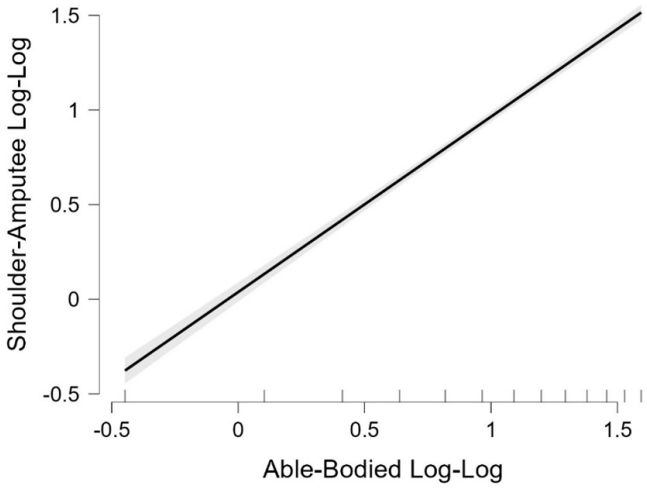
The comparison between the two cyclists presented significant differences and small effect sizes ($t = 2.720$; $p = 0.019$; $d = 0.18$). The linear regression between both cyclists presented a significant relationship and very high effect sizes for drag ($R^2 = 0.997$; $R^2a = 0.995$; $SEE = 0.996$; $p < 0.001$). The trendline (Figure 5) equation between the able-bodied (x axis) and the shoulder-amputee (y axis) is presented bellow:

Figure 5
Scattergram, 95% interval of confidence and trendline between the able-bodied and the shoulder-amputee



After logarithmic transformations, no significant differences were observed with a moderate effect (t = 1.768; p = 0.103; d = 0.490). The linear regression presented higher effect sizes after logarithmic transformation (R^2 = 0.995; R^2a = 0.994; SEE = 0.997; p < 0.001). The trendline (Figure 6) equation between the able-bodied and the shoulder-amputee drag values after logarithmic (log-log) transformation is presented bellow.

Figure 6
Scattergram, 95% interval of confidence and trendline between the log-log able-bodied and the shoulder-amputee



Discussion

The current study aimed to assess the aerodynamics of an able-bodied and a shoulder-amputee cyclist. It was hypothesised that the able-bodied cyclist presented a higher drag compared to the shoulder-amputee. The disabled cyclist presented a lower drag for velocities above 6 m/s. The results supported the null hypothesis.

To assess the drag, this study employed numerical simulations through CFD. While wind tunnel testing is acknowledged for delivering highly accurate results as experimental procedures, it is often considered as a very expensive method (Debraux et al., 2011a; Malizia & Blocken, 2021). Analytical procedures offer quicker insights, but the potential for bias rises as they rely on assumed values from the literature (Martin et al., 1998; Polanco et al., 2019). Alternatively, experimental field procedures like coast-down techniques are susceptible to environmental influences that can impact results (Bouillod et al., 2015; Debraux et al., 2011a, 2011b; Martin et al., 1998; Valenzuela et al., 2020). Despite being time-consuming, numerical simulations in CFD exhibit strong agreement with wind tunnel experiments (Defraeye et al., 2010). Although resource-intensive, these simulations provide outputs directly dependent on inputs and facilitate the mitigation of confounding factors. These methodologies have

been used to assess cyclists positions, equipment's and environmental conditions (Brownlie et al., 2010; Grappe et al., 1997; Terra et al., 2020b). Thus, for the present study, the CFD allowed to extract the drag values. The AC_d varied between 0.38 and 0.59 m^2 and decreased with velocity for the able-bodied cyclist and between 0.62 and 0.29 m^2 for the shoulder disarticulation. These values are in accordance with a similar study in which the AC_d ranged between 0.58 and 0.37 m^2 for an Able-bodied cyclist, and almost 0.58 to 0.44 m^2 and 0.61 to 0.41 for transtibial and the transradial amputees, respectively (Forte, Morais, et al., 2021). However, another study reported that the able-bodied cyclist presented higher drag compared to the transradial and the transtibial amputees (Forte, Marinho, Silveira, et al., 2020), which can possibly be explained by the vorticity around the arm and thigh. These studies are in line with the AC_d values observed in this research. However, it is worth mentioning that, in this case, the shoulder-amputee model presented lower drag compared to the able-bodied participant. This can be explained by the lower surface area in the amputee model (Forte et al., 2018).

When accessed able-bodied cyclists by wind tunnel experiments, it is possible to find AC_d values in the upright position 0.26 – 0.38 m^2 at ≈8.2 m/s (Zdravkovich et al., 2020), and 0.358 m^2 at ≈12.5 m/s (Jeukendrup & Martin, 2001). At the same velocities, the AC_d of the able-bodied cyclist was slightly above (≈ 0.4 m^2). The study from Defraeye et al. (Defraeye et al., 2010), in the same position presented an AC_d of 0.270, but the wind tunnel evaluations were made at 10 m/s and the cyclist and bicycle had different characteristics. The same study (Defraeye et al., 2010) ran CFD simulations and the AC_d was about 0.219 m^2. Again, the values were below the findings of the present study. A study from Blocken et al (Blocken et al., 2019) evaluated the AC_d by wind tunnel and CFD in the "back horizontal" position, the results were near 0.275 and 0.250 m^2 respectively, at 15 m/s (above the 11 m/s of the present study). The differences are possible to explain by the difference between the cyclist and bicycle dimensions and computational settings. The same study also presented an AC_d near 0.3 m^2 in the "Sprint regular" position. Considering the reduced area in comparison to the upright position, the values are close the reported in the results of this study.

The drag varied between 0.36 and 39.25 N and increased with velocity. These findings are similar to previous studies in this field (Forte, Marinho, Nikolaidis, et al., 2020; Forte, Marinho, Silveira, et al., 2020; Forte, Morais, et al., 2021). One study reported variations for the able-bodied, the transradial, and the transtibial amputee cyclists and the drag varied between 0.36 and 43.78 N (Forte, Morais, et al., 2021). The same study showed that the drag was higher for the transradial and the transtibial amputees compared to the able-bodied cyclist. These results were mainly due to the turbulence near the amputee members. Another study has shown that the drag is likely to increase more in the transradial and the transtibial amputees compared to the able-bodied cyclist (Forte, Marinho, Silveira, et al., 2020). In the present study, the drag was higher in the able-bodied compared to the shoulder-amputee cyclist. The able-bodied model presented higher surface area compared to the shoulder-amputee one, and so the able-bodied is expected to present higher drag. Finally, comparing with another study (Forte, Morais, et al., 2021), the arm and thigh increased the fluid flow turbulence, and so, it increased the drag. Therefore, it is possible to explain the differences in drag in the present study.

The simple linear regression showed that the amputee cyclist had a lower drag compared to the able-bodied one. The constant was negative and the slope was below 1. These results allow us to confirm that estimates based on disable cyclists may overestimate the drag of an able-bodied cyclist for velocities below 7 m/s. This procedure has already been used in swimming (to compare CFD with analytical procedures) (Barbosa et al., 2018), and cycling (comparing amputees) studies (Forte, Marinho, Silveira, et al., 2020). So far and to the best of our knowledge, this is the first study that compares the drag between an able-bodied cyclist and a shoulder-amputee one. It is worth noting that steady-speeds targets are between 6 and 12 m/s (Dyer, 2015). Thus, based in the present study, using the same AC_d of able-bodied cyclists in the mathematical models, will provide erroneous predictions of the performance (e.g. racing time, power needed, etc.) of the shoulder-amputee cyclists. After the log-log transformations, the results revealed no significant differences between variables. This suggest that the disparities in absolute values may have been influenced by the scale of the data. Thus, when considering the logarithmic scale, differences between groups are not as pronounced or even present. That can be explained by the quadratic relation of speed with inter-individual characteristics as A and C_d.

The pressure values for the shoulder-amputee model were between -3.12×10^2 and 9.12×10^1 Pa; whereas, for the able-bodied ranged between -2.81×10^2 and 8.12×10^1 Pa for the able-bodied. Here, the shoulder-amputee presented higher variance in comparison to the able-bodied. Previous studies reported that the amputee models presented higher differences between the higher and lower pressure zones for amputees (Forte, Morais, et al., 2021). Forte et al. (2021) presented high variance between the front and back boundaries for transtibial and transradial amputees. This is possible to justify by the reduced symmetry of the model with the amputations (Dyer, 2015; Dyer & Disley, 2018), resulting in different fluid flow behaviour for the right and left parts of the bodied. The differences between of pressure between the object boundaries result in higher pressure drag (Blocken, van Druenen, Toparlar, & Andrianne, 2018; Crouch et al., 2014; Dyer & Disley, 2018; Forte, Morais, et al., 2021; Griffith et al., 2014; Scarano et al., 2019).

Altogether, the shoulder-amputee presented lower drag compared to the able-bodied. This can be explained by the differences in the surface area and the greater turbulence in the able-bodied cyclist compared to the amputee, in which the

geometry shape/form has an important influence on drag variations (Forte et al., 2018). It is important to highlight that this is the first study that assesses an able-bodied and a shoulder-amputee cyclists' drag variations. This study allows coaches to understand that a non-disable cyclist presents lower drag in slower velocities (up to 7 m/s) compared to a shoulder-amputee cyclist. Based on this study, coaches may use the data to adjust drag values from an able-bodied to a shoulder-amputee cyclist. Nevertheless, this study presents some limitations: (i) the pressure and viscous drag contributions were not assessed; (ii) the analyses were all made at the same temperature (15º C); (iii) only one cyclist was recruited, although representative of his competitive level; (iv) different domains are needed to check the influence of the distance between the boundary faces and the cyclist; (v) the study miss experimental validation (wind tunnel); (vi) Y+ values were not reported for each simulation (velocity). Future studies can be made with: (i) different domain size; (ii) different turbulence models; (iiii) different conditions such as environmental (i.e., temperatures); (iv) drafting effect with amputee cyclists; (v) comparisons with other methodologies (analytical procedures or experimental testing).

Conclusions

The current study demonstrates that the cyclist with an amputated shoulder has a lower drag compared to the non-disabled cyclist for speeds above 7m/s. Coaches and researchers should be aware that the drag estimations based on non-disabled cyclists may overestimate (above 7 m/s) the shoulder-amputee cyclist's drag and the differences can range between 2% and 19% for the selected velocities. The AC_d varied between 3% and 28% for the different velocities. In summary, this study highlights that cyclists with amputated shoulders exhibit significantly lower drag than non-disabled cyclists at speeds above 7m/s and cautioning against potential overestimation should be considered.

Ethics Committee Statement

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee: Scientific Committee of the Higher Institute of Educational Sciences of the Douro approved this research (PF2019.10, October 2019).

Conflict of Interest Statement

Authors must declare no conflicts of interest.

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Authors' Contribution

Conceptualization P.F., T.M.B. & D.A.M.; Methodology P.F.; Software P.F.; Validation H.P.N., J.E.M. & A.M.M.; Formal Analysis P.F., T.S; Investigation P.F., J.E.T; Resources D.A.M., J.E.M.; Data Curation L.B.; Writing – Original Draft P.F. & L.B; Writing – Review & Editing D.A.M., H.P.N., A.J.S, T.M.B., A.M.M, J.E.T.; Visualization T.S. & L.B.; Supervision A.J.S.; Project Administration P.F.; Funding Acquisition P.F. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author (pedromigue.forte@iscedouro.pt).

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Observational Analysis of the Construction of Sequences That end in a Shot in U14 Basketball According to the Players' Position

Análisis Observacional de la Construcción de las Secuencias que Acaban en Lanzamiento en Baloncesto Sub-14 en Función de la Demarcación de los Jugadores

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Abstract

Using observational methodology, a study was carried out on the offensive sequences that end in a shot—both effective and ineffective—for FC Barcelona's elite U14 team, champions of the Minicopa Endesa 2020. An observation instrument was adapted from one with proven validity. The data was recorded using the free software Lince. The observational sample is composed of all the sequences that end in a shot. The reliability of the recordings was guaranteed by inter-observer agreement using Cohen's kappa coefficient. Complementary use of the decision tree analysis technique and the detection of T-patterns —using the software Theme— made it possible to characterise the construction of the sequences that end in shots that were both effective and ineffective. It may be concluded that in the elite U14 category, ineffective sequences still predominate over effective ones, except for the inside shots of players in a point guard position

Keywords: Match analysis, U14 basketball, efficiency, tree analysis technique, T-patterns.

Resumen

En el seno de la metodología observacional se ha realizado un estudio de las secuencias ofensivas que acaban en lanzamiento -eficaces e ineficaces- de un equipo de élite de la categoría sub-14: el FC Barcelona, campeón de la "Minicopa Endesa 2020". Se ha realizado una adaptación de un instrumento de observación que cuenta con probadas evidencias de validez. El registro de los datos se ha realizado mediante el programa libre Lince. El muestreo observacional está compuesto por la totalidad de las secuencias que finalizan en lanzamiento. Se ha garantizado la fiabilidad de los registros, mediante concordancia inter-observadores, a través del coeficiente Kappa de Cohen. La utilización de forma complementaria de la técnica de análisis de árboles de decisión y de la detección de T-patterns -mediante el software Theme- han permitido caracterizar la construcción de las secuencias que acaban en lanzamiento -eficaces e ineficaces-. Se concluye que en la élite de la categoría sub 14 todavía predominan las secuencias ineficaces sobre las eficaces, salvo en los lanzamientos interiores del jugador con demarcación base.

Palabras clave: Match analysis, baloncesto sub-14, eficacia, árboles de decisión, T-patterns.

Introduction

This paper studies the offensive sequences that end in a shot —both effective and ineffective— of FC Barcelona's U14 team, champion of the Minicopa Endesa 2020. The Minicopa is a competition in which the youth teams of the eight teams that have qualified for the Copa del Rey de Baloncesto (ACB) take part. To highlight the importance and relevance of this youth competition, it is worth noting that it takes place at the same time as the Copa del Rey (ACB) and in the same location.

Analyses of efficiency are common in elite basketball (Alsasua et al., 2019; Sampaio et al., 2010). The most common performance indicator in this field is shot success (Erculj & Strumbelj, 2015), which is analysed in a wide range of contexts: comparisons between winning and losing teams (Fernández & Piñar, 2017), home and away (Ribeiro et al., 2016) and league and play-off games (Nunes et al., 2022).

However, to better understand what happens during a basketball game, it is important to analyse not only how and where shots are taken, but the actions leading to said shots (Fernández et al., 2009; Romarís et al., 2012). That is why, in order to define basketball performance, the analysis of offensive sequences that end in a shot is particularly important (Fernández & Piñar, 2017; Kubatko at al., 2007; Ozakaki & Rodacki, 2012; Sampaio et al., 2010).

Although the study of effectiveness in team sports —and specifically in basketball— has traditionally been based on a series of indicators related to frequencies or occurrences, this type of data is insufficient to address the complexity of sport interrelationships in a sport as complex as the one in question (Alsasua et al., 2018; Serna et al., 2022). By contrast, match analyses carried out as part of the observational methodology allow for rigorous diachronic analyses that make possible to detect the underlying structure from the dataset collected during time and using intrasessional following (Anguera et al., 2020; Anguera et al., 2021).

Regarding basketball training games, as the age category increases so does the structuring and systematization of the game (Piñar et al., 2014). The younger the players are, the more their basketball playing is characterized by a minimally sophisticated collective game with a larger number of counterattacks (Ortega et al., 2006), lesser use and efficiency in external shots (Lorenzo et al., 2010), and most shots taken close to the basket (Monteiro et al., 2013).

The aim of this article is to characterise the construction of sequences that end in a shot —both effective and ineffective— of FC Barcelona's U14 team, champion of the Minicopa Endesa 2020, with the innovative contribution of taking into account the position of the players who perform the shot. Meeting this objective will contribute to generating relevant information that can be taken into consideration by trainers in youth basketball for the U14 age group.

Method

In this study observational methodology was used (Anguera, 1979). According to Anguera et al. (2011) the observational design is: idiographic —the champion team—; intersessional follow-up —performance in all the matches of the Minicopa Endesa 2020, the championship under study— and intrasessional follow-up —which enables diachronic analyses of behaviour—; and multidimensional, with proxemic and gestural dimensions.

Participants

According to Otzen and Manterola (2017), purposive sampling was carried out for the FC Barcelona team in the Minicopa Endesa 2020 tournament. This championship pits the best national teams in the youth category (players aged 13 and 14) against each other. From the detailed information on the championship website (https://www.acb.com/articulo/ver/152559-plantillas-minicopa-endesa-malaga-2020.html), the FC Barcelona squad is made up of point guards —players with numbers 4, 11 and 13—, small forwards —players 1, 2, 3, 5, 6, 7 and 12—, and power forwards —players 8, 9, 10, 14 and 15—.

This study obtained the approval of the Ethics Committee of the University of La Rioja (file CE_56_2023) as it complies with the guidelines established by the Belmont Report and the Declaration of Helsinki.

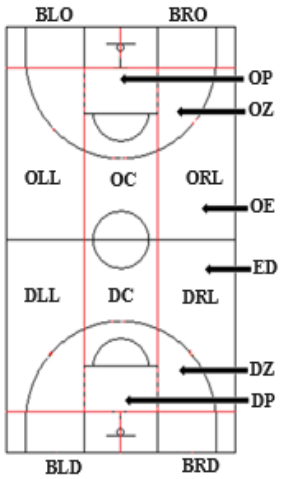
Observation Instrument

An adaptation was made of the observation instrument proposed by Alsasua et al. (2018), based on the SOB2 of Fernández et al. (2009). The adaptation (see table 1) consisted of the addition of two new dimensions —player and position— which will allow us to meet the study aim with a greater degree of certainty.

This observation instrument is a combination of field format and category systems —exhaustive and mutually exclusive—.

Table 1
Observation instrument

n	Criterion	Categories: codes and short description	Basketball court
1	Start of the game	Ball in play (BP); defensive bottom throw-in (DBT); defensive throw-in (DT); initial jump (IJ); offensive bottom throw-in (OBT); offensive throw-in (OT); free shot (FS).	
2	Laterality	Offensive right lateral (ORL); bottom right offensive (BRO); offensive centre (OC); offensive left lateral (OLL); bottom left offensive (BLO); defensive right lateral (DRL); bottom right defensive (BRD); defensive centre (DC); defensive left lateral (DLL); bottom left defensive (BLD).	
3	Area	Offensive exterior (OE); offensive zone (OZ); offensive paint (OP); defensive exterior (DE); defensive zone (DZ); defensive paint (DP).	
4	Game Action	Ball recovered (BR); offensive rebound (OR); defensive rebound (DR); penultimate pass (P1); reception 1 (R1); last pass (P2); reception 2 (R2); completion (C1); rebound and offensive pass (ROP); rebound and penultimate offensive pass (RP1OP); rebound and last offensive pass (ROP2); rebound and defensive pass (RDP); rebound and penultimate defensive pass (RP1DP); rebound and last defensive pass (RDP2).	
5	Type of completion	Favourable (fav): Score (SC); received foul (RF); score and foul (A1). Unfavourable (unfav): Miss (MS); foul given (FG); violation (VI); block (BL).	
6	Player	Player 1 (P1); player 2 (P2); player 3 (P3); player 4 (P4); player 5 (P5); player 6 (P6); player 7 (P7); player 8 (P8); player 9 (P9); player 10 (P10); player 11 (P11); player 12 (P12); player 13 (P13); player 14 (P14); player 15 (P15).	
7	Positions	Point guard (PG); small forward (SF); power forward (PF); centre (C); shooting guard (SG).	



Procedure

The data was recorded using the free software Lince, version 1.4. (Gabin et al., 2012) (see Figure 1). The data obtained are type IV, time-based and concurrent, according to Bakeman's (1978) classic classification for observational data. The 441 sequences in which FC Barcelona achieved a shot throughout the competition were recorded (table 2); in total 2134 multi-events were recorded (Bakeman & Quera, 2011). Each sequence comprised the shot itself and a maximum of five actions immediately preceding the shot (maximum of six rows for each sequence in the dataset).

Figure 1
Screenshot from recording using Lince, version 1.4.

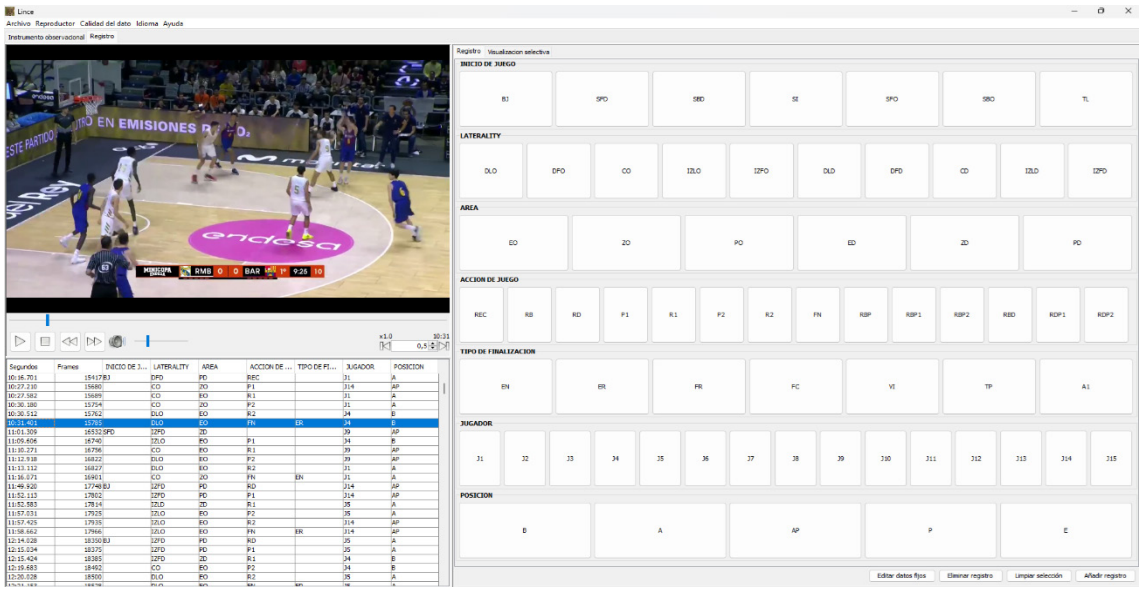


Table 2
Games analysed, cumulative sequences and number of multi-events recorded

Phase	Date	Rival	Result	Sequences	Cumulative sequences	Registered multi-events
Groups	12/02/20	Cajasiete Canarias	48 – 76	97	1-97	490
Groups	13/02/20	Joventut Badalona	50 – 84	82	98-179	392
Groups	14/02/20	Valencia Basket	46 – 76	83	180-262	388
Semifinal	15/02/20	Coosur Real Betis	71 – 72	96	263-358	446
Final	16/02/20	Real Madrid	65 – 67	83	359-441	418

Data Quality Control

Data recording was carried out by two expert observers –university professors responsible for the subject of Basketball, with considerable experience in observational methodology– who followed a training process based on Anguera (2003). Both observers recorded all the sequences that make up the observational sample.

The reliability of the data packages was ensured by inter-observer agreement using Cohen's kappa coefficient (1960). This coefficient was calculated using GSEQ software, version 5.1 (Bakeman & Quera, 2011). The inter-observer concordance score was higher than .83 in all the games included in the study (Cajasiete = .91; Joventut Badalona = .84; Valencia Basket = .83; Coosur Real Betis = .88; Real Madrid = .84). According to the classic reference values of Landis and Koch (1977), the consideration of agreement is almost perfect.

In terms of categories, "Positions" is made up of the positions reflected on the Championship website. In the relationship provided to the tournament organisation by FC Barcelona of the five categories that make up this criterium, three were the positions: point guard, small forward and power forward. To guarantee the reliability of the categorisation used, the position assigned to each player was subjected to the consideration of both observers –separately and at the end of the complete record of the observational sample–. Agreement was verified between the relationship published on the championship website with that carried out by both observers.

Data Analysis

The Two analytical techniques were used to meet the objective set out in this study: one of a synchronic nature –which doesn't adhere to the structure of the intrasessional sample carried out– and the other diachronic –from the structure of the record generated during the intrasessional follow-up (Anguera et al., 2021)–.

Firstly, the decision tree technique was used. Its widespread application in different areas and backing in the literature make it a prominent tool for classification and prognosis (Lee et al., 2022). Decision tree analysis is an analytical method widely used in the field of data mining, creating a tree-based classification model that classifies cases or predicts values of a consequent dimension based on the categories or values of antecedent dimensions (Yang & Zhou, 2020). In particular, it is a technique that can be useful for three interlinked analyses. Firstly, it facilitates the search for the best associations of the antecedent dimensions with the consequent dimension. Secondly, it allows us to discover which categories or values of an antecedent dimension are homogeneous in relation to the consequent dimension. And, finally, it is an appropriate technique for detecting interactions between antecedent dimensions (Berlanga et al., 2013; Escobar, 2007).

In the context of decision trees, it is possible to distinguish between classification and regression trees, the difference being determined by the nature of the consequent dimension. If the dimension is qualitative, they are called classification trees, while if it is quantitative, they are classified as regression trees. In this analysis, the classification tree has been chosen, as the consequent dimension of 'shot result' is of a categorical nature.

A variety of statistical algorithms, such as CHAID (Chi-square Automatic Interaction Detector), CRT (Classification and Regression Trees) and QUEST (Quick, Unbiased, Efficient and Statistical Tree), among others, are available for the construction of decision trees, offering fast and efficient options for data mining (Shamrat et al., 2022; Song & Ying, 2015). In this study, the CRT algorithm was used to generate a classification tree, chosen for its effectiveness as a case classifier, achieving maximum intra-group homogeneity and maximum inter-group heterogeneity (Escobar, 2007). Furthermore, it has the valuable feature of automatically grouping large categorical variables into a few categories (Sharma & Kumar, 2016).

The construction of the CRT classification tree is based on binary splitting, using the Gini index as a measure to select the splitting attribute. This process continues until the data can no longer be separated, allowing the formation of a structured

tree (Arabfard et al., 2023; Milani et al., 2020; Sharma & Kumar, 2016). For this purpose, IBM SPSS Statistics 28.0 software was used.

Initially, level filters restrict the development of the tree in terms of depth by limiting the number of levels below the root node (node 0), which represents the consequent dimension, in our case, the 'type of completion'. In this context, it is important to note that the automatic adjustment of the SPSS programme limits the tree to five levels for the CRT growth method (Berlanga et al., 2013). Secondly, size filters regulate the expansion of the trees by limiting the number of frequencies in the tree segments or nodes, both parent (internal) and branch (leaf or terminal). In this research, the recommended rule of thumb was followed: 100 cases for internal nodes and 50 cases for terminal nodes (Escobar, 2007). Thirdly, the Gini index was used as a metric to assess the impurity of the split nodes, seeking to maximise the homogeneity of the secondary nodes. This index summarises the purity or impurity of a specific group in relation to the consequent dimension, with it being a determining factor in allowing or avoiding further segmentations (Escobar, 2007; Yang & Zhou, 2020). It should be noted that this algorithm does not allow for further segmentations unless a set minimum rate of improvement is exceeded, the default value in the SPSS programme being 0.001 for a minimum change in improvement. Finally, the analysis concludes by assessing the predictive accuracy of the segmentation as a whole, representing the goodness-of-fit of the model's performance, through estimation of risk of classificatory ability (Berlanga et al., 2013).

In the second type of analysis used —diachronic analysis— we searched for regular behavioural structures, T-patterns, using THEME 6 Edu software (Anguera et al., 2023; Magnusson, 2000). Although the main contribution of THEME is the detection of temporal patterns, the software also offers the possibility of detecting sequential structures according to the parameter of order —based on a constant duration assigned to each behaviour unit (1 in this study)— which provides very significant possibilities for the analysis of sequentiality, since it allows us to deduce whether the behaviours are consecutive or whether there are gaps in the T-pattern (interspersed behaviours) between the detected multi-events (Lapresa et al., 2013).

According to the reference manual (PatternVision Ltd & Noldus Information Technology bv, 2004) the Free Pattern option was selected, whereby the detection of critical interval relationships occurs by raising the lower limit of the critical interval until a significant relationship is found. In addition, the following search parameters were set:

- A minimum number of occurrences equal to or greater than three.
- Significance level of .005; this significance level has been set by reducing the probability of accepting a critical interval due to chance to .5%.
- Redundancy reduction, so that if more than 90% of the occurrences of a newly detected pattern start and end in the critical interval of the already detected patterns, the new pattern is discarded.

Subsequently, qualitative filters were applied (Amatria et al., 2017), selecting T-patterns that incorporate the 'type of completion' multi-event, and whose internal intervals between multi-events are equal to 1 or 2, then grouping them according to the position of the players and by sequences that end with a shot, whose result is favourable or unfavourable.

Results

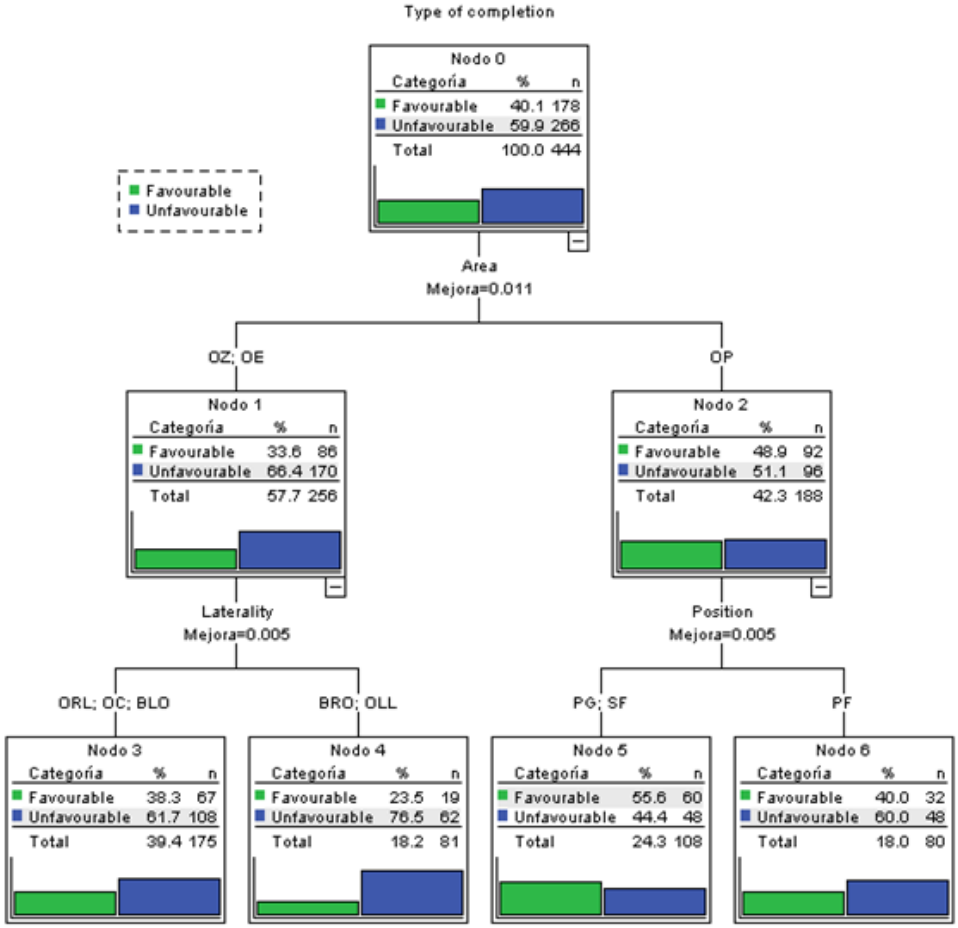
The results of the classification tree are shown in figure 2. The final tree structure includes four division dimensions: 'type of completion, 'area', 'laterality' and 'player position'. In short, it is a classification tree with two levels of depth and seven nodes, four of which are terminal (nodes 3, 4, 5 and 6).

The analysis of the obtained decision tree reveals, firstly, that the most influential dimension in the prediction of 'type of completion' is 'area', followed by the dimensions 'position' and 'laterality'. Moreover, a significant double interaction was identified. In relation to the first association, a connection was made between the dimensions 'area' and 'laterality'. This interaction classifies, on the one hand, that the shots with the highest probability of obtaining an unfavourable result (76.5%) belong to the group of shots taken from the side —'bottom right offensive' (BRO) and 'offensive left lateral' (OLL)— if they have been taken from the areas 'offensive zone' (OZ) and from the 'offensive exterior' (OE) (node 4). Moreover, this failure rate is reduced (61.7%) for shots made from the 'offensive right lateral' (ORL) and 'offensive left lateral' (OLL) if the shots were made from the same areas (node 3).

As for the second interaction, an association was identified between the dimensions 'area' and 'position'. This association classifies that 44.4% of the shots with the lowest probability of obtaining an unfavourable result in the shot belong to the group of shots made by both the point guard (PG) and the small forward (SF), if they were made from the 'offensive paint' (OP) (node 5). On the other hand, the failure rate increases (60.0%) for shots taken by the power forward (PF), from this same area (node 6).

In terms of goodness-of-fit, it was found that the CART algorithm correctly classifies 62.6% of the shots. Specifically, for the category of shots with unfavourable results from the subsequent dimension, it shows a higher scoring rate (82.0%) than for the category of shots with favourable results (33.7%).

Figure 2
Graphic illustration of the decision tree



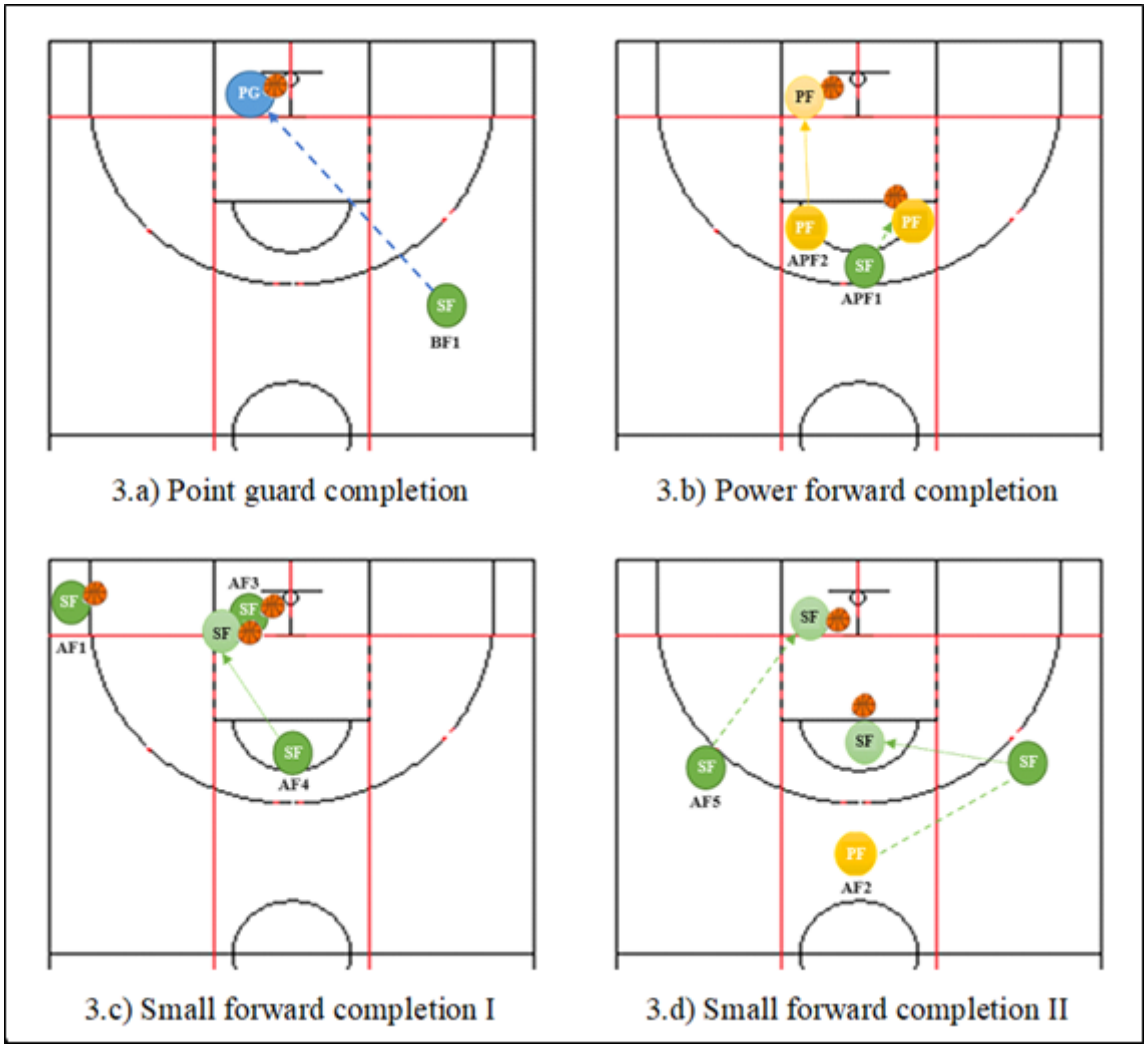
Note: BLO= bottom left offensive; BRO= bottom right offensive; OC= offensive centre; OE= offensive exterior; OLL= offensive left lateral; OP= offensive paint; ORL= offensive right lateral; OZ= offensive zone; PF= power forward; PG= point guard; SF= small forward.

With regard to the T-patterns that were detected by applying the pre-set search parameters, qualitative filters were applied both for their selection and for their grouping. First, we present the T-patterns whose constitutive multi-events reflect sequences that achieve shots with a favourable result (table 3); because of their relevance, we added a graphic illustration of the information contained in these T-patterns, showing shots with a favourable result (figure 3). Next, we present those T-Patterns related to sequences that achieve a shot with a unfavourable result (table 4) and, finally, identified T-Patterns that reflect the same game situations in which both favourable and unfavourable results were achieved (table 5).

Table 3
Identified T-patterns (identifier, string format, occurrences, constitutive multi-events and the mean of their internal intervals) that reflect offensive sequences ending with a favourable result

ID	T-Pattern	Occurrences, multi-events	Mean of the internal intervals
BF1	(orl,oe,p2,sf blo,op,c1,fav,pg)	*n* = 3, length = 2	2
AF1	(blo,oe,r2,a blo,oe,c1,fav,sf)	*n* = 4, length = 2	1
AF2	((oc,oe,r1,pf orl,oe,r2,sf) oc,oz,c1,fav,sf)	*n* = 3, length = 3	2; 1
AF3	(bp,blo,op,or,sf blo,op,c1,fav,sf)	*n* = 3, length = 2	1
AF4	(oc,oz,r2,sf izfo,op,c1,fav,sf)	*n* = 3, length = 2	1
AF5	(oll,oe,p2,sf blo,op,c1,fav,sf)	*n* = 3, length = 2	2
APF1	(oc,oz,p2,sf oc,oz,c1,fav,pf)	*n* = 3, length = 2	2
APF2	(oc,oz,r2,pf blo,op,c1,fav,pf)	*n* = 3, length = 2	1

Figure 3
Graphic illustration of T-Patterns whose favourable result constitution does not coincide with T-Patterns whose constitution ends with an unfavourable result



Note: --------→ = non-consecutive action -I.I. = 2-; ——————→ = consecutive action -I.I. = 1- ;
PG = Point guard; SF = Small forward; PF = Power forward; = Basket.

Table 4
Identified T-patterns (identifier, string format, occurrences, constitutive multi-events and the mean of their internal intervals) that reflect offensive sequences ending with a shot with an unfavourable result

ID	T-Pattern	Occurrences, multi-events	Mean of the internal intervals
BD1	(oll,oe,r2,pg oc,oz,c1,unfav,pg)	*n* =5, length = 2	1
BD2	(oll,oe,r2,pg oll,oz,c1,unfav,pg)	*n* = 4, length = 2	1
BD3	(oc,oe,r2,pg oc,oe,c1,unfav,pg)	*n* = 3, length = 2	1
BD4	(oll,oe,r2,pg blo,oz,c1,unfav,pg)	*n* = 3, length = 2	1
BD5	(orl,oe,r2,pg oc,oz,c1,unfav,pg)	*n* = 3, length = 2	1
AD1	(oc,oz,r2,sf oc,oz,c1,unfav,sf)	*n* = 5, length = 2	1
AD2	(oc,oz,p2,sf oc,oz,c1,unfav,sf)	*n* = 4, length = 2	2
AD3	(orl,oe,r2,sf bro,oz,c1,unfav,sf)	*n* = 4, length = 2	1

AD4	(oc,oe,r2,sf bro,op,c1,unfav,sf)	*n* = 3, length = 2	1
AD5	(bro,oe,r2,sf bro,oe,c1,unfav,sf)	*n* = 3, length = 2	1
AD6	(oll,oe,r2,sf oc,oz,c1,unfav,sf)	*n* = 3, length = 2	1
AD7	(oll,oe,r2,sf blo,oz,c1,unfav,sf)	*n* = 3, length = 2	1
APD1	(bro,oz,r2,pf bro,op,c1,unfav,pf)	*n* = 7, length = 2	1
APD2	(orl,oe,r1,sf (orl,oe,p2,sf bro,op,c1,unfav,pf))	*n* = 6, length = 3	1; 2
APD3	(bro,op,r2,pf bro,op,c1,unfav,pf)	*n* = 6, length = 2	1
APD4	(bro,oz,r2,pf bro,oz,c1,unfav,pf)	*n* = 6, length = 2	1
APD6	(oll,oe,p2,sf bro,op,c1,unfav,pf)	*n* = 6, length = 2	2
APD6	(blo,op,r2,pf blo,op,c1,unfav,pf)	*n* = 6, length = 2	1
APD7	(blo,oz,r2,pf blo,op,c1,unfav,pf)	*n* = 6, length = 2	1
APD8	(bp,bro,op,or,pf bro,op,c1,unfav,pf)	*n* = 5, length = 2	1
APD9	(oll,oe,p1,pg (orl,oe,r1,sf (orl,oe,p2,sf bro,op,c1,unfav,pf)))	*n* = 3, length = 4	1; 1; 2
APD10	(orl,oe,r1,sf (orl,oe,p2,sf (bro,oz,r2,pf bro,op,c1,unfav,pf)))	*n* = 4, length = 4	1; 1; 1
APD11	(oc,oz,p2,sf bro,op,c1,unfav,pf)	*n* = 4, length = 2	2
APD12	((oll,oe,p2,sf blo,oz,r2,pf) blo,oz,c1,unfav,pf)	*n* = 3, length = 3	1;1
APD13	((oll,oe,r1,sf blo,oz,r2,pf) blo,oz,c1,unfav,pf)	*n* = 3, length = 3	2;1
APD14	((obt,bro,oz,p2,pg bro,oz,r2,pf) bro,oz,c1,unfav,pf)	*n* = 3, length = 3	1; 1
APD15	(oc,oz,p2,sf (bro,op,r2,pf bro,op,c1,unfav,pf))	*n* = 3, length = 3	1; 1
APD16	(oc,oz,p2,sf blo,oz,c1,unfav,pf)	*n* = 3, length = 2	2
APD17	(orl,oe,p2,sf bro,op,c1,unfav,pf)	*n* = 3, length = 2	2
APD18	(oll,oe,r2,pf oll,oe,c1,unfav,pf)	*n* = 3, length = 2	1

Table 5

Identified T-patterns (identifier, string format, occurrences, constitutive multi-events and the mean of their internal intervals) that reflect the same offensive sequences that obtain shots with both favourable and unfavourable results

ID	T-Pattern	Occurrences, multi-events	Mean of the internal intervals
BFD1	(oll,oe,r2,pg oll,oe,c1,fav,pg)	*n* = 5, length = 2	1
	(oll,oe,r2,pg oll,oe,c1,unfav,pg)	*n* = 13, length= 2	1
BFD2	(orl,oe,r2,pg orl,oe,c1,fav,pg)	*n* = 4, length = 2	1
	(orl,oe,r2,pg orl,oe,c1,unfav,pg)	*n* = 7, length = 2	1
BFD3	(bro,oe,r2,pg bro,oe,c1,fav,pg)	*n* = 3, length = 2	1
	(bro,oe,r2,pg bro,oe,c1,unfav,pg)	*n* = 3, length = 2	1
AFD1	(oll,oe,r2,sf oll,oe,c1,fav,sf)	*n* = 9, length = 2	1
	(oll,oe,r2,sf oll,oe,c1,unfav,sf)	*n* = 14, length = 2	1
AFD2	(orl,oe,r2,sf orl,oe,c1,fav,sf)	*n* = 6, length = 2	1
	(orl,oe,r2,sf orl,oe,c1,unfav,sf)	*n* = 12, length = 2	1
AFD3	(orl,oe,r2,sf oc,oz,c1,fav,sf)	*n* = 4, length = 2	1
	(orl,oe,r2,sf oc,oz,c1,unfav,sf)	*n* = 8, length = 2	1
AFD4	(oc,oe,r2,sf oc,oz,c1,fav,sf)	*n* = 4, length = 2	1
	(oc,oe,r2,sf oc,oz,c1,unfav,sf)	*n* = 6, length = 2	1
AFD5	(oc,oe,r2,sf oc,oe,c1,fav,sf)	*n* = 4, length = 2	1
	(oc,oe,r2,sf oc,oe,c1,unfav,sf)	*n* = 5, length = 2	1
AFD9	(oll,oe,r2,sf blo,op,c1,fav,sf)	*n* = 3, length = 2	1
	(oll,oe,r2,sf blo,op,c1,unfav,sf)	*n* = 4, length = 2	1

AFD10	(bp,bro,op,or,sf bro,op,c1,fav,sf)	*n* = 4, length = 2	1
	(bp,bro,op,or,sf bro,op,c1,unfav,sf)	*n* = 3, length = 2	1
AFD13	(blo,op,r2,sf blo,op,c1,fav,sf)	*n* = 3, length = 2	1
	(blo,op,r2,sf blo,op,c1,unfav,sf)	*n* = 3, length = 2	1
APFD1	(blo,oz,r2,pf blo,oz,c1,fav,pf)	*n* = 4, length = 2	1
	(blo,oz,r2,pf blo,oz,c1,unfav,pf)	*n* = 9, length = 2	1
APFD13	(oc,oz,r2,pf oc,oz,c1,fav,pf)	*n* = 6, length = 2	1
	(oc,oz,r2,pf oc,oz,c1,unfav,pf)	*n* = 4, length = 2	1
APFD14	(oc,oz,r2,pf bro,op,c1,fav,pf)	*n* = 5, length = 2	1
	(oc,oz,r2,pf bro,op,c1,unfav,pf)	*n* = 4, length = 2	1

Discussion

In order to meet the objective of characterising the construction of the sequences that end in a shot —both effective and ineffective— of FC Barcelona's U14 team, champion of the Minicopa Endesa 2020, taking into account the position of the players who perform the shot, two types of analysis were carried out: one synchronous (decision trees) and the other diachronic (detection of T-patterns). Although the true potential of observational methodology is obtained from diachronic analysis with data that incorporate order and/or duration, synchronic statistical analyses which look for association relationships between dimensions that provide categorical data, are also relevant to meet the objectives set out in match analysis (O'Donoghue, 2009).

Firstly, the results obtained using the decision tree technique are discussed. The data reveal a clear predominance of ineffective sequences —shots that have an unfavourable result— with the dimension 'area' having the strongest association with the criterion 'type of completion'. Moreover, a significant increase in the number of sequences achieving a shot with an unfavourable result is observed when the dimensions 'area' and 'laterality' are combined. These results are in line with the lower shot efficiency identified in lower categories —U12 (Alsasua et al., 2018); U14 (Fernández & Piñar, 2017); U16 (Ortega et al., 2007)— in relation to professional basketball (Fernández et al., 2009; Mexas et al., 2005).

As a result of the analysis of the position of the player who makes the shot and the area from where it is made, it can be seen that both the point guard (PG) and the small forward (SF) manage to complete sequences with a favourable result from the offensive paint (OP); while in these types of shots the unfavourable result prevails if they are made by a player in a power forward (PF) position. These completion areas, depending on the position of the player who makes the shot, do not fit in with the traditional game profiles (García et al., 2019) of these positions (point guard: passer and outside scorer; inside players: power forwards and centres, specialists in the game close to the hoop; forwards: intermediate functions); and point to the versatility of play towards which current basketball is moving (Rolland et al., 2020). In relation to efficiency, the results obtained are in line with those obtained in U16 basketball by Alsasua et al. (2018), who found the greatest efficiency in shooting from positions close to the basket.

On the diachronic side, the T-patterns identified using Theme software reflect relevant information on the construction of offensive sequences that achieve shots according to the position of the players. With regard to the player occupying the point guard position, T-patterns were identified that reflect the point guard's shots, with both favourable and unfavourable results, made from the outside: specifically a last ball reception and shot from the sides (offensive left lateral (OLL) —T-patterns with ID BFD1— and offensive right lateral (ORL) —BFD2—) and the back of the court (bottom right offensive (BRO) —BFD3—). These regular behavioural structures reflect the play specialisation of the point guard who, in addition to having the main mission of ordering the team's play (Gómez & Lorenzo, 2007), generates outside shots when the inside game does not have options for positive progress (Romarís et al. 2012). This play situation of taking advantage of outside space after inside play favours successful finishing in elite basketball.

The T-patterns reflecting offensive sequences that end in a shot by the player occupying the small forward position reflect their versatility in the game, both inside and outside (García-Rubio et al., 2019). Looking at the inside game, T-patterns were identified reflecting offensive sequences that achieve favourable completion from the zone (intermediate zone (IZ) —ID AF2—) and offensive paint (OP) —AF4 and AF5— and baskets scored after an offensive rebound (OR) —AF3—. T-patterns were also detected reflecting inside play with shots made by the small forward generating an unfavourable result, both from the zone —AD1, AD2, AD3, AD6 and AD7— and from the paint —AD4—. In reference to the outside play of the forwards, the T-patterns presented reflect offensive sequences that end with both favourable —AF1— and unfavourable results —AFD1, AFD2, AFD5—.

Regarding the player occupying the power forward position, the T-patterns presented —APF1 and APF2— reflect sequences with effective finishing from the paint. The fact that this type of sequence is related to the power forward position highlights the specialisation that this position requires (García-Rubio et al., 2019) in order to take advantage of the greater efficiency that comes with shooting close to the basket (Romarís et al., 2012). T-patterns —APD1, APD2, APD3, APD5, APD6, APD7, APD8, APD9, ADP10, ADP11 and APD17— have also been identified reflecting sequences with shots that achieve an unfavourable result made by power forwards from the offensive paint (OP). These types of sequences, with both favourable and unfavourable results, have also been identified in U16 players (Alsasua et al., 2018) and in elite players (Gómez & Lorenzo, 2007).

Conclusion

The complementary use of the decision tree analysis technique and the detection of T-patterns —through Theme software— have made it possible to characterise the construction of the sequences that end in a shot, both effective and ineffective, of FC Barcelona's U14 team, champion of the Minicopa Endesa 2020, taking into account the position of the players who perform the shot.

It may be concluded that in the elite U14 category there is still a predominance of ineffective sequences —whose shots generate an unfavourable result— over effective ones; this aspect must be optimised during ensuing formative stages, gradually converging on the efficiency shown by elite teams.

Specifically, the player with the position of point guard has a role based on support and construction of offensive action, completing plays from outside areas —with effective and ineffective shots— but also with inside play actions with effective shots close to the hoop. Forwards have more versatile sequences of play, both inside and outside (effective and ineffective). Finally, the power forward position is characterised by its ability to finish close to the basket, although ineffectively.

The limitations and prospects of this work converge in that we are faced with a study that analyses a team's match-play, which can serve as a reference in the building of players who aspire to the Basketball elite in the U14 category. We continue to be interested in shedding light on the evolution of match-play in basketball in relation to age category, in order to offer trainers and coaches relevant information with which to reflect on the training process of their players.

Ethics Committee Statement

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee: University of La Rioja (file CE_56_2023, date of approval: 13-09-2023).

Conflict of Interest Statement

The authors declare that there are no conflicts of interest. The funding bodies or institutions had no influence on the design of the study, the analysis of the data or the interpretation of the results.

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Authors' Contribution

Conceptualization M.A., R.A., J.A. & D.L.; Methodology M.A., R.A., J.A. & D.L.; Software M.A. & R.A.; Validation M.A., J.A. & D.L.; Formal Analysis M.A., R.A., J.A. & D.L.; Resources M.A. & R.A.; Data Curation M.A. & R.A.; Writing – Original Draft M.A., R.A., J.A. & D.L.; Writing – Review & Editing M.A., R.A., J.A. & D.L.; Visualization M.A., R.A., J.A. & D.L.; Supervision D.L.; Funding Acquisition D.L. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author (daniel.lapresa@unirioja.es).

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Compliance with 24-Hour Movement Patterns in Schoolchildren: Infant Versus Primary Stage

Cumplimiento de las Pautas de Movimiento de 24 Horas en Escolares: Etapa Infantil Versus Etapa Primaria

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Abstract

Physical activity, sedentary behavior and sleep are the three main behaviors that interact during the day. The objective of the present study was, on the hand, to analyze the level of compliance with the 24 hours of movement in schoolchildren (pre-school versus primary school) and, on the other hand, to determine the differences between different times of the week. The sample consisted of 260 schoolchildren (93 from the infant stage and 167 from the primary stage). The 24 hours movement assessment was carried out including; physical activity, sedentary behavior and sleep. Physical activity time was determined by means of a questionnaire (Leisure Time Sedentary Behavior Questionnaire) throughout the week, as well as the hours of sleep by means of a weekly diary. From the results, compliance with the recommendations of 24 hours of movement was over 75%. In addition, the Primary stage performs more physical activity, experiences higher levels of sedentary behavior and gets more hours of sleep compared to the Infant stage. The conclusion is to increase physical activity levels from an early age and to keep a stricter control of daily sedentary behavior and sleep hours.

Keywords: Physical activity, sedentarism, sleep, recommendations, schoolchildren.

Resumen

Tanto la actividad física, como la conducta sedentaria y el sueño, son los tres principales comportamientos que interactúan durante el día. El objetivo del presente estudio fue, por un lado, analizar el nivel de cumplimiento de las 24 horas de movimiento en escolares (Infantil versus Primaria) y por otro determinar las diferencias entre diferentes momentos de la semana. La muestra estaba formada por 260 escolares (93 de la etapa Infantil y 167 de la etapa Primaria). Se llevó a cabo la evaluación de las 24 horas de movimiento que incluye; la actividad física, conducta sedentaria y sueño. El tiempo de actividad física se determinó por medio de una pulsera de actividad física durante 7 días; el tiempo de conducta sedentaria por medio de cuestionario (Cuestionario de conducta sedentaria en el tiempo libre) a lo largo de la semana, al igual que las horas de sueño por medio de diario semanal. De los resultados destaca el cumplimiento de las recomendaciones de 24 horas de movimiento por encima del 75%. Además, la etapa Primaria realiza más actividad física, experimenta mayores valores de conducta sedentaria y consume más horas de sueño respecto a la etapa Infantil. Se concluye incrementar los niveles de actividad física desde edades tempranas y llevar un control más estricto de la conducta sedentaria diaria y de las horas de sueño.

Palabras clave: Actividad física, sedentarismo, sueño, recomendaciones, escolares.

Introduction

The benefits of performing physical activity in the prevention or reduction of disease have been recognized by the scientific literature in the adolescent stage, especially at moderate (e.g., walking at a brisk pace) or vigorous (e.g., playing a game of basketball) intensities (Bull et al., 2020; Poitras et al., 2016).

According to the most recognized health recommendations, for ages 6 to 17 years, 60 min of moderate to vigorous physical activity (MVPA) is recommended, according to the Center for Disease Control and Prevention and the guidelines of the U.S. On the other hand, the guidelines set by the United Kingdom and the E.U. Physical Activity Guidelines established that, for ages under five years, it is recommended that a child perform 60 min of MVPA per day (Department of Health, Physical Activity, Health Improvement and Protection, 2011; Education and Culture of European Commission. EU Physical Activity Guidelines, 2008) and 180 min of total physical activity per day, according to the World Health Organization (WHO, 2019). In this regard, according to Miraflores et al. (2016), in children aged 3 to 6 years, it has been determined that they should perform 3 hours of physical activity per day, of any intensity and in different settings. Measuring physical activity in step volume is considered as an alternative, with recommendations around 13,000 steps per day for these ages (Cardon & De Bourdeaudhuij, 2007; Tanaka & Tanaka, 2009).

The adoption of a healthy lifestyle characterized by high levels of physical activity, low screen time, and optimal sleep duration has been found to provide more health benefits than the adoption of just one of these behaviors (Carson et al., 2017; Chaput et al., 2014). These health patterns have typically been studied in isolation, but, however, there is compelling evidence that these movement-related behaviors, interact throughout the day (24 hours) (Janssen et al., 2017; Poitras et al., 2016; Saunders et al., 2016). Time spent in physical activity inevitably and excludably interacts with sedentary and sleep time (Chaput et al., 2014). Consequently, both physical activity, sedentary behavior and sleep are the main behaviors that interact during the day. In this line, taking into account the time contained in a day and attending to scientific veracity, authors such as Tremblay et al. (2016) elaborated, for a healthy use of the 24 hours a day, the following recommendations regarding sedentary behavior and sleep: recreational screen time (< 2 hours) and sleep duration (9-11 hours in children between 5 and 13 years). In contrast, for the 3-6 years stage, according to Ramos Berzosa (2021), sedentary behavior time should be less than 1 hour per day. Furthermore, according to the American Academy of Pediatrics (A.A.P, 2016), the daily amount of sleep for children aged 3 to 5 years is 10 to 13 hours. Thus, attending to a holistic view of behavior throughout the 24 h can be employed as health indicators (Rollo et al., 2020; Tremblay et al., 2016), mainly associated with benefits at the physical, psychological and cognitive levels in children and adolescents (Carson et al., 2016; Chaput et al., 2016; Lissak, 2018; Poitras et al., 2016; Rollo et al., 2020; Tarokh et al., 2016; Wu et al., 2017). More specifically, a joint adherence to 24-hour movement recommendations (physical activity, sedentary behavior, and sleep duration) have been associated with additional health benefits, especially improved quality of life, diet, fitness, adiposity, and mental and social health (Carson et al., 2017; Janssen et al., 2017; Lee et al., 2018; Rollo et al., 2020; Walsh et al., 2018).

However, despite the independent and combined benefits of these three behaviors interacting 24 hours a day, a large percentage of young people do not meet the daily recommendations (Tremblay et al., 2016). Recently, a study conducted in more than 140 countries, showed that more than 75% of adolescents aged 11-17 years do not meet the international recommendations for physical activity, i.e., only 1 in 4 young people (Guthold et al., 2020).

The percentage of non-compliance can increase notably when the three 24h movement recommendations are examined together (Tapia-Serrano et al., 2022), especially in the transition from primary to secondary education (Chong et al., 2022). In this regard, a meta-analysis by authors such as Tapia-Serrano et al. (2022), with a sample of 387,437 young people from 63 studies and 23 countries, showed that only 11% of preschoolers, 10% of children and only 3% of adolescents meet the three recommendations (physical activity, sedentary behavior and sleep). Furthermore, it should be noted that only 9% of preschoolers, 16% of children and 28% of adolescents did not comply with any of the above three recommendations. In this regard, several studies have shown the benefits of physical activity in children, but little research has been conducted in children under three years of age (Díaz-Quesada et al., 2021).

In turn, it would be interesting to know at what times these recommendations are most clearly met. Among other circumstances, because the school has been considered an ideal place to promote the practice of physical activity and thus achieve the daily recommendations from an early age (Martínez-Gómez et al., 2014); even being indicated as the context where half of the daily physical activity time is spent (Pate et al., 2006). And is that, it has been shown that academic performance can be improved through physical activity at school (Carriedo & González, 2019).

Thus, in the scientific literature it has been shown that preschool children who regularly attend school perform the same amount of AFMV as those who do not go to school (Statler et al., 2020). Consequently, children have a higher level of physical activity outside school hours than during school time (Pate et al., 2006). In this line, different studies have also shown that preschool children perform more AFMV on weekdays compared to weekend days (Roscoe et al., 2019).

Another study has reflected that Chinese preschool-aged children spent significantly more time performing vigorous physical activity on weekdays than on weekends (Ji et al., 2018). However, most studies examining the level of physical activity intensity focus on the primary and secondary educational stages, while studies at younger ages remain scarce, despite the health benefits of physical activity in younger children (González-Díaz et al., 2017). On the other hand, less empirical attention has been paid to Spanish children in this context (Díaz-Quesada et al., 2022). In turn, there is a lack of information on what happens according to the educational stage analyzed, not only in terms of physical activity, but also sedentary behavior and sleep.

Therefore, the objectives of the present study are: a) To analyze the level of compliance with the 24-hour movement patterns in schoolchildren (pre-school versus primary school) and, b) To determine the differences between different times of the week.

Method

Sample

A total of 260 schoolchildren were selected, 93 Infant Education (average age = 4 years; height = 1.08 m; mass = 19.30 kg; BMI = 16.29 kg/ m^2) and 167 Primary Education (average age = 9.15 years; height = 1.40 m; mass = 37.06 kg; and BMI = 18.76 kg/ m^2). The sample selection was performed through a purposive sampling method according to the criteria of accessibility and proximity (Otzen & Manterola, 2017). The guardians signed a written consent to participate in the study and this study is approved by the ethics committee of the local entity.

Procedure

Assessment of 24-hour movement patterns including physical activity, sedentary behavior and sleep duration was conducted.

Physical Activity

Minutes of daily physical activity were determined using Garmin vivofit® jr. fitness wristbands (Garmin Ltd., Schaffhausen, Switzerland) for students aged 3 to 5 years and Xiaomi mi Band 4 Anhui Huami Information Technology Co., Ltd., China) for students aged 6 to 12 years. Both physical activity wristbands are wearable and designed for ages from 3 years old (Müller-Riemenschneider et al., 2017; Wang et al., 2017). The design of this wristband is comfortable, durable, and waterproof. The wearable device is paired with its app via a cell phone or tablet (APP Vivofit Jr. Ltd., Schaffhausen, Switzerland; and, Mi Fit, Anhui Huami Information Technology Co., Ltd., China; respectively). Both devices have been shown to be accurate in assessing physical activity in minutes or steps (Alsubheen et al., 2016; El-Amrawy & Nounou, 2015; Wang et al., 2017), being previously employed with early age populations (Gorny et al., 2017; Diaz-Quesada et al., 2021).

The participants wore the physical activity bracelet for seven consecutive days of a week of school routine, not taking it off either to sleep or to take a shower. Subsequently, the data from the application were consulted to obtain the average number of daily steps throughout the week. Students were considered to meet the physical activity recommendations when they performed a minimum of 13,000 steps (Cardon & De Bourdeaudhuij, 2007; Tanaka & Tanaka, 2009) (NASPE, 2014; Tremblay et al., 2016; Tremblay et al., 2017).

Sedentary Behavior

Sedentary behavior was assessed by means of the Health Behaviour in School-aged Children (HBSC) questionnaire validated in Spanish children and adolescents (Moreno et al., 2008). Participants had to respond to six items indicating the number of hours per day they spent watching television or Tablet, using a computer or cell phone and doing homework, both on weekends and during the week. This questionnaire was completed by the parent or guardian in the case of children between 3 and 6 years of age. The mean daily time spent in each sedentary behavior was calculated using a ratio of 5:2; that is: (daily time in sedentary behavior on weekdays (5 days) + (daily time in sedentary behavior on weekends (2 days) / 7 days). The daily sedentary behavior time was measured by summing the different daily sedentary time behaviors (Tapia-Serrano et al., 2022). Students were considered to meet the sedentary behavior recommendations when students aged 3 and 4 years spent less than 1 hour/day (Tremblay et al., 2017) and, students aged 5 to 12 years spent less than 2 hours/day (Tapia-Serrano et al., 2022; Tremblay et al., 2016).

Sleep Duration

The participants in the physical activity diary recorded the hours of sleep on each day of the week. In the case of children aged 3 to 6 years, these were completed by parents or guardians. The daily hours of sleep were calculated based on the ratio 5:2; that is: (hours of sleep during the week (5 days) + (hours of sleep at the weekend (2 days) / 7 days). Students were considered to meet the sleep recommendations when students aged 3 and 4 years accumulated between 10 and 13 hours

of sleep each day (Tremblay et al., 2017) and students aged 5 to 12 years accumulated between 9 and 11 hours of sleep each day (Tremblay et al., 2016).

Compliance With Recommendations

Participants were classified into one of eight possibilities based on their compliance with the 24h guidelines: 1) they did not meet any of the three guidelines; 2) they met only one guideline (physical activity, screen time or sleep duration); 3) they met two guidelines (physical activity + screen time; physical activity + sleep duration; screen time + sleep duration) or 4) they met all three 24 h guidelines assessed (physical activity screen time + sleep duration) based on previous studies (Tapia-Serrano et al., 2022).

Statistical Analysis

A descriptive analysis of the data was performed in the form of mean and standard deviation. Next, a Shapiro-Wilk normality test was performed which confirmed the non-normal distribution of the data. Next, a frequency analysis was performed to find out which participants met the individual 24-hour movement guidelines (met only sleep duration, met only physical activity, met only screen time, or met no recommendation) and in combination (met sleep duration + physical activity, met only sleep duration + screen time, met only physical activity + screen time, met only physical activity + screen time, or met all three recommendations). Subsequently, the variables were analyzed using the nonparametric Mann-Whitney U test, where the results are shown as mean and standard deviation, as well as the significance value *p*. The Mann-Whitney U test was used to observe the differences in the distribution of 24 h of movement between different times (all week, weekdays versus weekends and school hours versus after-school hours) between the Infant versus Primary stage, where physical activity, sedentary behavior and hours of sleep were evaluated. A confidence level of 95% was used for all analyses. The statistical program IBM SPSS Statistics 27.0 for Windows IBM Software (Group, Chicago, Illinois, United States) and the Jamovi program version 2.3.24 were used.

Results

Table 1 shows the compliance with the recommendations of 24 h of movement in terms of the eight possibilities of physical activity, sedentary behavior and hours of sleep.

Table 1
Compliance with the recommendations of 24h of movement for each of the eight situations (Infant versus Primary)

	Total (n = 260)	Infant (n = 93)	Primary (n = 167)	Difference Infant vs Primary (%)
Don't meet any of the 3 guidelines	0.40%	0.80%	0.00%	+ 0.80
They meet only 1 guideline	11.40%	11.40%	11.37%	+ 0.03
PA	78.46%	78.49%	78.44%	+ 0.05
Sedentary Behavior	79.60%	79.56%	79.64%	- 0.80
Sleep Duration	83.85%	83.87%	83.83%	+ 0.04
They meet only 2 guidelines	34.40%	34.50%	34.24%	+ 0.26
PA + SD	63.10%	63.44%	62.87%	+ 0.57
PA + SB	62.30%	62.36%	62.24%	+ 0.12
SD + SB	70.45%	69.90%	71.00%	- 1.1
Meet the 3 guidelines PA + SB + SD	53.83%	53.76%	53.90%	- 0.14

Note: PA: Physical Activity; SB: Sedentary Behavior; SD: Sleep Duration.

Compliance with the established recommendations is above 75%. Likewise, compliance with the three guidelines is above 50%. The compliance with the recommendations regarding the hours of sleep between the Infant and Primary stages stands out, with 83.8%. It is also observed that the Primary stage always shows a higher percentage than the Infant stage.

Table 2 shows the differences in the distribution of 24 hours of movement between the Early Childhood Education stage versus the Primary Education stage.

Table 2
Differences in the distribution of 24h of movement Infant stage versus Primary stage

Variable	Total (n = 260)	Infant (n = 93)	Primary (n = 167)	Value of *p*
Physical Activity				
The whole week (steps/day)	10947.20 ± 3780.99	9204.26 ± 2656.27	11917.8 ± 3967.97	< .001
Weekdays (M-F) (steps/day)	11235.65 ± 3948.41	9470.22 ± 3116.26	12218.79 ± 4027.85	< .001
Weekend (S-S) (steps/day)	10226.09 ± 4684.68	8539.34 ± 2985.94	11165.42 ± 5178.64	< .001
School hours (steps/day)	5120.77 ± 1473.62	4511.06 ± 960.09	5460.30 ± 1597.83	< .001
After school hours (steps/day)	6114.88 ± 3123.23	4959.16 ± 2788.70	6758.49 ± 3121.59	< .001
Sedentary Behavior				
The whole week (hours/day)	9.55 ± 5.26	7.45 ± 5.20	10.71 ± 4.93	< .001
Weekdays (M-F) (hours/day)	4.02 ± 3.16	3.34 ± 3.70	4.40 ± 2.76	< .001
Weekend (S-S) (hours/day)	5.52 ± 3.02	4.11 ± 2.76	6.31 ± 2.88	< .001
Sleep Hours				
The whole week (hours/day)	9.50 ± 0.75	9.30 ± 0.81	9.62 ± 0.70	.005
Weekdays (M-F) (hours/day)	9.47 ± 0.75	9.26 ± 0.82	9.58 ± 0.69	.057
Weekend (S-S) (hours/day)	9.59 ± 1.07	9.33 ± 1.07	9.74 ± 1.04	.004

In general, the Primary stage performs more physical activity, experiences higher values of sedentary behavior and consumes more hours of sleep compared to the Infant stage.

It was observed that, in terms of physical activity, in general, students in the infant stage performed less physical activity in steps/day compared to students in the primary stage throughout the week, with highly significant differences ($p < .001$) between the two stages. Regarding the steps taken in the variable's weekdays (M-F) (steps/day) and weekends (S-D) (steps/day), significant differences ($p < .001$) were observed between the different stages, where the Primary stage showed more steps taken at both times compared to the Infant stage. In the analysis of the variables school time (steps/day) and out-of-school time (steps/day), significant differences were also observed ($p < .001$), with students in the Primary stage performing more physical activity in steps/day both at school and out-of-school time compared to the Infant stage.

The results regarding sedentary behavior showed that students in primary school had higher values than those in infant school ($p < .001$). When analyzing the variables between weekdays (M-F) (hours/day) and weekends (S-D) (hours/day), significant differences were observed, where the Primary stage had more sedentary behavior in relation to the Infant stage, at both times.

The analysis of the hours of sleep showed significant differences between the different stages. In general, the primary school subjects obtained more hours of sleep during the week compared to the infant stage. The results showed significant differences in the analysis of the variable weekend (S-D) (hours/day) ($p = .004$), where the Primary stage slept more compared to the Infant stage. No significant differences in hours of sleep were found in the analysis of the midweek variable (M-F) (hours/day).

Discussion

The objectives of the present study were to analyze the level of compliance with the 24-hour movement patterns in schoolchildren (infant versus primary) and to determine the differences between different times of the week. The results indicate that compliance with the three movement patterns is above 53%, with physical activity, sedentary behavior and sleep individually above 75%. Relatively speaking, the infant stage has a lower volume of steps, but also less sedentary behavior than the participants in the primary stage, an aspect that can be seen both throughout the week and at the different times evaluated.

Knowing the behavior with respect to movement patterns can generate strategies that involve healthy lifestyle habits in the future. The results of this study are very interesting if it is established that they are Spanish population. Regarding the infant stage, 78.4%, 79.5% and 83.8% comply with the recommendations for physical activity, sedentary behavior and sleep, respectively (Table 1). Regarding physical activity, different studies indicate that physical activity compliance is around 30-90% (Berglind et al., 2018; Chaput et al., 2017; Cliff et al., 2017; Kracht et al., 2019). This range is very wide, mainly due to the country (Berglind et al., 2018; Chaput et al., 2017) or the measurement instrument (accelerometer or questionnaire) (Cliff et al., 2017; Walsh et al., 2018), so the results of this study are above 50-60% (Chaput et al., 2017; Chia et al., 2020) in children from Canada or Singapore and below that determined in countries such as the USA or Australia (Cliff et al., 2017; Kracht et al., 2019). In the same way, it happens with sedentary behavior, where most researches mark around 17-31% (Carson et al., 2017; Chaput et al., 2017; Chia et al., 2020; Cliff et al., 2017), the present results being in line with those found by Berling et al. (2018) and Roberts et al. (2017) between 63 and 70%. The importance of compliance with sleep recommendations is currently one of the most discussed issues, due to its implication in lifestyle habits acquired from an early age (Rollo et al., 2020; Tremblay et al., 2016). The results of 83% are in line with research conducted by other investigators, who place sleep compliance at around 70-98% (Berling et al., 2018; Chaput et al., 2017; Chia et al., 2020; Cliff et al., 2017). To highlight that sleep is an essential activity that interacts and modulates a psychic and physiological balance in the individual (Fabres & Moya, 2021) and, in children, its lack, can cause low cognitive functioning (Hirshkowitz et al., 2015). Regarding the primary school stage, the results of the present study obtained percentage values similar to those of children, both in physical activity (78.4%), sedentary behavior (79.9%) and sleep (83.8%), respectively. Here there are differences to those found in other studies in the population aged 8-11 years. Physical activity is around 20-44% in studies even attending to twelve different countries, while sedentary behavior compliance is reduced at these ages around 20-30% and sleep around 30-40% (Dumuid et al., 2018; Laurson et al., 2014; Sampasa-Kanyinga et al., 2017; Thiyel et al., 2019). It is obvious that the reasons for these differences can be very varied as discussed above, what is certain is that, although there are fewer longitudinal studies, it seems that as age advances, compliance with 24 h movement recommendations tends to decrease (Chong et al., 2022). In turn, for example, in terms of physical activity values, percentages to those found are around 78% closer to 89% analyzed by Manyanga et al. (2019) in a total of 683 children aged 9 to 11 years in Mozambique; highlighting those differences in terms of the geographical area of the world and sociocultural variability may be important factors to consider when observing the causes and generating future intervention strategies (Sampasa-Kanyinga et al., 2017).

It is true that, from a more global approach, 53% of the total sample of this study complied with the three movement patterns (Table 1). This fact is very relevant, since scientific evidence indicates, on the one hand, differential values between ages 3-4 years and 9-11 years, ranging from 13-30% (Chaput et al., 2017; Chia et al., 2020; Cliff et al., 2017) and 5-10% (Dumuid et al., 2018; Guerrero et al., 2019; Laurson et al., 2014; Sampasa-Kanyinga et al., 2017; Thivel et al., 2019), respectively. In the present study, the data are substantially above and also without age being a determinant. As highlighted above, it may be due to social, cultural, economic or geographical factors, which may have a determining influence on the child population, where although they have not been taken into account in the present research, they are a possibility for future analysis. But it is a value to highlight, because what is evidenced is that compliance with the 3 24h guidelines is associated with a better quality of life (Sampasa-Kanyinga et al., 2017), less impulsivity (Guerrero et al., 2019), as well as the high use of screens can lead to psychosocial problems (Chong et al., 2022).

Another important question to consider is to know what this behavior is like at different times of the week. In this sense, when contrasting the absolute values, the differences between educational stages are more evident (Table 2). Thus, it can be seen that the primary school stage obtains a greater volume of steps (about 12,000 steps per day compared to approximately 9,500 steps in the infant stage), the difference being statistically significant, not only throughout the week but also at the different times evaluated (Table 2). It is true that the steps developed by the Infant Stage, are in accordance with other studies that mark a value of 10,000 steps/day during the week, although with lower values of 8,000 steps/day at the weekend (De Craemer et al., 2018), being the trend at ages of approximately two years lower (Díaz-Quesada et al., 2021). Independent of this casuistry, both in physical activity and sedentary behavior, it is shown how at the weekend compliance with the recommendations tends to fall (Chong et al., 2022; De Craemer et al., 2018; Leppanen et al., 2019). Regarding sleep, no such clear differences are shown, with both groups having a duration between 9 and 11 hours at the different times evaluated. It is interesting to note that, normally, the hours of sleep at the weekend tend to be longer than during the week (Chong et al., 2022; Leppanen et al., 2019), although no such trend was observed in this sample. Although it is necessary to further delve into the behavior of movement patterns at different times, these results may contribute to generate strategies involving a healthier daily habit.

Finally, this study is not without some limitations. The small size and difficulty of accessing the child sample would be one of the limitations. Also, due to the nature of the study itself, as it is a cross-sectional study, causal relationships cannot be established.

Conclusions

It is concluded that compliance with the recommendations of 24 h of movement in terms of physical activity, sedentary behavior and sleep in the schoolchildren analyzed are above 75% in both stages. In addition, the Primary stage performs more physical activity, experiences higher values of sedentary behavior; being the hours of sleep similar to those of the Infant stage. This study can contribute to future intervention policies to promote behaviors according to the 24h movement guidelines from early ages, from an integrated and holistic approach.

Practical Applications

The findings obtained in this study may provide useful information that will contribute to raise awareness of the importance of achieving a balance between physical activity, control of sedentary behavior, and hours of sleep. Likewise, at the school level, this study serves as a reference point to encourage the creation of strategies and educational programs to increase the levels of physical activity in the different educational stages and to reduce sedentary behavior. Finally, this study reflects a current framework of the behavior of children at an early age throughout the week and serves as a reference for future action points in this regard.

Ethics Committee Statement

The study was performed following the ethical standards of the Declaration of Helsinki (1975) and was approved by the Ethics Committee of the University of Jaén (JUN.22/1.PRY, 7/7/2022).

Conflict of Interest Statement

The funding bodies or institutions had no influence on the design of the study, the analysis of the data or the interpretation of the results.

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Authors' Contribution

Conceptualization D.G.M., G.D.Q. & G.T.L.; Methodology G.D.Q. & G.T.L.; Software D.G.M., G.D.Q. & G.T.L.; Validation D.G.M. & G.D.Q.; Formal Analysis D.G.M. & G.D.Q.; Investigation D.G.M., G.D.Q. & G.T.L.; Resources D.G.M., G.D.Q. & G.T.L.; Data Curation D.G.M., G.D.Q. & G.T.L.; Writing – Original Draft D.G.M. & G.D.Q.; Writing – Review & Editing G.T.L.; Visualization G.T.L.; Supervision D.G.M., G.D.Q. & G.T.L.; Project Administration D.G.M., G.D.Q. & G.T.L.; Funding Acquisition G.T.L. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author (gmdiaz@ujaen.es).

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Cumplimiento de las Pautas de Movimiento de 24 Horas en Escolares: Etapa Infantil Versus Etapa Primaria

Compliance With 24-Hour Movement Patterns in Schoolchildren: Infant Versus Primary Stage

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Resumen

Tanto la actividad física, como la conducta sedentaria y el sueño, son los tres principales comportamientos que interactúan durante el día. El objetivo del presente estudio fue, por un lado, analizar el nivel de cumplimiento de las 24 horas de movimiento en escolares (Infantil versus Primaria) y por otro determinar las diferencias entre diferentes momentos de la semana. La muestra estaba formada por 260 escolares (93 de la etapa Infantil y 167 de la etapa Primaria). Se llevó a cabo la evaluación de las 24 horas de movimiento que incluye; la actividad física, conducta sedentaria y sueño. El tiempo de actividad física se determinó por medio de una pulsera de actividad física durante 7 días; el tiempo de conducta sedentaria por medio de cuestionario (Cuestionario de conducta sedentaria en el tiempo libre) a lo largo de la semana, al igual que las horas de sueño por medio de diario semanal. De los resultados destaca el cumplimiento de las recomendaciones de 24 horas de movimiento por encima del 75%. Además, la etapa Primaria realiza más actividad física, experimenta mayores valores de conducta sedentaria y consume más horas de sueño respecto a la etapa Infantil. Se concluye incrementar los niveles de actividad física desde edades tempranas y llevar un control más estricto de la conducta sedentaria diaria y de las horas de sueño.

Palabras clave: Actividad física, sedentarismo, sueño, recomendaciones, escolares.

Abstract

Physical activity, sedentary behavior and sleep are the three main behaviors that interact during the day. The objective of the present study was, on the hand, to analyze the level of compliance with the 24 hours of movement in schoolchildren (pre-school versus primary school) and, on the other hand, to determine the differences between different times of the week. The sample consisted of 260 schoolchildren (93 from the infant stage and 167 from the primary stage). The 24 hours movement assessment was carried out including; physical activity, sedentary behavior and sleep. Physical activity time was determined by means of a questionnaire (Leisure Time Sedentary Behavior Questionnaire) throughout the week, as well as the hours of sleep by means of a weekly diary. From the results, compliance with the recommendations of 24 hours of movement was over 75%. In addition, the Primary stage performs more physical activity, experiences higher levels of sedentary behavior and gets more hours of sleep compared to the Infant stage. The conclusion is to increase physical activity levels from an early age and to keep a stricter control of daily sedentary behavior and sleep hours.

Keywords: Physical activity, sedentarism, sleep, recommendations, schoolchildren.

Introducción

Los beneficios de la realización de la actividad física en la prevención o reducción de enfermedades han sido reconocidos por la literatura científica en la etapa adolescente, en especial, a intensidades moderadas (ej., caminar a un ritmo rápido) o vigorosas (ej., jugar un partido de baloncesto) (Bull et al., 2020; Poitras et al., 2016).

De acuerdo a las recomendaciones más reconocidas de salud, para las edades comprendidas entre 6 y 17 años se recomienda realizar 60 min de actividad física moderada a vigorosa (AFMV), de acuerdo al centro de control y prevención de enfermedades y a las directrices de EE.UU. Por otro lado, las directrices marcadas por el Reino Unido y la U.E. Physical Activity Guidelines establecieron que, para edades inferiores a cinco años, se recomienda que un niño realice 60 min de AFMV al día (Department of Health, Physical Activity, Health Improvement and Protection, 2011; Education and Culture of European Commission. EU Physical Activity Guidelines, 2008) y 180 min de actividad física total al día, de acuerdo a la Organización Mundial de la Salud (OMS, 2019). En este sentido, de acuerdo a Miraflores et al. (2016), en niños de 3 a 6 años, se ha determinado que deben realizar 3 horas de actividad física al día, de cualquier intensidad y en los diferentes ámbitos. Se considera como alternativa el medir la actividad física en volumen de pasos, con recomendaciones en torno a los 13,000 pasos diarios para estas edades (Cardon & De Bourdeaudhuij, 2007; Tanaka & Tanaka, 2009).

Se ha constituido que la adopción de un estilo de vida saludable, caracterizado por niveles elevados de actividad física, poco tiempo frente a la pantalla y una duración óptima del sueño proporciona más beneficios para la salud que la adopción de uno solo de estos comportamientos (Carson et al., 2017; Chaput et al., 2014). Estas pautas de salud se han estudiado normalmente de forma aislada, pero, sin embargo, hay pruebas convincentes de que estas conductas relacionadas con el movimiento, interactúan a lo largo del día (24 horas) (Janssen et al., 2017; Poitras et al., 2016; Saunders et al., 2016). El tiempo dedicado a la actividad física interacciona inevitablemente y de forma excluyente con el tiempo sedentario y de sueño (Chaput et al., 2014). Por consiguiente, tanto la actividad física, conducta sedentaria y el sueño son los comportamientos principales que interaccionan durante el día. En esta línea, teniendo en cuenta el tiempo que contiene un día y atendiendo a la veracidad científica, autores como Tremblay et al. (2016) elaboraron, para un uso saludable de las 24 horas diarias, las siguientes recomendaciones en cuanto a conducta sedentaria y sueño: tiempo de pantalla recreativa (< 2 horas) y duración de sueño (9-11 horas en niños entre 5 y 13 años). En cambio, para la etapa de 3 a 6 años, según Ramos Berzosa (2021), el tiempo de conducta sedentaria debe ser menor a 1 hora al día. Además, según la American Academy of Pediatrics (A.A.P, 2016), la cantidad de sueño diario para niños de 3 a 5 años es de 10 a 13 horas. De esta forma, atender a una visión holística del comportamiento a lo largo de las 24 h pueden emplearse como indicadores de salud (Rollo et al., 2020; Tremblay et al., 2016), asociados principalmente a beneficios a nivel físico, psicológico y cognitivo en niños y adolescentes (Carson et al., 2016; Chaput et al., 2016; Lissak, 2018; Poitras et al., 2016; Rollo et al., 2020; Tarokh et al., 2016; Wu et al., 2017). Más concretamente, un cumplimiento de manera conjunta de las recomendaciones de movimiento de 24 horas (actividad física, conducta sedentaria y duración del sueño) se han asociado con beneficios adicionales en la salud, especialmente con una mayor calidad de vida, alimentación, condición física, adiposidad y salud mental y social (Carson et al., 2017; Janssen et al., 2017; Lee et al., 2018; Rollo et al., 2020; Walsh et al., 2018).

Sin embargo, pese a los beneficios de forma independientes y combinada de estos tres comportamientos que interaccionan durante las 24 horas de un día, un gran porcentaje de jóvenes no cumplen las recomendaciones diarias (Tremblay et al., 2016). Recientemente, un estudio realizado en más de 140 países, mostró que más del 75% de adolescentes entre 11 y 17 años no cumplen las recomendaciones internacionales de actividad física, es decir, solo 1 de cada 4 jóvenes (Guthold et al., 2020).

El porcentaje de incumplimiento puede incrementar notablemente cuando se examina las tres recomendaciones de movimiento de 24 h de forma conjunta (Tapia-Serrano et al., 2022), especialmente en la transición de educación primaria a secundaria (Chong et al., 2022). En este sentido, en un metaanálisis realizado por autores como Tapia-Serrano et al. (2022), con una muestra de 387,437 jóvenes procedentes de 63 estudios y 23 países, mostró que solamente un 11% de preescolares, el 10% de los niños y tan solo un 3% de los adolescentes cumplen las tres recomendaciones (actividad física, conducta sedentaria y sueño). Además, cabe destacar que solo un 9% de los preescolares, un 16% de los niños y un 28% de los adolescentes no cumplieron con ninguna de las tres recomendaciones anteriores. En este sentido, diversos estudios han mostrado los beneficios que tiene la actividad física en los niños, pero, se han realizado pocas investigaciones en edades inferiores a los tres años (Díaz-Quesada et al., 2021).

A su vez, sería interesante conocer en qué momentos se cumplen de una manera más manifiesta estas recomendaciones. Entre otras circunstancias, porque el colegio se ha considerado un lugar idóneo para la promoción de la práctica de actividad física y así conseguir alcanzar las recomendaciones diarias desde edades tempranas (Martínez-Gómez et al., 2014); indicándose incluso, como el contexto donde desarrollar la mitad del tiempo diario de actividad física (Pate et al., 2006). Y es que, se ha demostrado que el rendimiento académico se puede mejorar a través de la actividad física en la escuela (Carriedo & González, 2019).

Así, en la literatura científica se ha llegado a demostrar que los niños en edad preescolar que asisten regularmente a la escuela, realizan la misma cantidad de AFMV que los que no van al colegio (Statler et al., 2020). Por consiguiente, los niños tienen un mayor nivel de actividad física fuera del horario escolar que en el tiempo lectivo (Pate et al., 2006). En esta línea, diferentes estudios también han demostrado que los niños en edad preescolar realizan más AFMV los días laborables en comparación con los días de fin de semana (Roscoe et al., 2019). Otro estudio ha reflejado que los niños chinos en edades preescolares pasaron significativamente más tiempo realizando actividad física vigorosa los días laborables que los fines de semana (Ji et al., 2018). Sin embargo, la mayoría de los estudios que examinan el nivel de intensidad de actividad física se centran en las etapas educativas de primaria y secundaria, mientras que los estudios en edades más tempranas siguen siendo escasos, a pesar de los beneficios para la salud de la actividad física en los niños más pequeños (González-Díaz et al., 2017). Por otro lado, se ha prestado menos atención empírica a los niños españoles en este contexto (Díaz-Quesada et al., 2022). A su vez, falta información sobre qué ocurre según la etapa educativa analizada, no solo en lo que respecta a actividad física, sino también a la conducta sedentaria y el sueño.

Por lo tanto, los objetivos del presente estudio son: a) Analizar el nivel de cumplimiento de

las pautas de 24 horas de movimiento en escolares (actividad física, conducta sedentaria y sueño en Infantil versus Primaria y, b) Determinar las diferencias entre diferentes momentos de la semana (toda la semana, entre semana, fin de semana, horario escolar, horario extraescolar).

Método

Muestra

Se seleccionaron un total de 260 escolares (146 niños y 114 niñas), 93 de Educación Infantil (edad promedio = 4 años; talla = 1.08 m; masa = 19.30 kg; IMC = 16.29 kg/ m^2) y 167 Educación Primaria (edad promedio = 9.15 años; talla = 1.40 m; masa = 37.06 kg; e IMC = 18.76 kg/ m^2). La selección de la muestra se realizó a través de un método de muestreo intencional de acuerdo con los criterios de accesibilidad y proximidad (Otzen & Manterola, 2017). Los tutores firmaron un consentimiento por escrito para participar en el estudio y este estudio está aprobado por el comité de ética de la entidad local.

Procedimiento

Se llevó a cabo la evaluación de las pautas de 24 horas de movimiento incluyendo la actividad física, la conducta sedentaria y la duración del sueño.

Actividad Física

Se determinaron los minutos de actividad física diaria empleando las pulseras de actividad física Garmin vivofit® jr. (Garmin Ltd., Schaffhausen, Switzerland) para el alumnado de 3 a 5 años y Xiaomi mi Band 4 Anhui Huami Information Technology Co., Ltd., China) para el alumnado de 6 a 12 años. Ambas pulseras de actividad física son portátiles y están diseñadas para edades desde los tres años de edad (Müller-Riemenschneider et al., 2017; Wang et al., 2017). El diseño de esta pulsera es cómodo, duradero e impermeable. El dispositivo portátil está emparejado con su aplicación a través de un teléfono móvil o una Tablet (APP Vivofit Jr. Ltd., Schaffhausen, Suiza; y, Mi Fit, Anhui Huami Information Technology Co., Ltd., China; respectivamente). Ambos dispositivos han demostrado ser precisos para evaluar la actividad física en min o pasos (Alsubheen et al., 2016; El-Amrawy & Nounou, 2015; Wang et al., 2017), siendo previamente empleado con poblaciones de edades tempranas (Gorny et al., 2017; Díaz-Quesada et al., 2021).

Los participantes portaron la pulsera de actividad física durante siete días consecutivos de una semana de rutina escolar, no quitándosela ni para dormir ni para la ducha. Posteriormente se consultaban los datos de la aplicación para obtener la media de pasos diarios a lo largo de toda la semana. Se consideró que el alumnado cumplía las recomendaciones de actividad física cuando realizaban un mínimo 13,000 pasos (Cardon & De Bourdeaudhuij, 2007; Tanaka & Tanaka, 2009) (NASPE, 2014; Tremblay et al., 2016; Tremblay et al., 2017).

Conducta Sedentaria

La conducta sedentaria se evaluó por medio del cuestionario *Health Behaviour in School-aged Children* (HBSC) validado en niños y adolescentes españoles (Moreno et al., 2008). Los participantes tuvieron que responder a seis ítems indicando el número de horas diarias que dedicaban a ver la televisión o Tablet, uso de ordenador o móvil y realizando deberes, tanto en fin de semana como entre semana. Este cuestionario fue completado por el progenitor o tutor en el caso de los niños entre los 3 y 6 años de edad. El tiempo medio diario dedicado a cada comportamiento sedentario se calculó utilizando una proporción de 5:2; es decir: (el tiempo diario en conducta sedentaria entre semana (5 días) + (el tiempo diario en conducta sedentaria fin de semana (2 días) / 7 días). El tiempo de conducta sedentaria diaria se midió sumando los diferentes comportamientos de tiempo sedentario diario (Tapia-Serrano et al., 2022). Se consideró que el alumnado cumplía las recomendaciones de conducta sedentaria cuando el alumnado de 3 y 4 años pasaba menos de 1 hora/día

(Tremblay et al., 2017) y, el alumnado de 5 a 12 años pasaba menos de 2 horas/día (Tapia-Serrano et al., 2022; Tremblay et al., 2016).

Duración del Sueño

Los participantes en el diario de actividad física anotaron las horas de sueño cada uno de los días de la semana. En el caso de los niños/as de 3 a 6 años, las mismas fueron completadas por los progenitores o tutores. Las horas de sueño diarias se calcularon en base a la proporción 5:2; es decir: (horas de sueño entre semana (5 días) + (horas de sueño en el fin de semana (2 días) / 7 días). Se consideró que el alumnado cumplía las recomendaciones de sueño cuando el alumnado de 3 y 4 años acumulaba entre 10 y 13 horas de sueño cada día (Tremblay et al., 2017) y el alumnado de 5 a 12 años acumulaba entre 9 y 11 horas de sueño cada día (Tremblay et al., 2016).

Cumplimiento de Recomendaciones

Se clasificó a los participantes en una de las ocho posibilidades en función de su cumplimiento de las pautas de 24 h: 1) no cumplían ninguna de las tres pautas; 2) cumplían una sola pauta (actividad física, tiempo de pantalla o duración del sueño); 3) cumplían dos pautas (actividad física + tiempo de pantalla; actividad física + duración del sueño; tiempo de pantalla + duración sueño) o 4) cumplían las tres pautas de 24 h evaluadas (actividad física tiempo de pantalla + duración del sueño) en función de estudios anteriores (Tapia-Serrano et al., 2022).

Análisis Estadístico

Se realizó un análisis descriptivo de los datos en forma de media y desviación típica. Seguidamente, se efectuó una prueba de normalidad de Shapiro-Wilk la cual confirmó la no distribución normal de los datos. A continuación, se llevó a cabo un análisis de frecuencias para saber los participantes que cumplían las pautas de 24 horas de movimiento individuales (cumplían solo la duración del sueño, cumplían solo la actividad física, cumplían solo el tiempo de pantalla o no cumplían ninguna recomendación) y en combinación (cumplían la duración del sueño + actividad física, cumplían solo la duración del sueño + tiempo de pantalla, cumplían solo actividad física + tiempo de pantalla o cumplían las tres recomendaciones). Posteriormente, se analizaron las variables mediante la prueba no paramétrica U de Mann-Whitney, donde los resultados se muestran como media y desviación típica, así como el valor de significación *p*. La prueba U de Mann-Whitney se utilizó para observar las diferencias de la distribución de 24 h de movimiento entre distintos momentos (toda la semana, entre semana versus fin de semana y horario escolar versus horario extraescolar) entre la etapa de Infantil versus etapa de Primaria, donde se evaluó la actividad física, la conducta sedentaria y las horas de sueño. Para todos los análisis se empleó un nivel de confianza del 95%. Se utilizó el programa estadístico IBM SPSS Statistics 27.0 para Windows IBM Software (Group, Chicago, Illinois, United States) y el programa Jamovi versión 2.3.24.

Resultados

En la Tabla 1 se observa el cumplimiento de las recomendaciones de 24 h de movimiento en cuanto a las ocho posibilidades de actividad física, conducta sedentaria y horas de sueño.

Tabla 1
Cumplimiento de las recomendaciones de 24h de movimiento de cada una de las ocho situaciones (Infantil versus Primaria)

	Total (n = 260)	Infantil (n = 93)	Primaria (n = 167)	Diferencia Infantil vs Primaria (%)
No cumplen ninguna de las 3 pautas	0.40%	0.80%	0.00%	+ 0.80
Cumplen solo 1 pauta	11.40%	11.40%	11.37%	+ 0.03
AF	78.46%	78.49%	78.44%	+ 0.05
Conducta Sedentaria	79.60%	79.56%	79.64%	- 0.80
Duración del sueño	83.85%	83.87%	83.83%	+ 0.04
Cumplen solo 2 pautas	34.40%	34.50%	34.24%	+ 0.26
AF + DS	63.10%	63.44%	62.87%	+ 0.57
AF + CS	62.30%	62.36%	62.24%	+ 0.12
DS + CS	70.45%	69.90%	71.00%	- 1.1
Cumplen las 3 pautas AF + DS + TP	53.83%	53.76%	53.90%	- 0.14

Nota: AF: Actividad Física; CS: Conducta Sedentaria; DS: Duración Sueño.

Se observa el cumplimiento de las recomendaciones establecidas por encima del 75%. De igual forma, resulta destacable el cumplimiento de las tres pautas por encima del 50%. Destaca el cumplimiento de las recomendaciones de las horas de sueño entre la etapa Infantil y etapa Primaria, con un 83.8%. También, se observa como la etapa Primaria, siempre arroja un porcentaje más elevado respecto a la etapa Infantil.

En la Tabla 2 se representan las diferencias de la distribución de 24 horas de movimiento entre la etapa de Educación Infantil versus la etapa de Educación Primaria.

Tabla 2
Diferencias de la distribución de 24h de movimiento Etapa Infantil versus Etapa Primaria

Variable	Total (n = 260)	Infantil (n = 93)	Primaria (n = 167)	Valor de *p*
Actividad Física				
Toda la semana (pasos/día)	10947.20 ± 3780.99	9204.26 ± 2656.27	11917.8 ± 3967.97	< .001
Entre semana (L-V) (pasos/día)	11235.65 ± 3948.41	9470.22 ± 3116.26	12218.79 ± 4027.85	< .001
Fin de semana (S-D) (pasos /día)	10226.09 ± 4684.68	8539.34 ± 2985.94	11165.42 ± 5178.64	< .001
Horario escolar (pasos/día)	5120.77 ± 1473.62	4511.06 ± 960.09	5460.30 ± 1597.83	< .001
Horario extraescolar (pasos/día)	6114.88 ± 3123.23	4959.16 ± 2788.70	6758.49 ± 3121.59	< .001
Conducta Sedentaria				
Toda la semana (horas/día)	9.55 ± 5.26	7.45 ± 5.20	10.71 ± 4.93	< .001
Entre semana (L-V) (horas/día)	4.02 ± 3.16	3.34 ± 3.70	4.40 ± 2.76	< .001
Fin de semana (S-D) (horas/día)	5.52 ± 3.02	4.11 ± 2.76	6.31 ± 2.88	< .001
Horas de Sueño				
Toda la semana (horas/día)	9.50 ± 0.75	9.30 ± 0.81	9.62 ± 0.70	.005
Entre semana (L-V) (horas/día)	9.47 ± 0.75	9.26 ± 0.82	9.58 ± 0.69	.057
Fin de semana (S-D) (horas/día)	9.59 ± 1.07	9.33 ± 1.07	9.74 ± 1.04	.004

En general, la etapa Primaria realiza más actividad física, experimenta mayores valores de conducta sedentaria y consume más horas de sueño respecto a la etapa Infantil.

Se observa que, en actividad física, en general, el alumnado de la etapa Infantil realiza menos actividad física en pasos/día en comparación a los alumnos/as de la etapa Primaria a lo largo de toda la semana, existiendo diferencias altamente significativas ($p < .001$) entre ambas etapas. En cuanto a los pasos realizados en las variables entre semana (L-V) (pasos/día) y fin de semana (S-D) (pasos /día), se observaron diferencias significativas ($p < .001$) entre las distintas etapas, donde la etapa Primaria mostraba realizar más pasos en ambos momentos respecto a la etapa Infantil. En el análisis las variables horario escolar (pasos/día) y horario extraescolar (pasos/día), de igual forma se observaron diferencias significativas ($p < .001$), los alumnos/as de la etapa Primaria realizaban más actividad física en pasos/día tanto en horario escolar como extraescolar respecto a la etapa Infantil.

Los resultados referentes a conducta sedentaria mostraron que el alumnado de Primaria obtiene valores más altos respecto a la etapa Infantil ($p < .001$). Al analizar las variables entre semana (L-V) (horas/día) y fin de semana (S-D) (horas/día), se observaron diferencias significativas, donde la etapa Primaria realizaba más conducta sedentaria en relación a la etapa Infantil, en ambos momentos.

El análisis de las horas de sueño mostró diferencias significativas entre las distintas etapas. En general, los sujetos de Primaria obtuvieron más horas de sueño a lo largo de la semana respecto a la etapa Infantil. Los resultados mostraron diferencias significativas en el análisis de la variable fin de semana (S-D) (horas/día) ($p = .004$), donde la etapa Primaria dormía más respecto a la etapa Infantil. No se encontraron diferencias significativas en horas de sueño en el análisis de la variable entre semana (L- V) (horas/día).

Discusión

Los objetivos del presente estudio fueron analizar el nivel de cumplimiento de las pautas de 24 h de movimiento en escolares (Infantil versus Primaria) y determinar las diferencias entre diferentes momentos de la semana. Los resultados indican un cumplimiento de los patrones de las tres pautas de movimiento por encima del 53%, estando de manera indivi-

dual actividad física, conducta sedentaria y sueño por encima del 75%. De manera relativa, la Etapa de Infantil tiene menos volumen de pasos, pero también menos conducta sedentaria que los participantes de la Etapa de Primaria, aspecto que se vislumbra tanto en toda la semana como en los diferentes momentos evaluados.

Conocer el comportamiento respecto a los patrones de movimiento puede generar estrategias que impliquen hábitos de vida saludables en el futuro. Los resultados de este estudio son muy interesantes si se establece que son población española. Respecto a la Etapa de Infantil, se observa cómo el 78.4%, 79.5% y 83.8% cumplen las recomendaciones de actividad física, conducta sedentaria y sueño respectivamente (tabla 1). En cuanto a la actividad física, son diferentes los estudios que indican que el cumplimiento de actividad física está en torno al 30-90% (Berglind et al., 2018; Chaput et al., 2017; Cliff et al., 2017; Kracht et al., 2019). Este rango es muy amplio, debido fundamentalmente al país (Berglind et al., 2018; Chaput et al., 2017) o el instrumento de medida (acelerómetro o cuestionario) (Cliff et al., 2017; Walsh et al., 2018), por lo que los resultados de este estudio están por encima del 50-60% (Chaput et al., 2017; Chia et al., 2020) en niños de Canadá o Singapur y por debajo de lo determinado en países como EEUU o Australia (Cliff et al., 2017; Kracht et al., 2019). De la misma forma, ocurre con la conducta sedentaria, donde la mayoría de las investigaciones marcan en torno al 17-31% (Carson et al., 2017; Chaput et al., 2017; Chia et al., 2020; Cliff et al., 2017), estando los presentes resultados en consonancia con los hallados por Berling et al. (2018) y Roberts et al. (2017) entre el 63 y 70%. La importancia del cumplimiento de las recomendaciones respecto al sueño es actualmente una de las cuestiones más tratadas, por su implicación en los hábitos de vida que se adquieren desde edades tempranas (Rollo et al., 2020; Tremblay et al., 2016). Los resultados del 83% están acordes a las investigaciones realizadas por otros investigadores, que sitúan cumplimiento en sueño en torno al 70-98% (Berling et al., 2018; Chaput et al., 2017; Chia et al., 2020; Cliff et al., 2017). Resaltar que el sueño es una actividad imprescindible que interactúa y modula un balance psíquico y fisiológico en el individuo (Fabres & Moya, 2021) y, en niños, su falta, puede ocasionar bajo funcionamiento cognitivo (Hirshkowitz et al., 2015). En cuanto a la Etapa de Primaria, los resultados del presente estudio, obtienen valores porcentuales similares a la edad infantil, tanto en actividad física (78.4%), conducta sedentaria (79.9%) y sueño (83.8%) respectivamente. Aquí si existen diferencias a lo encontrado por otros estudios en población en torno a los 8-11 años. La actividad física se sitúa en torno al 20-44% en estudios incluso atendiendo a doce países diferentes, mientras que el cumplimiento de la conducta sedentaria se reduce en estas edades en torno al 20-30% y el sueño en torno al 30-40% (Dumuid et al., 2018; Laurson et al., 2014; Sampasa-Kanyinga et al., 2017; Thiyel et al., 2019). Es obvio que los motivos de estas diferencias pueden ser muy variados como se ha comentado anteriormente, lo que si es cierto es que, aunque existen menos estudios de carácter longitudinal, parece que según avanza la edad, el cumplimiento de las recomendaciones de movimiento de 24h tiende a disminuir (Chong et al., 2022). A su vez, por ejemplo, en cuanto a los valores de actividad física, porcentajes a los hallados están en torno al 78% más cercano al 89% analizado por Manyanga et al. (2019) en un total de 683 niños de entre 9 y 11 años de Mozambique; poniendo de manifiesto que las diferencias en cuanto a la zona geográfica del mundo y la variabilidad sociocultural pueden ser factores importantes a tener en cuenta a la hora de observar las causas y generar estrategias de intervención de futuro (Sampasa-Kanyinga et al., 2017).

Si es cierto, que, desde un enfoque más global, la muestra total de este estudio cumple las tres pautas de movimiento en un 53% (tabla 1). Este hecho si es muy relevante, ya que las evidencias científicas indican, por un lado, valores diferenciales entre edades de 3-4 años y 9-11 años, situándose en rangos de 13 al 30% (Chaput et al., 2017; Chia et al., 2020; Cliff et al., 2017;) y 5-10% (Dumuid et al., 2018; Guerrero et al., 2019; Laurson et al., 2014; Sampasa-Kanyinga et al., 2017; Thivel et al., 2019), respectivamente. En el presente estudio los datos están sustancialmente por encima y además sin que la edad sea determinante. Como se ha destacado anteriormente, puede deberse a factores sociales, culturales, económicos o geográficos, que pueden influir de manera determinante en la población infantil, donde a pesar de que no se han tenido en cuenta en la presente investigación, si son una posibilidad de análisis en el futuro. Pero si es un valor a destacar, porque lo que sí está evidenciado es que el cumplimiento de las 3 pautas de 24 h está asociado con una mejor calidad de vida (Sampasa-Kanyinga et al., 2017), menos impulsividad (Guerrero et al., 2019), así como el alto uso de pantallas puede acarrear problemas de carácter psicosocial (Chong et al., 2022).

Otra de las cuestiones importantes a considerar, es conocer, cómo es este comportamiento en diferentes momentos de la semana. En este sentido, al contrastar los valores de forma absoluta, las diferencias entre etapas educativas son más patentes (tabla 2). Así, se observa como la Etapa de Primaria obtiene un mayor volumen, cerca de 12,000 pasos al día frente a los aproximadamente 9,500 pasos de la Etapa de Infantil), siendo estadísticamente significativa la diferencia, no solo a lo largo de la semana sino en los distintos momentos evaluados (tabla 2). Es cierto que los pasos desarrollados por la Etapa de Infantil, están acorde a otros estudios que marcan un valor de 10,000 pasos/día entre semana, aunque con valores más bajos de 8,000 pasos/día en el fin de semana (De Craemer et al., 2018), siendo la tendencia en edades de aproximadamente dos años más bajos (Díaz-Quesada et al., 2021). Independiente de esta casuística, tanto en actividad física como en conducta sedentaria, se muestra como en el fin de semana suele caer el cumplimiento de las recomendaciones (Chong et al., 2022; De Craemer et al., 2018; Leppanen et al., 2019). Respecto al sueño, no se muestran unas diferencias tan patentes, estando ambos grupos con una duración entre 9 y 11 horas en los diferentes momentos evaluados. Es curioso de resaltar, que, nor-

malmente las horas de sueño en el fin de semana tiende a ser mayor que en entre semana (Chong et al., 2022; Leppanen et al., 2019), aunque en esta muestra no se ha observado tal tendencia. Aunque sea necesario seguir profundizando en el comportamiento de los patrones de movimiento en diferentes momentos, estos resultados pueden contribuir a generar estrategias que impliquen un hábito diario más saludable.

Por último, este estudio no está exento de algunas limitaciones. El escaso tamaño y dificultad de poder acceder a la muestra infantil sería una de las limitaciones. También, la propia naturaleza del estudio, al tratarse de un estudio transversal, no se pueden establecer relaciones de causalidad.

Conclusiones

Se concluye que el cumplimiento de las recomendaciones de 24 h de movimiento en cuanto a actividad física, conducta sedentaria y sueño en los escolares analizados están por encima del 75% en ambas etapas. Además, la etapa Primaria realiza más actividad física, experimenta mayores valores de conducta sedentaria; siendo las horas de sueño similar a los de la Etapa de Infantil. Este estudio puede contribuir a las futuras políticas de intervención para promover los comportamientos según las directrices de movimiento 24 h desde edades tempranas, desde un enfoque integrado y holístico.

Aplicaciones Prácticas

Los hallazgos obtenidos en este estudio pueden proporcionar información de gran utilidad que contribuya a tomar conciencia de la importancia que tiene conseguir un equilibrio entre la realización de actividad física, control de la conducta sedentaria, así como las horas de sueño. Asimismo, a nivel escolar, este estudio sirve de punto de referencia para que se fomente la creación de estrategias y programas educativos que aumenten los niveles de actividad física en las diferentes etapas educativas y se reduzca los valores de conducta sedentaria. Por último, este estudio refleja un marco actual del comportamiento que tienen los niños/as en edades tempranas a lo largo de la semana y sirve de referencia para futuros puntos de actuación al respecto.

Declaración del Comité de Ética

El estudio se realizó siguiendo las normas éticas de la Declaración de Helsinki (1975) y fue aprobado por el Comité de Ética de la Universidad de Jaén (JUN.22/1.PRY, 7/7/2022).

Conflicto de Intereses

Las entidades/instituciones no tuvieron influencia en el diseño del estudio, en el análisis de los datos o en la interpretación de los resultados.

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Contribución de los Autores

Conceptualization D.G.M., G.D.Q. & G.T.L.; Methodology G.D.Q. & G.T.L.; Software D.G.M., G.D.Q. & G.T.L.; Validation D.G.M. & G.D.Q.; Formal Analysis D.G.M. & G.D.Q.; Investigation D.G.M., G.D.Q. & G.T.L.; Resources D.G.M., G.D.Q. & G.T.L.; Data Curation D.G.M., G.D.Q. & G.T.L.; Writing – Original Draft D.G.M. & G.D.Q.; Writing – Review & Editing G.T.L.; Visualization G.T.L.; Supervision D.G.M., G.D.Q. & G.T.L.; Project Administration D.G.M., G.D.Q. & G.T.L.; Funding Acquisition G.T.L. Todos los autores han leído y están de acuerdo con la versión publicada del manuscrito.

Declaración de Disponibilidad de Datos

Datos disponibles bajo demanda al autor de correspondencia (gmdiaz@ujaen.es).

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Analysis of Body Composition and Physical Fitness in a Population of Students With Down Syndrome: a Trend Study (10 Years) in two Different Periods and Subject Groups

Análisis de la Composición Corporal y Condición Física en una Población de Estudiantes con Síndrome de Down: un Estudio de Tendencia (10 años) en dos Periodos y Grupo de Sujetos Distintos

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Abstract

The aim of this study was to analyze the body composition and physical fitness of a population of students with Down syndrome at two time points (in 2009 and 2019) and different subject groups. It is a trend study that examines the relationship between body composition, physical fitness, and age in a population divided into two groups based on a 10-year interval between evaluations. The results indicate a positive correlation of hip circumference in both groups of women, albeit weaker in 2019 compared to 2009. Men show weaker relationships in 2019 compared to 2009. Physical fitness in women exhibits a somewhat unpredictable trend, with maximum VO2 showing a negative relationship only in 2019, unlike dynamometry, where the positive relationship is observed only in the 2009 group. Men show that flexibility and abdominal capacity have positive relationships in the 2009 group, contrasting with maximum VO2 where the negative relationship is present in 2019. In conclusion, body composition exhibits somewhat unpredictable behavior over time, while physical fitness shows a more homogeneous trend.

***Keywords*:** Physical capacity, anthropometry, special population and genotype.

Resumen

El objetivo del estudio fue analizar la composición corporal y la condición física de una población de estudiantes con Síndrome de Down en dos momentos (año 2009 y 2019) y grupos de sujetos distintos. Es una investigación de tendencia, que relaciona la composición corporal, condición física y edad en una población dividida en dos grupos diferenciados por 10 años de cuando habían sido evaluados. Los resultados hacen referencia a la correlación positiva del perímetro de cadera en ambos grupos de mujeres, se ve menor relación en el año 2019 con respecto al 2009. Los hombres muestran relaciones menores en el 2019 en contraste con el 2009. La condición física en las mujeres tiene una tendencia poco predecible, el VO2 máximo tiene una relación negativa solo en el año 2019, a diferencia de la dinamometría, donde la relación positiva se observa únicamente en el grupo de 2009. Los hombres muestran que la flexibilidad y la capacidad abdominal tienen relaciones positivas en el grupo 2009. Caso contrario con el VO2 máximo donde la relación negativa está presente en el 2019. En conclusión la composición corporal exhibe un comportamiento poco predecible a lo largo del tiempo, en cambio la condición física tiene una tendencia homogénea.

Palabras clave: Capacidad física, antropometría, población especial y genotipo.

Introduction

Down syndrome (DS) is one of the most prevalent genetic anomalies worldwide, with an estimated incidence of approximately 1 in 1000 live births (Rodriguez et al., 2019). DS occurs when an individual has an extra copy of chromosome 21, resulting in both genotypic and phenotypic traits. Genotypically, individuals with DS typically have trisomy 21, meaning they possess three copies of chromosome 21 rather than the usual two. Phenotypically, DS manifests in observable characteristics shaped by both genetic expression and environmental interactions (Jojoa-Acosta et al., 2021).

DS is associated with distinct phenotypic features, such as hypotonia, joint hypermobility, ocular alterations, and gastrointestinal disorders (Pino et al., 2021), Alterations in some higher executive functions, such as attention and memory, have also been observed (Vega-Díaz & González-García, 2020). These conditions, combined with lifestyle factors, make overweight and obesity prevalent within this population (De la Piedra et al., 2017). Additionally, DS individuals often exhibit sedentary lifestyles and low physical fitness levels (Martínez-Espinoza et al., 2020).

These factors contribute to slower motor development and significantly affect the overall health of people with DS, influencing both their physical fitness and body composition (Bergamo et al., 2021). Body composition and physical fitness are shaped by the lifestyle and pathology characteristics of individuals with DS (Herrera-Quintana et al., 2022). While certain traits are common, not all individuals with DS exhibit the same features. Alongside genetic predispositions, individual factors—such as abilities, family environment, education, and social interaction—play crucial roles in shaping each person's lifestyle (Filgueira et al., 2019).

As trends within the DS population continue to evolve due to technological advancements, economic development, and cultural shifts, common lifestyle patterns and functional characteristics emerge. Notably, body composition and physical fitness are influenced by both the individual's lifestyle and the pathology's unique traits (Herrera-Quintana et al., 2022). One notable trend is the increased life expectancy and quality of life among individuals with DS, primarily due to enhanced understanding of the syndrome and improvements in health, social, and educational assistance programs (Arenas Angulo et al., 2018).

Similarly, Chile has seen a rise in the number of people with disabilities, including those with DS, enrolled in schools over the past two decades, leading to improvements in motor skills and greater social inclusion (Valle-Ramírez et al., 2022). Recommendations for adapted physical activities have also had a positive impact on the quality of life and functionality of this population, regardless of age (Gámez-Calvo et al., 2022).

Thus, while individuals with DS may display specific baseline traits that affect their quality of life, it is essential to recognize the changes and trends brought about by modern societal demands, particularly in terms of physical fitness and body composition. These factors significantly influence well-being and provide increased opportunities for participation throughout the lifespan.

Given this context, the primary objective of this research was to analyze the body composition and physical fitness of students with DS in the commune of Talca, Maule region, Chile, at two points in time (2009 and 2019), across different subject groups.

Methodology

Design

This study follows a longitudinal trend design, analyzing changes over a 10-year period in anthropometric and physical condition variables among a population with Down syndrome (DS) attending schools in Talca, Maule region, Chile. The analysis compares two distinct samples, as the measurements were conducted on different groups of subjects at two separate time points (2009 and 2019).

Participants

The study assessed individuals with DS aged 11 to 26, enrolled in special schools in Talca, Maule region, Chile. Data collection occurred across two time periods, with different subjects representing the target population. In 2009, 53 subjects participated, of which 24 were women and 29 were men. In 2019, 55 subjects were evaluated, of which 24 were women and 31 were men. An exclusion criterion ensured that the age difference between the two samples did not significantly affect the results to avoid bias related to biological maturation trends. For participants under 18, informed consent was obtained from parents or guardians. For those over 18 with sufficient cognitive ability to understand the research procedures, both assent and consent from a guardian or parent were required. The study adhered to the Declaration of Helsinki and received approval from the Ethics Committee of Universidad Santo Tomás (Code no. ID-116).

Procedure and Instruments

The assessments in 2009 and 2019 took place in the participants' educational establishments (controlled settings) between September and October, over a period of three consecutive weeks. Both evaluations were conducted by the same research team from Universidad Santo Tomás, Chile. The following organization of tests was applied:

Table 1
Distribution of application of the test

Test	Factor	Weeks of application
Wells and Dillons	Measuring Trunk Flexion	1-2-3
Abdominal in 60 seg	Abdominal Muscle strength	2-3
Test of Rockport ou 1 mile (1609 mts)	Aerobic Capacity	1-2-3
Body Mass Index (BMI)	Health index	1
Waist Hip Index (WHI)	Regionalisation of body fat and risk of metabolic conditions.	1
Anthropometry/skinfold measurement	Sum of skinfolds	1
Manual Dynamometry	Measuring Muscle Strength	2-3

Regarding the physical condition variables, flexibility was evaluated by means of the Wells and Dillon or Seat and Reach test, in which the seated subject must flex the trunk as far as possible over the flexibility box (Baseline®, Sit&Reach box). This test has a generally high reliability with values around *0.89 - 0.99* (Ayala et al., 2012).

To evaluate the resistance of the abdominal musculature, the abdominal crunches per minute test was used, where the participants were placed in a supine position, with their knees bent and feet resting on the floor. Starting from this initial position, as many trunk flexions as possible were performed with a straight back, where a monitor stabilizes the participant's knees (Terblanche & Boer, 2013).

Manual muscle strength was measured by means of the static hand-grip strength test, which is highly reliable (between *0.88 - 0.92*). In the measurement, the subjects had to stand with their back straight and arms extended along the body, instructing the subject to squeeze as hard as possible for 3-5 seconds, separating the arm with an approximate angle of 30º with respect to the side of the body and without flexing the elbow. A digital dynamometer (Baseline®, model 12-086) was used. Two attempts were made with the right hand and two with the left hand, recording the highest value for each hand (Bofill & San Molina, 2009).

To measure VO2 max, the participant was asked to walk the distance of one mile (1609,34 m) at his or her personal pace, monitoring the time and heart rate with a heart rate monitor once the test was completed. To favor the functional response of the subjects during the test, taking into account the low level of physical activity and cognitive or behavioral difficulties typical of DS, the application considered the following complementary aspects of the protocol proposed by Bofill-Ródenas and San Molina (2009), to be accompanied by a monitor, which was maintained during all evaluations, having the task of motivating the recording of time and heart rate variables. The test was performed in three moments, during three consecutive weeks (one opportunity per week) in order to have the most specific data to the subject and to seek the highest reliability of the test for the person with DS.

The determination of VO2 max is made from the following equation:

VO2 max = 132.6 - (0.17 x body weight) - (0.39 x Age) + (6.31 x Sex [0=Female and 1=Men]) - (3.27 x Time) - (0.156 x Heart Rate).

For the measurement of anthropometric variables, the standardized protocol proposed by the International Society for the Advancement of Kineanthropometry (ISAK) was used. The sum of skinfolds was made by measuring the triceps, subscapular, supraspinatus, abdominal, front thigh and calf skinfolds (6 skinfolds). All measurements were performed three times on the right side of the body, considering the average value.

Body mass (kg) was estimated with the participant dressed in light clothing and barefoot on a calibrated digital scale (Tanita, model SC 240-MA). Height (cm) was measured with the participant barefoot using a portable stadiometer (Seca, model 213). Body mass index (BMI) was considered using the formula: [kg/m²]. Waist circumference (WCi) and hip circumference (HCa) were assessed with a tape measure (Seca) with an accuracy of 1 mm. The waist-hip index (WHI) was considered using the formula: [PCi / PCa].

Analysis

Statistical analysis was performed in the SPSS Statistics 22 program. The data were subjected to the Kolmogorov-Smirnov test to determine normality. Descriptive statistics of mean and standard deviation were calculated. To analyze the behavior of the groups, Pearson's correlation test was used between the variables of age, physical condition and body composition, where indices up to .390 were considered as a weak correlation, between .400 to .690 as a moderate correlation, from .700

to .890 as a strong correlation, while ≥ .900 was considered a very strong correlation (Schober et al., 2018). The significance value was $p \leq 0.05$.

Results

Table 2 shows the values of the variables evaluated, according to each group.

Table 2
Characterizations of the subjects

			ANTHROPOMETRIC VARIABLES					PHYSICAL CONDITION VARIABLES				
	Age	**Weight (kg)**	**Size (cm)**	**Waist (cm)**	**Hips (cm)**	**Whi**	**Folds**	**Flex. (cm)**	**Abd (rep)**	**VO2 Max**	**Dyn Right**	**Dyn Left**
2009	14.9 ± 2.58	49 ± 15.36	141.8 ± 10.34	74.7 ± 11.72	85.5 ± 11.68	0.9 ± 0.05	85.5 ± 27.56	21.9 ± 4.93	21.1 ± 7.64	29.3 ± 5.60	19.3 ± 4.75	18.1 ± 4.50
Men	14.9 ± 2.72	53.1 ± 17.17	144.9 ± 11.32	77.5 ± 12.38	87.4 ± 12.53	0.9 ± 0.05	91.0 ± 30.76	21 ± 4.71	21.3 ± 7.41	30 ± 5.73	20.5 ± 4.91	19.2 ± 4.87
woman	14.8 ± 2.32	43.5 ±10.48	137.7 ± 7.21	71.1 ± 10.05	83.2 ±10.08	0.9 ± 0.05	78.4 ± 20.58	20.9 ± 5.35	20.7 ± 8.01	28.4 ± 5.30	17.9 ± 4.17	16.6 ± 3.57
2019	16.6 ± 4.27	58.9 ± 10.7	150.6 ±10.5	82.8 ± 10.20	93.5 ± 10.52	0.9 ± 0.06	86.6 ± 18.61	27.2 ± 9.10	14.2 ± 7.15	27 ± 11.76	19.4 ± 8.60	21.2 ± 8.18
Men	17.3 ± 3.90	63.9 ± 9.10	153 ± 9.91	86.7 ± 9.30	97 ± 10.4	0.9 ± 0.06	89.6 ± 14.93	28.2 ± 7.45	15.1 ± 7.52	26.5 ± 11.63	22.5 ± 8.99	23.5 ± 8.10
woman	15.9 ± 4.13	52.4 ± 9.01	147.5 ± 10.67	77.6 ± 9.27	89 ± 9.32	0.9 ± 0.06	82.8 ± 22.27	25.9 ± 10.77	13.1 ± 6.77	27.7 ± 12.12	15.3 ± 6.08	18.2 ± 7.38

Table 3 shows the correlations of the physical condition and age of both groups independent of sex, it is observed that the trend is homogeneous since in both groups there are no changes in significance, except in the VO2 max, which has in the year 2019 a significant negative relationship of moderate type.

Table 3
Correlations of physical fitness and age

	Flex. (cm)	**Abd. (rep)**	**VO2 Max**	**Dyn Right**	**Dyn Left**
Age 2019	*.110*	*.235*	*- .444[c]*	*.490*	*.415*
Age 2009	*- .375*	*- .294*	*- .250*	*.357*	*.270*

Note: a: very high significant correlations, b: high correlations, c: moderate correlations.

Table 4 describes the relationships of body composition and age in the population with DS. It shows a trend that is not very predictable, as there are changes between both groups. Specifically, the weight and height variables have a lower value in the 2019 group with respect to 2009. Regarding the other variables, there are significant relationships in 2009, but not in 2019.

Table 4
Correlations of body composition and age

	Weight (kg)	**Size (cm)**	**BMI**	**P. Waist**	**P. Hip**	**Whi**	**Folds**
Age 2019	.54[c]	.521[c]	.301	.345	.290	.152	.310
Age 2009	.801[a]	.634[b]	.718[b]	.790[b]	.870[a]	.051	.673[b]

Note: a: very high significant correlations, b: high correlations, c: moderate correlations.

Table 5 shows the correlations according to the sex of the groups. In women, a not very predictable trend is observed, since the VO2 max and dynamometry variables change their significance. As for men, the trend is similar, due to the fact that the relationships of flexibility and abdominal capacity are not present in 2019, while the opposite is true for VO2 max.

Table 5
Gender correlations between physical fitness and age

	Flex.	Abd.	VO2 Max	Dyn Right	Dyn Left
Woman 2009	- .288	- .169	- .264	.597[b]	.553[c]
Woman 2019	- .000	.010	- .476[c]	- .036	.080
Men 2009	- .355[c]	- .411[c]	- .230	.191	.060
Men 2019	.080	.155	- .398[c]	.070	- .009

Note: a: very high significant correlations, b: high correlations, c: moderate correlations.

Specifically, in women, dynamometry measurements showed moderate correlations in 2009, but not in 2019. Likewise, VO2 max presented only moderate correlations in 2019. As for men, VO2 max showed a moderate relationship only in 2019, while flexibility and number of sit-ups presented moderate correlations in the 2009 group, but not in 2019.

Table 6 shows the correlations according to the sex of the groups. In women, a not very predictable trend is observed, as the variables of VO2 max and dynamometry change their significance. As for men, the trend is similar, due to the fact that the relationships of flexibility, abdominal capacity are not present in 2019, while in VO2 max the opposite occurs.

Specifically, in women, dynamometry measurements showed moderate correlations in 2009, but not in 2019. Likewise, VO2 max presented only moderate correlations in 2019. As for men, VO2 max showed a moderate relationship only in 2019, while flexibility and number of sit-ups presented moderate correlations in the 2009 group, but not in 2019.

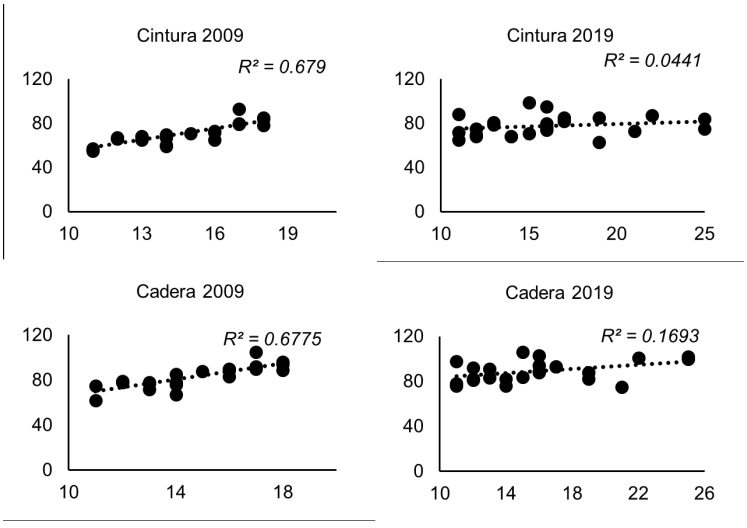
Also, table 6 also shows the correlations of body composition variables and age according to sex. In women, a more homogeneous trend is shown, where only the height and waist circumference variables have a relationship in 2009 and not so in 2019. As for the parameters of weight, BMI, hip circumference and folds, a decrease in the value of the relationships is observed. In the case of men, the trend is low, since only waist and hip perimeters show correlations in both groups, and these tend to decrease as time goes by.

Table 6
Sex correlations between body composition and age

	Weight (kg)	Size (cm)	BMI	P. Waist	P. Hip	Whi	Folds
Woman 2009	.827[a]	.643[c]	.675[c]	.824[a]	.823[a]	.115	.681[c]
Woman 2019	.745[b]	.281	.555[c]	.209	.411[c]	- .238	.525[c]
Men 2009	.731[b]	.634[c]	.633[c]	.687[b]	.764[b]	- .125	.460[c]
Men 2019	.320	.164	.173	.410[c]	.461[c]	- .090	.330

Note: a: very high significant correlations, b: high correlations, c: moderate correlations.

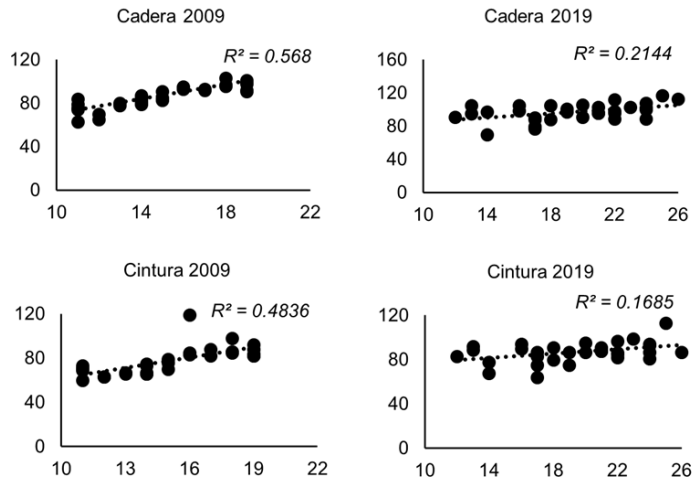
Graph 1
Relationships of waist and hip circumferences to age in women with DS



Graph 1 shows the waist and hip circumference variables that show positive correlations in both groups of women. When contrasting the values between the groups, a lower relationship is seen in the year 2019 with respect to 2009.

Graph 2 shows the relationship of waist and hip circumference variables with age in both groups of men. It is observed that the relationship values are lower in the 2019 group in contrast to 2009.

Graph 2
Relationships of waist and hip circumference to age in men with DS



Discussion

The objective of this study was to analyze the body composition and physical condition of students with DS from Talca, Maule Region, Chile, at two distinct time points (2009 and 2019).

The key findings indicate contrasting trends between body composition and physical condition. Body composition exhibited an unpredictable pattern, with significant changes in certain parameters, while physical condition followed a more consistent trend, with minimal significant changes in most capacities.

This pattern aligns with typical DS characteristics, where, as individuals age, they tend to develop an unhealthy anthropometric profile characterized by weight gain (Nixon, 2018). Gómez-Campos et al. (2021) also noted that overweight and obesity are prevalent across childhood, adolescence, and adulthood, contributing to metabolic and cardiac diseases (Ferreira et al., 2021).

The body composition variables were higher in the 2009 group compared to 2019, suggesting a decreased impact of anthropometric variables over time. This is relevant given the slower maturational development and higher prevalence of increased adiposity in individuals with DS (Ghiglione & Lopez, 2022). These findings suggest a positive trend in the health of this population.

In women, a decrease in anthropometric values related to obesity was observed, a noteworthy finding given the propensity for weight gain with age in individuals with DS (Pirett et al., 2023). Males, too, showed a shift from high to moderate correlations in certain parameters, with a reduced impact of these variables in 2019 compared to 2009. This is significant given the longitudinal evidence showing an increase in fat mass over time in individuals with intellectual disabilities (Lahtinen et al., 2007).

Waist and hip circumference exhibited significant correlations in both time periods, with lower values in the 2019 group. This reduction indicates a shift towards a healthier profile (Lip-Licham & Velasquez, 2023), potentially influenced by advances in nutrition, physical activity, and medical care that have improved life expectancy in individuals with DS (Gatica-Mandiola et al., 2018). The decrease in weight, waist, and hip measurements, as well as BMI, correlates with improved health outcomes (Gómez-Campos et al., 2022). In terms of physical fitness, most variables showed stable behavior across both groups and time periods. However, VO2 max showed significant temporal changes, with an inverse relationship between age and oxygen consumption in 2019 (r= - .04). This reflects a decline in aerobic capacity, consistent with previous findings that highlight reduced aerobic performance in individuals with DS as they age (Silva et al., 2017).

Manual dynamometry remained stable between the two groups, though sex was an influential factor in the relationship between age and strength. In women, significant relationships were observed in 2009 but not in 2019, indicating a decline

in strength over time. Since strength is a predictor of health and functionality in individuals with DS (Legerlotz, 2018), this trend may have negative implications for the population's development.

Flexibility and abdominal strength showed sex-specific variations, with men in 2009 exhibiting a negative correlation with age, a trend not seen in 2019. This finding suggests that, over time, these variables have less impact on the population, which is significant given the role these capacities play in enhancing independence and functionality in adults with DS (Cabeza-Ruiz & Gómez, 2022; Oppewal et al., 2014).

Ultimately, the observed behaviors in physical fitness and body composition are likely attributable to evolving contexts over the 10-year period between the groups.

Limitations

The age differences between the groups (2009: 14.9 ± 2.6; 2019: 16.6 ± 4) may have influenced the analysis of results and trends. Given that individuals with DS experience earlier growth spurts (at 11 years for boys and 9.5 years for girls) (Sarmiento & Gómez, 2022; Zamel et al., 2015), care was taken to minimize significant age discrepancies between the groups.

Conclusion

This study reveals distinct trends in body composition and physical fitness among individuals with DS across the evaluated periods. Physical fitness generally displayed more consistency between the two periods, with fewer changes, whereas body composition demonstrated a less predictable pattern, fluctuating over time. These findings suggest that physical fitness is less susceptible to external factors such as age or sex compared to body composition. This should be considered in designing interventions aimed at improving the physical condition and health of individuals with DS. The study also highlights that waist and hip circumference relationships with age primarily decrease in the 2019 group.

Ethics Committee Statement

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of university Santo Tomas (Código n.° ID-116).

Conflict of Interest Statement

The entities and authors of this article were not involved in the design of the study, the analysis of the data, or the interpretation of the results.

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Authors' Contribution

Conceptualization Pino, M. & Benavides, L.; Methodology Pino, M. & Benavides, L.; Software Benavides, L; Validation Pino, M. & Benavides, L; Formal Analysis Benavides, L.; Investigation Pino, M.; Resources Pino, M.; Data Curation Pino, M.; Writing – Original Draft Pino, M. & Benavides, L.; Writing – Review & Editing Pino, M. & Benavides, L.; Visualization Pino, M; Supervision Pino, M; Project Administration Benavides, L.; Funding Acquisition Pino, M. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

Data available on request from the author of the correspondence **(**benavides.roca@gmail.com**)**.

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Análisis de la Composición Corporal y Condición Física en una Población de Estudiantes con Síndrome de Down: un Estudio de Tendencia (10 años) en dos Periodos y Grupo de Sujetos Distintos

Analysis of Body Composition and Physical Fitness in a Population of Students With Down Syndrome: a Trend Study (10 Years) in two Different Periods and Subject Groups

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Resumen

El objetivo del estudio fue analizar la composición corporal y la condición física de una población de estudiantes con Síndrome de Down en dos momentos (año 2009 y 2019) y grupos de sujetos distintos. Es una investigación de tendencia, que relaciona la composición corporal, condición física y edad en una población dividida en dos grupos diferenciados por 10 años de cuando habían sido evaluados. Los resultados hacen referencia a la correlación positiva del perímetro de cadera en ambos grupos de mujeres, se ve menor relación en el año 2019 con respecto al 2009. Los hombres muestran relaciones menores en el 2019 en contraste con el 2009. La condición física en las mujeres tiene una tendencia poco predecible, el VO2 máximo tiene una relación negativa solo en el año 2019, a diferencia de la dinamometría, donde la relación positiva se observa únicamente en el grupo de 2009. Los hombres muestran que la flexibilidad y la capacidad abdominal tienen relaciones positivas en el grupo 2009. Caso contrario con el VO2 máximo donde la relación negativa está presente en el 2019. En conclusión la composición corporal exhibe un comportamiento poco predecible a lo largo del tiempo, en cambio la condición física tiene una tendencia homogénea.

Palabras clave: Capacidad física, antropometría, población especial y genotipo.

Abstract

The aim of this study was to analyze the body composition and physical fitness of a population of students with Down syndrome at two time points (in 2009 and 2019) and different subject groups. It is a trend study that examines the relationship between body composition, physical fitness, and age in a population divided into two groups based on a 10-year interval between evaluations. The results indicate a positive correlation of hip circumference in both groups of women, albeit weaker in 2019 compared to 2009. Men show weaker relationships in 2019 compared to 2009. Physical fitness in women exhibits a somewhat unpredictable trend, with maximum VO2 showing a negative relationship only in 2019, unlike dynamometry, where the positive relationship is observed only in the 2009 group. Men show that flexibility and abdominal capacity have positive relationships in the 2009 group, contrasting with maximum VO2 where the negative relationship is present in 2019. In conclusion, body composition exhibits somewhat unpredictable behavior over time, while physical fitness shows a more homogeneous trend

***Keywords*:** Physical capacity, anthropometry, special population and genotype.

Introducción

El síndrome de Down (SD) es descrito como una de las anomalías genéticas más comunes en todo el mundo, con una incidencia reportada de aproximadamente 1 en 1000 nacidos vivos (Rodríguez et al., 2019). Esta condición genética aparece cuando una persona presenta una copia adicional del cromosoma 21, lo que da lugar, por una parte, a características genotípicas referidas a la composición genética de un organismo. En el caso del SD, el genotipo típico es trisomía 21, lo que significa que tienen tres copias del cromosoma 21 en lugar de las dos habituales. Por otro lado, a las características fenotípicas hace referencias a las particularidades que son observables y medibles de un organismo, que son producto de la expresión de su genotipo y la interacción con el entorno.

Respeto a este último punto, el SD tiene característicos rasgos fenotípicos que pueden incluir la hipotonía, la hipermovilidad articular, alteraciones oculares y trastornos gastrointestinales (Pino et al., 2021). También se han visto alteraciones en algunas funciones ejecutivas superiores (atención y memoria) (Vega-Díaz, & González-García, 2020). junto con esto, los estilos de vida que adquieren hacen que el sobrepeso y la obesidad se posicionen como elementos de prevalencia (De la Piedra et al., 2017), al igual que el sedentarismo y el bajo nivel de condición física (Martínez-Espinoza et al., 2020).

Estos elementos contribuyen a un desarrollo motor más lento e impactan directamente en la salud general de la población con SD, tanto en el desarrollo de la condición física como de la composición corporal (Bérgamo et al., 2021). La composición corporal y la condición física de las personas con SD se ven influenciadas por el estilo de vida que adquieren durante el transcurso de su vida y por las características de su patología (Herrera-Quintana et al., 2022).

Si bien es cierto, existe un fenotipo que hace que los individuos con SD posean una serie de rasgos característicos, ninguno de ellos está presente en todos los individuos. Es por ello que, más allá de la predisposición genética que se pueda generar, las personas con SD también presentan características individuales y experimentan diferentes estilos de vida, los cuales pueden variar conforme a sus capacidades, entorno familiar, educación e interacción social, entre otros factores (Filgueira et al., 2019).

A pesar de que las tendencias de la población con SD están en constante cambio debido a una variedad de factores, como son la tecnológicos, aspectos demográficos, el desarrollo económico y transformaciones culturales, es posible encontrar aspectos comunes en los estilos de vida y la funcionalidad de estos sujetos a medida que avanzan en su desarrollo y envejecen. Respecto a ello, la composición corporal y la condición física se ven influenciado por el estilo de vida que adquieren durante el transcurso de su crecimiento y por las características de su patología (Herrera-Quintana et al., 2022).

Un aspecto que destaca en este sentido es el aumento en la expectativa y calidad de vida que han tenido las personas con SD en los últimos años, influenciado principalmente por el mayor conocimiento del mismo síndrome y a consecuencia de ello, el aumento y mejorar de los programas de asistencia en salud, social, educación, etc (Arenas Angulo et al., 2018).

En la misma línea, otro factor que destaca es el aumento en la escolarización de personas en situación de discapacidad en Chile en los último 20 años, entre ellos las personas con SD, lo cual conlleva mejoras en sus habilidades motoras y una mayor inclusión social (Valle-Ramírez et al., 2022). A partir de este contexto, por ejemplo, las recomendaciones de actividades físicas adaptadas para esta comunidad generan un impacto positivo en la calidad de vida y la funcionalidad, independientemente de la edad en la que se encuentren (Gámez-Calvo et al., 2022).

Por lo tanto, aunque los sujetos con SD puedan presentar características específicas de base que afectan en su calidad de vida y que de manera general explican el mayor riesgo de morbilidad y déficit en la adquisición de habilidades funcionales y cognitivas (Oliveira et al., 2023), resulta fundamental reconocer los posibles cambios o tendencias comunes que en esta población puedan presentarse producto de los nuevos estilos y requerimientos de la sociedad actual, especialmente respecto a la condición física y la composición corporal, debido a su gran influencia en el bienestar e incremento de las oportunidades de participación durante las diferentes etapas del ciclo vital.

Tomando en cuenta lo anterior, el principal objetivo es esta investigación fue analizar la composición corporal y la condición física de la población de estudiantes con SD de la comuna de Talca, región del Maule, Chile, en dos momentos (año 2009 y 2019) y en grupos de sujetos distintos.

Método

Diseño

El estudio es de tipo longitudinal de tendencia, ya que centra su análisis en los cambios través del tiempo (10 años) de las variables antropométricas y de condición Física de la población con SD escolarizada en la comuna de Talca, región del Maule, Chile, pero con la comparación de dos muestras, ya que las mediciones de las variables son realizadas con distintos grupos de sujetos, en dos periodos distintos (2009 y 2019).

Participantes

En este estudio se evaluó una población con SD entre los 11 a 26 años de edad, pertenecientes a las Escuelas Especiales de la comuna de Talca, región del Maule, Chile. La recolección de datos fue efectuada en dos periodos de tiempo con sujetos distintos, pertenecientes a la población antes mencionada. En el año 2009 participaron 53 sujetos, de los cuales 24 eran mujeres y 29 eran hombres. Por su parte en el en el año 2019, fueron evaluados 55 sujetos, donde 24 eran mujeres y 31 eran hombres. Para esta muestra en específica, e consideró como criterio de exclusión no generar una diferencia significativa en la edad en comparación con el grupo de 2019, con el objetivo de evitar la influencia en la tendencia de la maduración biológica. Los padres y/o tutores responsables de los sujetos menores de 18 años, fueron informados de los procedimientos asociados al estudio, para luego ser requerida su aceptación de participación. Para los sujetos mayores de 18 años con habilidades cognitivas que le permitían comprender los procedimientos de la investigación, les fue solicitado la firma de un asentimiento y consentimiento de los padres o tutores. Los protocolos informados están en concordancia a la declaración de Helsinki y fueron aprobados por el comité de ética de la Universidad Santo Tomás (Código n.° ID-116).

Procedimiento e Instrumento

La aplicación de los instrumentos en el 2009 y 2019 fue realizada en los establecimientos educacionales donde estaban escolarizados los sujetos (escenario controlado), entre los meses de septiembre-octubre, durante tres semanas consecutivas y dirigida por el mismo equipo de evaluación de la Universidad Santo Tomas, Chile, considerando la siguiente organización de las pruebas:

Tabla 1
Distribución aplicación de las pruebas

Prueba	Factor	Semanas de aplicación
Wells y Dillons	Medir Flexión de Tronco	1-2-3
Abdominales en 60 segundos	Resistencia de la Musculatura Abdominal	2-3
Test de Rockport o 1 milla (1609 mts)	Capacidad aeróbica	1-2-3
Indice de Masa Corporal (IMC)	Índice de salud	1
Indice Cintura Cadera (ICC)	Regionalización de grasa corporal y riesgo de afecciones metabólicas.	1
Antropometría/ pliegues cutáneos	Suma de Pliegues cutáneos	1
Dinamometría manual	Medir la Fuerza muscular	2-3

Respecto de las variables de la condición física, la flexibilidad se evaluó por medio de la prueba de Wells y Dillon o Seat and Reach, en la cual, el sujeto sentado debe flectar el tronco lo más posible por sobre el cajón de flexibilidad (Baseline®, Sit&Reach box). Esta prueba posee de forma generalizada una elevada fiabilidad con valores en torno a *0,89 - 0,99* (Ayala et al., 2012).

Para evaluar la resistencia de la musculatura abdominal, se utilizó la prueba de abdominales por minuto, donde los participantes se ubicaban en posición supina, con las rodillas dobladas y los pies apoyados en el suelo. Partiendo de esta posición inicial se realizaron la mayor cantidad de flexiones de tronco posible con espalda recta, donde el un monitor estabiliza las rodillas del participante (Terblanche & Boer, 2013).

La fuerza muscular manual se midió por medio de la prueba de fuerza estática de prensión en mano (hand-grip), la cual es altamente fiable (entre *0.88 -0.92*). En la medición, los sujetos debían estar de pie con la espalda recta y los brazos extendidos a lo largo del cuerpo, indicando al sujeto que apretara lo más fuerte posible durante 3-5 segundos, separando el brazo con un ángulo aproximado de 30º respecto al costado del cuerpo y sin flexionar el codo. Se utilizó un dinamómetro digital (Baseline®, modelo 12-086). Se realizaron dos intentos con la mano derecha y dos con la izquierda, haciendo registro del mayor valor de cada mano (Bofill & San Molina, 2009).

Para la medición del VO2 máximo, se pidió a la persona participante recorrer caminando, según el ritmo personal, la distancia de una milla (1609,34 m), controlando con un monitor de frecuencia cardiaca el tiempo de recorrido y frecuencia cardiaca una vez finalizada la prueba. Para favorecer la respuesta funcional de los sujetos durante la prueba, tomando en cuenta el bajo nivel de actividad física y dificultades cognitivas o conductuales propias del SD, la aplicación consideró los siguientes aspectos complementarios del protocolo planteado por Bofill-Ródenas y San molina (2009), realizar un acompañamiento por un monitor, el que se mantenía durante todas las evaluaciones, tendiendo la tarea de motivar registrar las

variables de tiempo y frecuencia cardiaca. La prueba fue realizada en tres momentos, durante tres semanas consecutivas (una oportunidad por semana) con el objetivo de tener el dato más específico al sujeto y buscar la mayor confiabilidad del test para la persona con SD.

La determinación del VO2 máximo se realiza a partir de la siguiente ecuación:

VO2 máximo = 132.6 – (0.170 x peso corporal) – (0.390 x Edad) + (6,31 x Sexo [0=Mujer y 1= hombres]) – (3.27 x Tiempo) – (0.156 x Frecuencia Cardiaca).

En el caso de la medición de variables antropométricas, se utilizó el protocolo estandarizado propuesto por la Sociedad Internacional para el Avance de la Cineantropometría (ISAK). La suma de pliegues, se realizó con la medición de los pliegues cutáneo tríceps, subescapular, supraespinoso, abdominal, muslo frontal y pantorrilla (formula seis pliegues). Todas las mediciones se realizaron tres veces en el lado derecho del cuerpo, considerando el valor promedio.

La masa corporal (kg) se estimó con el participante vestido con ropa liviana y descalzo sobre una balanza calibrada digital (Tanita, modelo SC 240-MA). La talla (cm) se midió con el participante descalzo utilizando un estadiómetro portátil (Seca, modelo 213). Se consideró el índice de masa corporal (IMC) utilizando la fórmula: [kg/m²]. El perímetro de cintura (PCi) y el perímetro de cadera (PCa), se evaluó con una cinta métrica (Seca) con una precisión de 1mm. Se consideró el índice de cintura-cadera (ICC) mediante la fórmula: [PCi / PCa].

Análisis

El análisis estadístico se realizó en el programa SPSS Statistics 22. Los datos se sometieron a la prueba de Kolmogorov-Smirnov para determinar su normalidad. Se calcularon estadísticos descriptivos de media y desviación estándar. Para analizar el comportamiento de los grupos se utilizó la prueba de correlación de Pearson entre las variables de edad, condición física y composición corporal, donde los índices de hasta .390 se consideraron como una correlación débil, entre .400 a .690 como una correlación moderada, de .700 a .890 como una correlación fuerte, mientras que "≥ .90 se consideró una correlación muy fuerte (Schober et al., 2018). El valor de significancia fue de p ≤ .050.

Resultados

En la tabla 2, se observan los valores de las variables evaluadas, según cada grupo.

Tabla 2
Caracterización de la muestra

	VARIABLES ANTROPOMÉTRICAS							VARIABLES DE CONDICIÓN FÍSICAS				
	Edad	**Peso (kg)**	**Talla (cm)**	**Cintura (cm)**	**Cadera (cm)**	**Icc**	**Pliegues**	**Flex. (cm)**	**Abd (rep)**	**VO2 Max**	**Din Derecha**	**Din Izquierda**
2009	14.9 ± 2.58	49 ± 15.36	141.8 ± 10.34	74.7 ± 11.72	85.5 ± 11.68	0.9 ± 0.05	85.5 ± 27.56	21.9 ± 4.93	21.1 ± 7.64	29.3 ± 5.60	19.3 ± 4.75	18.1 ± 4.50
Hombres	14.9 ± 2.72	53.1 ± 17.17	144.9 ± 11.32	77.5 ± 12.38	87.4 ± 12.53	0.9 ± 0.05	91.0 ± 30.76	21 ± 4.71	21.3 ± 7.41	30 ± 5.73	20.5 ± 4.91	19.2 ± 4.87
Mujeres	14.8 ± 2.32	43.5 ±10.48	137.7 ± 7.21	71.1 ± 10.05	83.2 ±10.08	0.9 ± 0.05	78.4 ± 20.58	20.9 ± 5.35	20.7 ± 8.01	28.4 ± 5.30	17.9 ± 4.17	16.6 ± 3.57
2019	16.6 ± 4.27	58.9 ± 10.7	150.6 ±10.5	82.8 ± 10.20	93.5 ± 10.52	0.9 ± 0.06	86.6 ± 18.61	27.2 ± 9.10	14.2 ± 7.15	27 ± 11.76	19.4 ± 8.60	21.2 ± 8.18
Hombres	17.3 ± 3.90	63.9 ± 9.10	153 ± 9.91	86.7 ± 9.30	97 ± 10.4	0.9 ± 0.06	89.6 ± 14.93	28.2 ± 7.45	15.1 ± 7.52	26.5 ± 11.63	22.5 ± 8.99	23.5 ± 8.10
Mujeres	15.9 ± 4.13	52.4 ± 9.01	147.5 ± 10.67	77.6 ± 9.27	89 ± 9.32	0.9 ± 0.06	82.8 ± 22.27	25.9 ± 10.77	13.1 ± 6.77	27.7 ± 12.12	15.3 ± 6.08	18.2 ± 7.38

La tabla 3 muestra las correlaciones de la condición física y la edad de ambos grupos independiente del sexo, se observa que la tendencia es homogénea ya que los en ambos grupos no se aprecian cambios en la significancia, exceptuando en el VO2 máximo, el cual tiene en el año 2019 una relación negativa significativa de tipo moderada.

Tabla 3
Correlaciones de condición física y edad

	Flex. (cm)	Abd. (rep)	VO2 Max	Din. Derecha	Din. Izquierda
Edad 2019	*.110*	*.235*	*- .444[c]*	*.490*	*.415*
Edad 2009	*- .375*	*- .294*	*- .250*	*.357*	*.270*

Nota: a: correlaciones significativas muy altas, *b:* correlaciones altas, *c*: correlaciones moderadas.

La tabla 4 describe las relaciones de la composición corporal y la edad de la población con SD. Se muestra una tendencia poco predecible, ya que existen cambios entre ambos grupos. Específicamente, las variables de peso y talla tienen un valor menor en el grupo del 2019 con respecto al 2009. En lo que respecta a las demás variables, existen relaciones significativas en el 2009, pero no así en el 2019.

Tabla 4
Correlaciones de composición corporal y edad

	Peso (Kg)	Talla (cm)	IMC	P. cintura	P. cadera	Icc	Pliegues
Edad 2019	.54[c]	.521[c]	.301	.345	.290	.152	.310
Edad 2009	.801[a]	.634[b]	.718[b]	.790[b]	.870[a]	.051	.673[b]

Nota: a: correlaciones significativas muy altas, *b:* correlaciones altas, *c*: correlaciones moderadas.

La tabla 5 muestra las correlaciones según el sexo de los grupos. En las mujeres se observa una tendencia poco predecible, ya que las variables de VO2 máximo y dinamometría cambian su significancia. En cuanto a los hombres, la tendencia es similar, debido a que las relaciones de flexibilidad y capacidad abdominal no están presentes en el año 2019, mientras que en el VO2 máximo ocurre lo contrario.

Tabla 5
Correlaciones según sexo entre la aptitud física y la edad

	Flex	Abd	Vo2 máx.	Din_d	Din_I
Mujeres 2009	- .288	- .169	- .264	.597[b]	.553[c]
Mujeres 2019	- .000	.010	- .476[c]	- .036	.080
Hombres 2009	- .355[c]	- .411[c]	- .230	.191	.060
Hombres 2019	.080	.155	- .398[c]	.070	- .009

Nota: a: correlaciones significativas muy altas, *b:* correlaciones altas, *c*: correlaciones moderadas.

Específicamente, en las mujeres las mediciones de dinamometría mostraron correlaciones moderadas en 2009, pero no en 2019. Asimismo, el VO2 máximo presentó únicamente correlaciones moderadas en 2019. En cuanto a los hombres, el VO2 máximo mostró una relación moderada solo en 2019, mientras que la flexibilidad y la cantidad de abdominales presentaron correlaciones moderadas en el grupo de 2009, pero no en 2019.

La tabla 6 muestra las correlaciones según el sexo de los grupos. En las mujeres se observa una tendencia poco predecible, ya que las variables de VO2 máximo y dinamometría cambian su significancia. En cuanto a los hombres, la tendencia es similar, debido a que las relaciones de flexibilidad, la capacidad abdominal no está presente en el año 2019, mientras que en el VO2 máximo ocurre lo contrario.

Específicamente, en las mujeres las mediciones de dinamometría mostraron correlaciones moderadas en 2009, pero no en 2019. Asimismo, el VO2 máximo presentó únicamente correlaciones moderadas en 2019. En cuanto a los hombres, el VO2 máximo mostró una relación moderada solo en 2019, mientras que la flexibilidad y la cantidad de abdominales presentaron correlaciones moderadas en el grupo de 2009, pero no en 2019.

También, en la tabla 6 también se observan las correlaciones de las variables de composición corporal y la edad según el sexo. En las mujeres, se muestra una tendencia más homogénea, donde solo las variables de talla y perímetro de cintura tienen una relación en el 2009 y no así en el 2019. En cuanto a los parámetros de peso, IMC, perímetro de cadera y pliegues, se observa una disminución en el valor de las relaciones. En el caso de los hombres, la tendencia es baja, dado

que únicamente los perímetros de cintura y cadera muestran correlaciones en ambos grupos, y estas tienden a disminuir a medida que transcurre el tiempo.

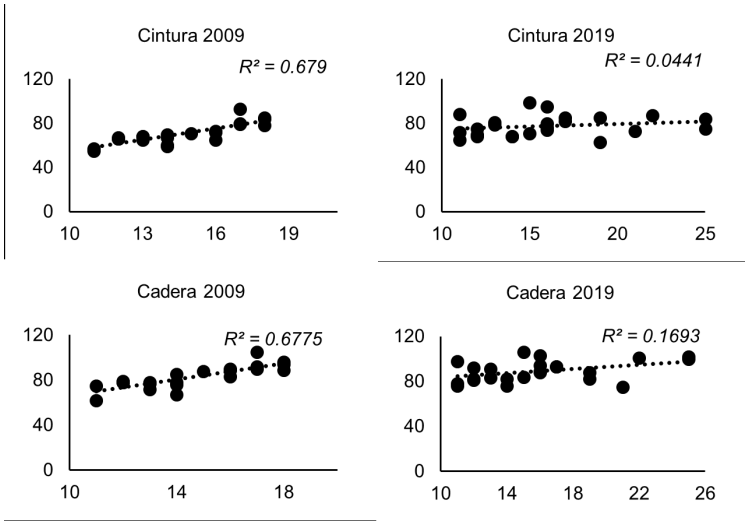
Tabla 6
Correlaciones según sexo entre la composición corporal y la edad

	Peso	Talla	IMC	Cintura	Cadera	Icc	Pliegues
Mujeres 2009	.827[a]	.643[c]	.675[c]	.824[a]	.823[a]	.115	.681[c]
Mujeres 2019	.745[b]	.281	.555[c]	.209	.411[c]	- .238	.525[c]
Hombres 2009	.731[b]	.634[c]	.633[c]	.687[b]	.764[b]	- .125	.460[c]
Hombres 2019	.320	.164	.173	.410[c]	.461[c]	- .090	.330

Nota: a: correlaciones significativas muy altas, *b:* correlaciones altas, *c*: correlaciones moderadas.

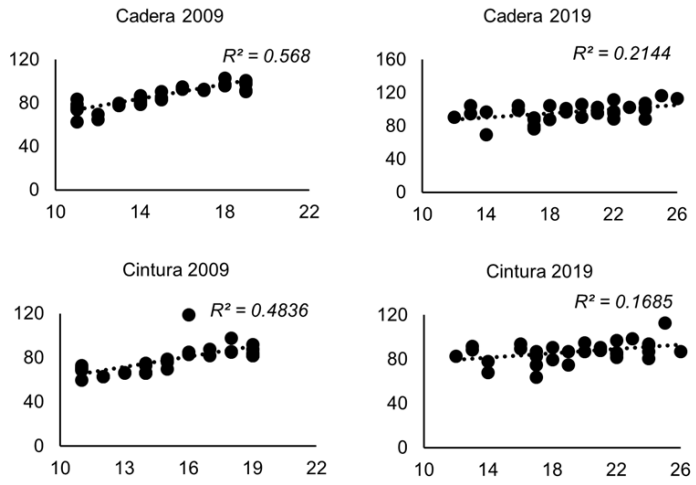
El Gráfico 1 muestra las variables de perímetros de cintura y cadera que presenta correlaciones positivas en ambos grupos de mujeres. Al contrastar los valores entre los grupos, se ve una menor relación en el año 2019 con respecto al 2009.

Gráfico 1
Relaciones de perímetros de cintura y cadera con la edad en mujeres con SD



En el Gráfico 2 se observa la relación de las variables de perímetro de cintura y cadera con la edad en ambos grupos de hombres. Se observa que los valores de relación son menores en el grupo 2019 en contraste con el 2009.

Gráfico 2
Relaciones del perímetro de cintura y cadera con la edad en hombres con SD



Discusión

El objetivo de este estudio fue analizar la composición corporal y la condición física de la población de estudiantes con SD de la comuna de Talca, región del Maule, Chile, en dos momentos (año 2009 y 2019) y grupos de sujetos distintos.

Los hallazgos más relevantes hacen referencia a las tendencias de las variables, la composición corporal tiene un comportamiento poco predecible, debido al cambio en las significancias de los valores de alguno de sus parámetros, mientras que la condición física muestra una tendencia homogénea, donde la mayoría de las capacidades físicas presentan modificaciones que no son significativas.

Dicha tendencia muestra consonancia con las características del SD respectos con la tipología de esta población, ya que a medida que van creciendo, existe una tendencia a un perfil antropométrico poco saludable, caracterizado principalmente por el aumento de peso (Nixon, 2018). Es más, Gómez-Campos et al. (2021) señalan que el sobrepeso y la obesidad está presente en las etapas de la infancia, adolescencia y adultez, lo que se vincula con enfermedades metabólicas y cardiacas (Ferreira et al., 2021).

Los datos de las variables de composición corporal presentan relaciones más altas en el grupo 2009 con respecto al grupo 2019. Esto sugiere que a medida que pasa el tiempo, la población tiende a presentar una menor influencia de las variables antropométricas en su desarrollo, este hallazgo resulta significativo considerando las características propias de las personas con SD quienes tienden a experimentar un desarrollo madurativo más lento y mostrar una mayor prevalencia al aumento de la adiposidad (Ghiglione & López, 2022). Por lo que estos resultados indican un comportamiento favorable para la salud de esta población.

Las mujeres presentan una tendencia positiva, ya que existe una disminución en los valores de las relaciones de las variables antropométricas vinculadas con la obesidad. Esta característica resulta relevante, debido a que los sujetos con SD tienden a presentar sobrepeso a medida que transcurren en edad (Pirett et al., 2023). De igual manera, los varones presentan datos donde los parámetros pasan de tener una relación alta a moderada, lo que sugiere que las variables tienen un impacto menor en la cohorte de 2009 a la del 2019. Esta diferencia resulta ser significativa debido a que los datos longitudinales propuestos por Lahtinen, Rintala & Malin, (2007) describen que la masa grasa aumenta su impacto con el correr del tiempo en sujetos con deficiencia intelectual.

Dentro del análisis de la composición corporal, el comportamiento de las variables de perímetro de cintura y cadera destacan por su significancia en ambos periodos de tiempo, donde el impacto que tienen estas variables en el grupo de 2019 es menor en comparación con el grupo de 2009. Por tanto existe una disminución de los valores de estos parámetros con el transcurso del tiempo. Este fenómeno refleja una tendencia hacia un perfil más saludable (Lip-Licham & Velásquez, 2023), lo que pudiese estar influenciado por el incremento en la comprensión del síndrome, así como también por los avances en nutrición, actividad física y farmacología. Estos avances han contribuido al aumento de la esperanza de vida en estas personas (Gatica-Mandiola et al., 2018), lo cual resulta significativo, ya que la disminución de la relación de las variables de peso, perímetros cintura y cadera e IMC se correlaciona con una mejora en la salud de individuos con SD (Gómez-Campos et al., 2022).

En cuanto los resultados que se expresan en la condición física, es posible identificar de manera general un comportamiento más estable de las distintas variables en los grupo y tiempo evaluados. Sin embargo, el VO2 máximo presenta cambios de acuerdo a la temporalidad, reflejado por la significancia de la relación inversa de la edad y el consumo de oxígeno en el grupo 2019 (*r: - ,040).* Estos resultados indican un deterioro progresivo de la capacidad aeróbica, que coincide con lo expresado por Silva et al. (2017) quienes destacan que las personas con SD experimentan un déficit en el funcionamiento aeróbico, que empeora a medida que envejecen.

Respecto con la dinamometría manual, no se observan cambios entre el grupo 2019 y 2009 de manera general, no obstante, el sexo se muestra como una variable influyente en la relación edad y fuerza de los sujetos, donde las mujeres tienen relaciones significativas en el año 2009 no así en el año 2019, lo que indica un comportamiento decreciente a medida que transcurre el tiempo de esta variable. Considerando que la fuerza es una capacidad predictora de la salud y funcionalidad de las personas con SD (Legerlotz, 2018), los datos mostrados en el presente estudio describen una tendencia poco favorable para el desarrollo de esta población.

Respecto a la flexibilidad y la capacidad abdominal, los hombres y las mujeres tienen un comportamiento distinto durante los periodos de evaluación, específicamente los hombres del año 2009 presentan una relación negativa de estas capacidades (flexibilidad y capacidad abdominal) con la edad, lo que no se observa en el grupo del 2019. Este hallazgo sugiere que, con el paso de los años, estas variables dejan de tener un impacto negativo en esta población, antecedente que resulta relevante, tomando en cuenta la importancia de estas capacidades en el mejora de la independencia y funcionalidad de la edad adulta de las personas con SD (Cabeza-Ruiz & Gómez, 2022; Oppewal et al., 2014).

Finalmente, el comportamiento observado en las variables de condición física y composición corporal dentro de esta población estudiada, se atribuye a los contextos que evolucionaron durante los 10 años de diferencia entre los grupos.

Limitaciones

Así mismo, la diferencia de edad entre los grupos que participaron de las evaluaciones en ambos periodos (grupo 2009 = 14.9 ± 2.6; grupo 2019 = 16.6 ± 4), puede ser un condicionante en el análisis los resultados y tendencias descritas. Lo anterior, ante el hecho de que las personas con SD presentan una tasa de crecimiento marcada por una mayor precocidad del estirón del crecimiento (a los 11 años en los niños y a los 9 y medio en las niñas) (Sarmiento & Gómez, 2022; Zamel et al., 2015). Sin embargo, se tuvo la precaución de no generar diferencias significativas entre la edad de los grupos.

Conclusión

De acuerdo a lo mostrado en el siguiente artículo, es posible identificar que la composición corporal y la condición física presentan diferentes tendencias en la población con SD en el contexto de los periodos evaluados. Por una parte, de manera general la condición física muestra un comportamiento más homogéneo entre ambos periodos, es decir, con menores niveles cambios, y en la segunda parte, la composición corporal, exhibe un comportamiento poco predecible y por lo mismo tendiente a cambios a lo largo del tiempo y entre ambos periodos evaluados.

Tomando en cuenta lo anterior, se puede inferir que la condición física es una variable menos susceptible al cambio o impacto de los distintos estímulos y variables (edad, sexo, etc) que puedes enfrentar la población con SD, en comparación con la composición corporal. Lo anterior, debe ser considerado en el diseño y programación de propuestas de intervención que pretendan mejorar la condición física y salud con esta población.

El comportamiento de la población de este estudio, tienen una relación de los perímetros de cintura y cadera con la edad, la que principalmente disminuye en el grupo del 2019.

Declaración del Comité de Ética

El estudio se realizó siguiendo la Declaración de Helsinki y fue aprobado por el Comité de Comité de Ética de la Universidad Santo Tomás (Código n.° ID-116).

Conflicto de Intereses

Las entidades y los autores del presente artículo no tuvieron influencia en el diseño del estudio, en el análisis de los datos o en la interpretación de los resultados.

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Contribución de los Autores

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Declaración de Disponibilidad de Datos

Datos disponibles bajo demanda al autor de correspondencia (benavides.roca@gmail.com).

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Effects of a Combined Physical Exercise Program on Cardiovascular Capacity in Women With Breast Cancer: a Preliminary Study

Efectos de un Programa de Ejercicio Físico Combinado en la Capacidad Cardiovascular de Mujeres con Cáncer de Mama: Estudio Preliminar

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Abstract

The aim of this study was to analyse the effect of a physical exercise program on cardiovascular capacity in women with breast cancer at any stage of the disease. A pre-experimental design based on Pre and Post-treatment was used. Nine breast cancer subjects participated for this study; the sample was divided into two groups. One group performed a combined and supervised physical exercise program, and the control group maintained their activities of daily living. Cardiovascular capacity, body composition, blood pressure, lower body functionality, hand grip strength and balance were measured both pre and post. Significant between-group differences were found at post in 6 minutes walking test distance travelled, waist-to-hip ratio, 30-seconds sit-to-stand test and balance with the non-dominant leg. Our 8-week combined and supervised physical exercise program is able to increase cardiovascular capacity, lower-body strength and non-dominant leg balance, and reduce waist-to-hip ratio of breast cancer patients at any time of the disease.

Keywords: Malignant tumour of breast, concurrent training, 6MWT, body composition, lower body strength.

Resumen

El objetivo de este estudio fue analizar el efecto de un programa de ejercicio físico en la capacidad cardiovascular de mujeres con cáncer de mama en cualquier momento de la enfermedad. Se utilizó un diseño preexperimental basado en Pre y Post- tratamiento. Participaron nueve sujetos de cáncer de mama, se dividió la muestra en dos grupos. Un grupo realizó un programa de ejercicio físico combinado y supervisado, y el grupo control mantuvo sus actividades de la vida cotidiana. Se midieron tanto en el pre como en el post, la capacidad cardiovascular, composición corporal, presión arterial, funcionalidad del tren inferior, fuerza de prensión manual y equilibrio. Se encontraron diferencias significativas entre grupos en el post, en la distancia recorrida en el test de los 6 minutos caminando, en el índice cintura-cadera, 30 segundos Sit to Stand y equilibrio con la pierna no dominante. Los principales resultados mostraron que un programa de ejercicio físico combinado y supervisado de 8 semanas es capaz de aumentar la capacidad cardiovascular, fuerza del tren inferior y equilibrio de la pierna no dominante, y de reducir el índice cintura-cadera de las pacientes de cáncer de mama en cualquier momento de la enfermedad.

Palabras clave: Cáncer de seno, entrenamiento concurrente, 6MWT, composición corporal, fuerza del tren inferior.

Introduction

Breast cancer is one of the tumours with the highest incidence worldwide; in 2020, it was the most frequently diagnosed cancer, with 2,261,419 cases in total. In 2023, 35,000 new cases of breast cancer were estimated in Spain (Sociedad Española de Oncología Médica [SEOM], 2023).

Treatments to address this disease produce a series of side effects that reduce the quality of life of patients (Courneya, 2001), with the most frequent ones being a decrease in cardiovascular capacity (Adams et al., 2004; Hurria et al., 2016); changes in body composition, such as weight gain and body fat; loss of muscle mass and bone density (Demark-Wahnefried et al., 2018; Goodwin et al., 1999; Hojan et al., 2013; Irwin et al., 2005); joint pain (Arem et al., 2016); peripheral neuropathies (Streckmann et al., 2014); and fatigue (Berger et al., 2012; Ficarra et al., 2022).

Cardiovascular capacity is one of the parameters most affected by treatments such as chemotherapy, radiotherapy, or some targeted therapies. The reduction in maximum oxygen consumption (VO_2max) in these patients can be between 5% and 22% (Hurria et al., 2016). The damage generated in the cells of the cardiovascular system and the toxicity produced by these treatments are some of the causes (Jones et al., 2011). A reduction in cardiovascular capacity linked to cardiotoxicity can increase the risk of various heart diseases, such as coronary artery diseases, myocardial infarction, and cardiomyopathies, among other conditions (Nikovia et al., 2023). In addition, it can affect the functional capacity of patients, their tolerance of daily activities and their daily performance (Aykol et al., 2023; Mera-Mamián et al., 2021), resulting in a decrease in quality of life and increased risk of mortality (Tranchita et al., 2023).

Moderate- and vigorous-intensity physical exercise has been shown to be safe, effective and feasible in women with breast cancer at any time during the disease (Gil-Herrero, McNeely, et al., 2022; Maginador et al., 2020; Schmitz et al., 2010). In addition, it reduces toxicity related to treatments, which helps restrict tumour growth (Maginador et al., 2020). Physical exercise, specifically resistance training, has been shown to be effective for increasing VO_2max. during and after treatment in patients with breast cancer (Kirkham et al., 2016). Increasing VO_2max increases quality of life and functionality and decreases cancer-related fatigue (Ficarra et al., 2022; Hojan et al., 2013; Lamkin & Garland, 2020). In addition, physical exercise improves the metabolic flexibility, number, density, content and oxidative capacity of mitochondria, thus improving the functionality of the cells (San-Millán, 2023).

There are numerous benefits of combined physical exercise (those interventions that combine strength and resistance training) for breast cancer patients (Malveiro et al., 2023; Martínez-Vizcaíno et al., 2023). Therefore, it has been proposed to analyse the impact of a combined physical exercise program on the cardiovascular capacity of this population. In addition, as secondary objectives, the effects of this program on parameters such as body composition, blood pressure, hand grip strength, lower body functionality and balance in women with breast cancer have been investigated.

Methods

Design

This research was carried out via an experimental methodology with a preexperimental design that was based on two small groups pre and post treatment (Thomas et al., 2004), owing to the difficulty of obtaining a large sample for this specific population.

Participants

This study included a sample of nine women with breast cancer belonging to the Asociación de Prevención y atención de Afectadas de Cáncer de Mama (APACAMA) of Toledo. The inclusion criterion in this study was women older than 18 years with a diagnosis of breast cancer at any stage of the disease (survivors with active treatment or advanced disease). The exclusion criteria were the presence of chronic obstructive pulmonary disease (COPD) and the contraindication to physical exercise by the referring physician. The samples were divided into an experimental group (n = 5) and a control group (n = 4). The groups were assigned according to the availability of the participants and not randomly.

Before starting the study, all participants who met the criteria and were interested in participating signed an informed consent form specifying that the study was conducted in accordance with the Declaration of Helsinki.

Procedure

First, an online meeting was organized with all the participants, where they reported on the benefits of physical exercise in patients with breast cancer. In addition, at this meeting, the procedure to be followed throughout the study was detailed, as were the physical exercise programme and assessment tests. Informed consent was subsequently obtained from all participants, and they were summoned to the facilities of the Toledo School of Sports Sciences. Prior to the evaluations, the

participants fasted for a minimum of 4 hours to ensure the correct evaluation of the body composition tests. The tests were carried out in the following order: anthropometric evaluation, body composition, blood pressure measurement, evaluation of hand grip strength, static balance, lower body functionality and, finally, the 6-minute walking test [6MWT] (But-Hadzic et al., 2021).

Instruments and Variables

To assess cardiovascular capacity, the 6MWT was used. It was done outside, on a hard and flat surface. A distance of 30 m was marked, with marks every 3 m, and two points were placed where the participant had to turn around when reaching them. The participant was asked to walk as much distance as possible on this trail for 6 minutes. The distance reached after 6 minutes was recorded, and VO_2max was estimated via the following formula: 22.506-0.271 × weight + 0.051 × distance (6MWT) - 0.065 × age (Mänttäri et al., 2018).

Anthropometric measurements were obtained via a standardized methodology, following the recommendations of the International Society for the Advancement of Kinanthropometry (ISAK). The participants were barefoot, without socks or stockings and with light clothing. A Seca 217 portable height rod (Seca, Ltd., Hamburg, Germany) was used for the height measurement. Waist and hip perimeters were measured with a tape measure, making two consecutive measurements, and if the difference was greater than 1 cm, a third measurement was performed, and the result was averaged over the other measurements.

For body composition, electrical bioimpedance was used (Tanita® Body Composition Monitor model MC 780-S MA, Tokyo, Japan). All the data were processed via DIETOWIN 2023 software, version 11.0 (Dietowin SL). An automatic arm blood pressure monitor (Walson HL888FA, Taipei, Taiwan) was used to assess blood pressure. Manual grip strength was measured via a dynamometer to obtain the grip strength of the dominant and nondominant hands (Takei TKK5401 GRIP-D handgrip dynamometer, Tokyo, Japan). It was measured three times with each arm, without rest, and the arms were alternated with each attempt. For each measurement, the participant was asked to press the dynamometer for 3 seconds. The highest force achieved in each of the arms was recorded.

Lower body functionality was measured with the 30-second sit-to-stand test [30STS] (Gavala-González et al., 2020). The participant was asked to stand up and sit down as many times as possible for 30 seconds. The total number of times the participant rose was recorded.

To evaluate the static balance of the participants, the one-leg standing test was used (Michikawa et al., 2009), where the participant stood with her eyes open. One leg was subsequently lifted at a 90° angle with respect to the hip and held for one minute or as long as possible. Two attempts were made with each leg, and the longest time reached in seconds was recorded.

After the initial assessment, the participants were divided according to their availability into two groups: an exercise group (n = 5) and a control group (n = 4). The interventions are summarized in Table 1, which uses the checklist template and the replication of interventions (Hoffmann et al., 2014).

Before starting the study, descriptive, demographic and medical history data were collected from the participants. After the 8-week intervention period, both groups were sent to the laboratory to perform all the assessments except for the those on the forms with which descriptive data were collected.

Statistical Analysis

The statistical package SPSS® V. 28.0 for Windows 10 (SPSS Inc., Chicago, IL, USA) was used. The Shapiro-Wilk test was performed because the sample size was less than 30 (n = 9) to analyse the distribution and normality of the data. For the variables of age, height, and demographic data and medical history, descriptive statistics (mean, standard deviation and standard error of the mean) were calculated. All the variables, except those referring to the one-way standing test, followed a normal distribution, so Student's t test was applied for related samples (with a 95% confidence interval) to observe the changes between the pre- and postintervention values of each group. Student's t test was used for between-group comparisons of independent samples, establishing a level of significance of $p \leq .05$. Cohen's d was used to study the effect size, in which values less than 0.2 were considered small effects, values between 0.5 and 0.7 were considered medium effects, and values greater than 0.8 were considered large effects (Dominguez-Lara, 2018).

For the variables related to the one-leg standing test, which is nonparametric, the Wilcoxon test was used to observe the differences between the pre- and postintervention values of each group. The Mann-Whitney U test was applied to analyse the differences between both groups, establishing a level of significance of $p \leq .05$. The effect size was studied via biserial correlation, considering values lower than .3 for a small effect, between .3 and .5 for a medium effect, and greater than .5 for a large effect (Dominguez-Lara, 2018).

Table 1
Intervention description using template for intervention and replication (TIDier) checklist

Item number	Item
Brief name	
1	Effects of a combined physical exercise program on cardiovascular capacity in women with breast cancer: A Preliminary study
Why	
2	Analyse the effect of a combined physical exercise program on cardiovascular capacity, body composition, blood pressure, handgrip strength, lower body functionality and balance in women with breast cancer at any stage of the disease.
What	
3	Exercise group had access to the following materials: • Dumbbells from 2 to14 kg • 20 kg Olympic bar • Mats • 1, 2.5, 5 and 10 kg plates • Low, medium and high intensity elastic bands Both groups received general physical activity recommendations.
4	8 weeks combined physical exercise program with strength and resistance exercises.
Who provided	
5	Two fourth year Physical Activity and Sport Sciences students, with previous experience in personal training in oncology patients.
How	
6	Supervised face-to-face sessions in groups of two to three people.
Where	
7	• Strength exercises: Multipurpose gymnasium of the Faculty of Sports Sciences of the University of Castilla-La Mancha in Toledo for strength training. • Resistance exercises: At Senda Ecológica in Toledo.
When and how much	
8	Two weekly sessions of 1 hour, with 48 hours between sessions, for 8 weeks. **Resistance exercises** • **Weeks 1 to 4**: Interval training of 5 x 20 s at moderate intensity (RPE 3-6) and increasing 5 s in intervals each week. Rest 2 to 3 minutes. • **Weeks 5 to 8**: Interval training of 5 x 20 s at vigorous intensity (RPE 7-8) and increasing 5 s intervals each week. Rest 2 to 3 minutes. **Strength exercises** Full-body workouts with the main movement patterns, performing two sets of 8-10 repetitions. • **Weeks 1 to 2**, "Isometric exercises" (30 seconds per repetition): Isometric floor press, Isometric band row, Isometric military press, Isometric pull down, Isometric wall squat, Isometric Romanian deadlift. • **Weeks 3 to 4**, "Exercises with self-loading": Floor press with elastic band, Rowing with elastic band, Military press with elastic band, Pull down with elastic band, Squat, Romanian deadlift with elastic band. • **Weeks 5 to 6**, "Exercises with light external loads" (RPE 4-5): Floor press with dumbbells, Rowing with dumbbells, Military press with dumbbells, Biceps curl with dumbbells, Back squat with barbell, Romanian deadlift with barbell. • **Weeks 7 to 8,** "Exercises with heavy external loads" (RPE 7-8): Floor press with dumbbells, Rowing with dumbbells, Military press with dumbbells, Biceps curl with dumbbells, Back squat with barbell, Romanian deadlift with barbell.
Tailoring	
9	Endurance training could be done walking or walking, depending on the subject's capabilities.
Modifications	
10	A third strength set was added from week 3 to meet the session duration.
How well	
11	Trainers trained in physical exercise in oncology patients.
12	Attendance to the exercise program (%) was 90.00 ± 12.96.

Results

Table 2
Characteristics of the sample

	Total
Age in years, *M* (*SD*)	51 (11.48)
Height in meters, *M* (*SD*)	156.73 (5.9)
Medical history, *n* (%)	
Cancer diagnosis	
LUMINAL A	3 (33.3)
LUMINAL B	3 (33.3)
TRIPLE NEGATIVE	1 (11.1)
HER2+	2 (22.2)
Type of patient	
Under treatment	7 (77.8)
Survivor	2 (22.2)
Menopause	
Premenopausal	7 (77.8)
Postmenopausal	2 (22.2)
Stage of cancer	
I	1 (11.1)
II	5 (55.5)
III	3 (33.3)
Metastasis	
No	6 (66.7)
Nodes	1 (11.1)
Bones	1 (11.1)
Multiple	1 (11.1)
Surgery	
Yes	8 (88.9)
No	1 (11.1)
Type of surgery	
No	1 (11.1)
Breast-sparing	4 (44.4)
Partial mastectomy	1 (11.1)
Total mastectomy	1 (11.1)
Double mastectomy	2 (22.2)
Chemotherapy	
Yes	7 (77.8)
No	2 (22.2)
Active chemotherapy	
Yes	3 (33.3)
No	6 (66.7)
Radiotherapy	
Yes	7 (77.8)
No	2 (22.2)
Hormonal treatment	
Yes	7 (77.8)
No	2 (22.2)

Characteristics of the Sample

As shown in Table 2, in this study, nine participants were recruited, and eight of them completed the final evaluation after the exercise program. The average age of the participants was 51 ± 11.4 years.

In terms of medical history, 66.6% of the participants had been diagnosed with luminal A (33.3%) or luminal B (33.3%) cancer. The majority (77.8%) were receiving treatment at the time of the study, and 77.8% had been diagnosed with cancer before menopause. A total of 55.5% of the participants had been diagnosed with stage II disease, and 66.7% did not have metastases. A total of 88.9% had surgery. Chemotherapy was administered to 77.8% of the participants, but currently, only 33% of them continue with the treatment. A total of 77.8% had received radiotherapy, and a similar number (77.8%) continued with hormonal treatment.

Comparison Before and After the Program

According to the data presented in Table 3, differences in fat-free mass (kg) and percentage were detected in the control group. In addition, differences were found in the systolic pressure values.

Regarding the exercise group, differences were found in the distance covered in the 6MWT, as well as in the number of repetitions performed in the 30STS.

Table 3
Changes in the variables evaluated pre-post combined physical exercise intervention

	CG (*n* = 4), *M* ± *SD*				EG (*n* = 5), *M* ± *SD*					
Variables	**Pre**	**Post**	**Δ**	***p*[a]**	**Pre**	**Post**	**Δ**	***p*[a]**	***p*[b]**	***ES***
Cardiovascular capacity										
6MWT distance travelled (m)	530.63 ± 70.54	574.75 ± 42.23	44.13	.192	645.75 ± 76.86	769.25 ± 134.73	123.5	**.024***	**.033***	-1.948[e]
VO2max estimated (ml/kg/min)	26.15 ± 3.85	28.43 ± 2.32	2.28	.196	32.97 ± 7.76	36.80 ± 12.93	3.83	.197	.248	**-0.846**[e]
Body composition										
Weight (kg)	70.60 ± 17.28	70.50 ± 17.49	-0.10	.572	62.60 ± 14.14	63.38 ± 12.65	0.77	.383	.534	0.467
Fat mass (kg)	25.90 ±10.33	26.90 ± 9.79	1.00	.088	20.85 ± 8.81	20.20 ± 8.66	-0.65	.102	.345	0.725[d]
Fat mass (%)	35.85 ± 6.91	37.53 ± 5.50	1.68	.144	32.40 ± 5.64	30.95 ± 6.50	-1.45	.071	.173	**1.092**[e]
Fat-free mass (kg)	44.18 ± 8.47	43.60 ± 8.62	-0.57	**.019***	41.75 ± 5.47	43.18 ± 4.32	1.43	.127	.933	0.062
Fat-free mass (%)	63.20 ± 5.33	62.48 ±5.50	-0.73	**.024***	67.63 ± 5.66	69.05 ± 6.50	1.43	.070	.173	**-1.092**[e]
Bone mass (kg)	2.333 ± 0.47	2.333 ± 0.47	0.00	-[c]	2.13 ± 0.26	2.20 ± 0.22	0.08	.058	.839	0.150
BMI	28.88 ± 4.82	28.80 ± 4.92	-0.07	.391	24.93 ± 4.30	25.25 ± 3.73	0.32	.340	.294	**0.813**[e]
Hip circumference (cm)	108.67 ± 7.57	103.25 ± 7.64	-5.42	**.001***	98.75 ± 4.19	105.38 ± 11.26	6.63	.204	.765	0.221
Waist circumference (cm)	101.04 ± 12.51	95.75 ± 15.58	-5.29	.051	78.38 ± 8.75	77.00 ± 11.30	-1.38	.740	.099	**1.378**[e]
WHR	0.93 ± 0.05	0.92 ± 0.08	0.00	.836	0.79 ± 0.09	0.73 ± 0.04	-0.06	.166	**.006***	**2.902**[e]
Blood pressure										
Systolic (mmHg)	125.75 ± 10.37	114.00 ± 5.60	-11.75	**.023***	114.75 ± 4.27	112.00 ± 4.83	-2.75	.382	.608	0.383
Diastolic (mmHg)	78.75 ± 6.24	82.25 ± 9.14	3.50	.544	76.25 ± 4.27	74.75 ± 3.30	-1.50	.620	.174	**1.091**[e]
Lower body functionality										
30STS	15.25 ± 1.71	18.25 ± 5.06	3.00	.199	16.25 ± 2.21	24.75 ± 5.05	8.5	**.014***	.119	-1.285[e]
Handgrip strength										
Dominant hand (kg)	23.10 ± 5.84	25.63 ± 7.82	2.53	.276	21.65 ± 4.94	23.75 ± 4.66	2.1	.391	.695	0.291
Nondominant hand (kg)	22.43 ± 9.54	23.38 ± 8.44	0.95	.586	22.4 ± 4.16	24.62 ± 4.60	2.22	.236	.804	-0.184
Balance										
Dominant leg (s)	50.75 ± 18.5	51.75 ± 16.5	1	.655	42.80 ± 19.15	60.00 ± 0.00	17.20	.180	.317	0.353[d]
Nondominant leg (s)	45.5 ±22.51	40.75 ± 16.68	-4.75	.593	54.00 ± 5.52	60.00 ± 0.00	6.00	.180	**.047***	**0.701**[e]

Note: CG = Control group; EG = Exercise group; 6MWT = six-minute walking test; 30STS = 30 seconds sit to stand; Δ = difference between pre and post.

a = Comparison between base and post.

b = Differences between groups at post.

c = T cannot be calculated because the standard error of the difference is 0.

d = Medium ES.

e = Large ES.

* = $p \leq .05$.

Comparison Between Groups

Significant differences in the distance travelled (m) in the 6MWT, in the waist-to-hip ratio (WHR) and in the time spent in balance with the nondominant leg were detected between the two groups.

In addition, a large effect size was observed for the variables referring to cardiovascular capacity, the percentage of fat mass and fat-free mass, BMI, waist circumference and the WHR. Similarly, a large effect size was observed for systolic pressure, 30STS repetitions, and nondominant leg balance. A medium effect size was observed for fat mass (kg).

Discussion

The objective of this study was to analyse the effect of a combined physical exercise program on the cardiovascular capacity of women with breast cancer at any time during the disease course.

Our findings revealed that, after 8 weeks of combined physical exercise, the exercise group was able to cover a greater distance in the 6MWT than the control group, with this increase being greater than 50 m, which is considered a significant clinical difference in most populations (Kirkham et al., 2016). The distance reached by the exercise group was similar to that reached by the group of active women with breast cancer in the cross-sectional study by Gil-Herrero, Pollán, et al. (2022). The increase in distance is not influenced by the stage of the cancer, type of surgery or hormonal treatment (But-Hadzic et al., 2021), so it allows us to compare the population of interest in this study, despite being at different stages of the disease.

In line with the above findings, the differences observed between the groups could be related to the inclusion of moderate-to-high intensity cardiovascular exercise. In agreement with other studies, physical exercise interventions with a duration of 8-14 weeks a training frequency of 2-3 times per week, which include between 20 and 45 minutes of moderate-to high-intensity aerobic exercise are effective in improving the cardiovascular capacity of patients with breast cancer during and after treatment (Kirkham et al., 2016).

Another objective of this study was to evaluate the impact of the combined physical exercise program on the body composition and blood pressure of this population. Our results showed that an 8-week physical exercise program is effective in reducing WHR in women with breast cancer, in accordance with the results of other interventions, such as those carried out by Nuri et al. (2012) and Rogers et al. (2009). A reduction in the WHR to less than 0.85 is essential in this population, since high WHR values increase the risk of death from any cause, metabolic complications, and increased risk of recurrence (Chan & Norat, 2015).

Although our results revealed an increase in the percentage of muscle mass and a decrease in the fat mass of the participants in the exercise group, this difference was not significant, but a large effect size was observed for these variables. This could be due to the duration of the program, since some studies have not shown improvements in body composition and body weight until week 20 of the intervention (Kirkham et al., 2016). However, multiple studies have shown differences in these variables with only 12 weeks of intervention (Casla-Barrio et al., 2021; Gil-Herrero, Courneya, et al., 2022; Lee & An, 2022). These improvements are important since the loss of muscle mass in cancer patients is associated with a worse quality of life and greater toxicity during chemotherapy, and the increase in fat mass increases the risk of metabolic and cardiovascular diseases in the long term (Gil-Herrero, Courneya, et al., 2022). In the control group, there were significant differences in fat-free mass and fat percentage. This is because both a sedentary lifestyle (Shur et al., 2021) and treatment (Hojan et al., 2013; Mijwel, Cardinale, et al., 2018; Tram et al., 2022) reduce muscle mass.

With respect to blood pressure, no significant differences were found, but a large effect size was observed for diastolic pressure, such as a decrease in systolic pressure (2.75 mmHg) and diastolic pressure (1.50 mmHg), which agrees with the results obtained in the review by Kirkham et al. (2016) in breast cancer patients during and after finishing the treatments.

Another objective of this study was to observe the impact of a combined physical exercise program on hand grip strength and lower body functionality in this population. After the program, the participants in the exercise group were able to perform a higher number of repetitions in the 30STS than were those in the control group. These results are consistent with those of multiple studies conducted with this group (Gavala-González et al., 2020; Herrero et al., 2006; Santagnello et al., 2020). These strength improvements are related to a better quality of life for patients because these patients show greater satisfaction with their physical condition (Hojan et al., 2013), better functionality and ease of performing activities of daily living.

With respect to hand grip strength, no differences were observed between the two groups. As we have commented previously, one of the main limitations of these differences is the duration of the program, since numerous studies show differences in these variables as the program lasts longer (Lee & An, 2022; Mijwel, Backman, et al., 2018). In turn, this could be because our participants had greater manual grip strength than the expected values for their age, as occurred in the study by Parkinson et al. (2023), where there was no improvement after one year of intervention.

Finally, another objective of the study was to examine the effect of a combined physical exercise program on balance in breast cancer patients at any time during the disease course. Our results revealed a significant improvement in the balance of the nondominant leg in the exercise group compared with the control group. Although we do not perform specific balance exercises in the program, the gain in strength obtained in the lower body contributes to balance in a keyway (McLay et al., 2019).

Limitations

One of the main limitations of this study is the sample size, due to the specificity of the population, in addition to being a group with little interest in practising physical exercise. Another limitation is the heterogeneity of the sample, due both to the types of breast cancer and to the time in which the disease was found in each one of them, which could affect the results obtained. Another limitation of the study is the division between groups, since it was not randomized because it was based on the availability of the participants to carry out the program. On the other hand, the duration of the exercise program was a limiting factor, since with a longer program, more differences could have been observed in the variables evaluated.

Conclusions

The findings of this study indicate that an 8-week supervised and combined physical exercise program improves the cardiovascular capacity, strength and functionality of the lower body, as well as the balance of the nondominant leg, in patients with breast cancer at any time of illness. In addition, this type of intervention has been shown to reduce the waist-hip ratio in this population.

Ethics Committee Statement

The study was conducted in accordance with the Declaration of Helsinki and participants signed an informed consent form prior to participation in the study.

Conflict of Interest Statement

The authors declare that they have no conflicts of interest.

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Authors' Contribution

Conceptualization: A.J. & M.C.; Data curation: A.J. & H.A.; Formal analysis A.J.; Investigation: A.J., E.M., H.A., & M.V.G.; Methodology: A.J., E.M., H.A. & M.C.; Project administration: M.C.; Resources: M.V.G.; Supervision: M.C. & M.V.G.; Validation: M.C. & M.V.G.; Visualization: A.J.; Writing – Original draft: A.J. & M.C; Writing – review & editing: A.J., E.M., H.A., M.C. & M.V.G. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author alejandroj.m.01@gmail.com.

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Efectos de un Programa de Ejercicio Físico Combinado en la Capacidad Cardiovascular de Mujeres con Cáncer de Mama: Estudio Preliminar

Effects of a Combined Physical Exercise Program on Cardiovascular Capacity in Women With Breast Cancer: a Preliminary Study

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Resumen

El objetivo de este estudio fue analizar el efecto de un programa de ejercicio físico en la capacidad cardiovascular de mujeres con cáncer de mama en cualquier momento de la enfermedad. Se utilizó un diseño preexperimental basado en Pre y Post- tratamiento. Participaron nueve sujetos de cáncer de mama, se dividió la muestra en dos grupos. Un grupo realizó un programa de ejercicio físico combinado y supervisado, y el grupo control mantuvo sus actividades de la vida cotidiana. Se midieron tanto en el pre como en el post, la capacidad cardiovascular, composición corporal, presión arterial, funcionalidad del tren inferior, fuerza de prensión manual y equilibrio. Se encontraron diferencias significativas entre grupos en el post, en la distancia recorrida en el test de los 6 minutos caminando, en el índice cintura-cadera, 30 segundos Sit to Stand y equilibrio con la pierna no dominante. Los principales resultados mostraron que un programa de ejercicio físico combinado y supervisado de 8 semanas es capaz de aumentar la capacidad cardiovascular, fuerza del tren inferior y equilibrio de la pierna no dominante, y de reducir el índice cintura-cadera de las pacientes de cáncer de mama en cualquier momento de la enfermedad.

***Palabras clave*:** Cáncer de seno, entrenamiento concurrente, 6MWT, composición corporal, fuerza del tren inferior.

Abstract

The aim of this study was to analyse the effect of a physical exercise program on cardiovascular capacity in women with breast cancer at any stage of the disease. A pre-experimental design based on Pre and Post-treatment was used. Nine breast cancer subjects participated for this study; the sample was divided into two groups. One group performed a combined and supervised physical exercise program, and the control group maintained their activities of daily living. Cardiovascular capacity, body composition, blood pressure, lower body functionality, hand grip strength and balance were measured both pre and post. Significant between-group differences were found at post in 6 minutes walking test distance travelled, waist-to-hip ratio, 30-seconds sit-to-stand test and balance with the non-dominant leg. Our 8-week combined and supervised physical exercise program is able to increase cardiovascular capacity, lower-body strength and non-dominant leg balance, and reduce waist-to-hip ratio of breast cancer patients at any time of the disease.

***Keywords*:** Malignant tumour of breast, concurrent training, 6MWT, body composition, lower body strength.

Introducción

El cáncer de mama es uno de los tumores con mayor incidencia en el mundo, siendo en 2020 el mayor diagnosticado con 2,261,419 casos. En 2023, se estima que habrá 35,000 nuevos casos de cáncer de mama en España (Sociedad Española de Oncología Médica [SEOM], 2023).

Los tratamientos para hacer frente a esta enfermedad producen una serie de efectos secundarios que reducen la calidad de vida de las pacientes (Courneya, 2001), siendo los más frecuentes la disminución de la capacidad cardiovascular (Adams et al., 2004; Hurria et al., 2016), cambios en la composición corporal como el aumento de peso y grasa corporal, así como la pérdida de masa muscular y densidad ósea (Demark-Wahnefried et al., 2018; Goodwin et al.,1999; Hojan et al., 2013; Irwin et al., 2005), dolores articulares (Arem et al., 2016), neuropatías periféricas (Streckmann et al., 2014), y la fatiga (Berger et al., 2012; Ficarra et al., 2022).

La capacidad cardiovascular es uno de los parámetros más afectados por tratamientos como la quimioterapia, radioterapia, o algunas terapias dirigidas. La reducción del consumo máximo de oxígeno (VO_2max) en estas pacientes puede llegar a ser entre un 5-22% (Hurria et al., 2016). El daño generado en las células del sistema cardiovascular y la toxicidad producida por los tratamientos son algunas de las causas (Jones et al., 2011). La reducción de la capacidad cardiovascular ligada a la cardiotoxicidad puede aumentar el riesgo de sufrir diversas enfermedades cardíacas, tales como enfermedades de la arteria coronaria, infarto de miocardio, cardiomiopatías, entre otras afecciones (Nikovia et al., 2023). Además, puede afectar a la capacidad funcional de las pacientes, a su tolerancia de las actividades cotidianas y a su desempeño diario (Aykol et al., 2023; Mera-Mamián et al., 2021), lo que resulta en una disminución de la calidad de vida y un mayor riesgo de mortalidad (Tranchita et al., 2023).

El ejercicio físico de intensidad moderada y vigorosa ha demostrado ser seguro, efectivo y factible en mujeres con cáncer de mama en cualquier momento de la enfermedad (Gil-Herrero, McNeely, et al., 2022; Maginador et al., 2020; Schmitz et al., 2010). Además, reduce la toxicidad relacionada con los tratamientos, lo que ayuda a restringir el crecimiento de tumor (Maginador et al., 2020). El ejercicio físico, en concreto el entrenamiento de resistencia, ha demostrado ser eficaz para incrementar el VO_2max durante y después del tratamiento en las pacientes con cáncer de mama (Kirkham et al., 2016). El incremento del VO_2max aumenta la calidad de vida, la funcionalidad, y disminuye la fatiga relacionada con el cáncer (Ficarra et al., 2022; Hojan et al., 2013; Lamkin & Garland, 2020). Además, el ejercicio físico mejora la flexibilidad metabólica, número, densidad, contenido y capacidad oxidativa de las mitocondrias, mejorando así la funcionalidad de las células (San-Millán, 2023).

Son numerosos los beneficios que el ejercicio físico combinado (aquellas intervenciones que combinan entrenamiento de fuerza y de resistencia) aportan a las pacientes de cáncer de mama (Malveiro et al., 2023; Martínez-Vizcaíno et al., 2023). Por ello, se ha planteado analizar el impacto de un programa de ejercicio físico combinado en la capacidad cardiovascular de esta población. Además, como objetivos secundarios se ha pretendido examinar el efecto de este programa en parámetros como la composición corporal, presión arterial, prensión manual, funcionalidad del tren inferior y en el equilibrio en mujeres con cáncer de mama.

Método

Diseño

La investigación se ha realizado mediante una metodología experimental, con un diseño preexperimental, basándose en un Pre Tratamiento Post de dos grupos reducidos (Thomas et al., 2004), debido a la dificultad para encontrar una amplia muestra de esta población especifica.

Participantes

El estudio está formado por una muestra de nueve mujeres con cáncer de mama pertenecientes a la Asociación de Prevención y atención de Afectadas de Cáncer de Mama (APACAMA) de Toledo. Los criterios de inclusión en este estudio fueron mujeres mayores de 18 años con un diagnóstico de cáncer de mama en cualquier etapa de la enfermedad (supervivientes, con tratamiento activo o con enfermedad avanzada). Se establecieron como criterios de exclusión la presencia de enfermedad pulmonar obstructiva crónica (EPOC) y la contraindicación para realizar ejercicio físico por parte del médico de referencia. La muestra se ha dividido entre el grupo experimental (n = 5) y el grupo control (n = 4). La asignación de grupos se realizó en función de la disponibilidad de las participantes, y no aleatoriamente.

Previamente a comenzar el estudio, todas las participantes que cumplían los criterios y estaban interesadas en participar, firmaron una hoja de consentimiento informado especificando que el estudio se realizó en acuerdo con la Declaración de Helsinki.

Procedimiento

En primer lugar, se organizó una reunión online con todas las participantes, donde se informó sobre los beneficios del ejercicio físico en pacientes con cáncer de mama. Además, en esta reunión se detalló el procedimiento a seguir durante todo el estudio, así como en que consistiría el programa de ejercicio físico y las pruebas de valoración. Posteriormente, se envió el consentimiento informado a todas las participantes y se citaron en las instalaciones de la Facultad de Ciencias del Deporte de Toledo. Previo a las valoraciones, las participantes realizaron un ayuno mínimo de cuatro horas con el objetivo de asegurar la correcta evaluación de las pruebas de composición corporal. Las pruebas se llevaron a cabo siguiendo el siguiente orden: evaluación antropométrica, composición corporal, medición de la presión arterial, evaluación de la fuerza de prensión manual, equilibrio en estático, funcionalidad del tren inferior y finalmente, el Test de los 6 Minutos Caminando [6MWT] (But-Hadzic et al., 2021).

Instrumentos y Variables

Para evaluar la capacidad cardiovascular se utilizó el 6MWT. Se realizó en el exterior, en una superficie dura y plana. Se marcó una distancia de 30 metros, con marcas cada 3 metros, y se colocaron dos puntos donde el participante tenía que darse la vuelta al alcanzarlos. Se le pidió a la participante que caminará la mayor distancia posible en este recorrido durante 6 minutos. Se anotó la distancia alcanzada tras los 6 minutos y se estimó el VO2max mediante la siguiente fórmula: 22.506 - 0.271 x peso + 0.051 x distancia (6MWT) – 0.065 x edad (Mänttäri et al., 2018).

La medición antropométrica se realizó a través de una metodología estandarizada, siguiendo las recomendaciones de la International Society for the Advancement of Kinanthropometry (ISAK). Las participantes iban descalzas, sin calcetines ni medias y con ropa ligera. Para la medición de la altura se empleó un Tallímetro portátil Seca 217 (Seca, Ltd., Hamburg, Germany). Los perímetros de cintura y cadera se midieron con una cinta métrica, realizando dos medidas consecutivas y si la diferencia era mayor a 1 cm, se realizaba una tercera y el resultado se hacía media con las demás medidas.

Para la composición corporal se empleó la biompedancia eléctrica (Tanita® Body Composition Monitor modelo MC 780-S MA, Tokio, Japón). Todos los datos fueron procesados a través del software DIETOWIN 2023, versión 11.0 (Dietowin SL). Se utilizó un tensiómetro de brazos automático (Walson HL888FA, Taipei, Taiwan) para evaluar la presión arterial. La fuerza de prensión manual se midió a través de un dinamómetro para obtener la fuerza de agarre de la mano dominante y no dominante (Takei T.K.K.5401 GRIP-D handgrip dynamometer, Tokyo, Japan). Se midió tres veces con cada brazo, sin descanso y alternando en cada intento el brazo. En cada medida, se pidió al participante que presionase el dinamómetro durante 3 segundos. Se registraba el valor de fuerza más alto alcanzado en cada uno de los brazos.

La funcionalidad del tren inferior se midió con el Test de los 30 segundos Sit to Stand [30STS] (Gavala-González et al., 2020). Se pidió a la participante que, desde la posición de sentado, se levantara y sentara el mayor número de veces durante 30 segundos. Se registró el número total de veces que la participante se levanta.

Para evaluar el equilibrio en estático de las participantes se utilizó el One-leg standing test (Michikawa et al., 2009), donde la participante se colocaba en bipedestación y con los ojos abiertos. Posteriormente se levantaba una pierna haciendo un ángulo de 90º respecto a su cadera y la mantiene durante un minuto o en su defecto el mayor tiempo posible. Se realizaron dos intentos con cada pierna y se registró el mayor tiempo alcanzado en segundos.

Tras la valoración inicial, se dividió a las participantes en función de su disponibilidad en dos grupos, un grupo de ejercicio (n = 5) y un grupo control (n = 4). La intervención queda resumida en la Tabla 1, utilizando plantilla de lista de comprobación y la replicación de intervenciones (Hoffmann et al., 2014).

Previamente a comenzar el estudio se recogieron datos descriptivos, demográficos y sobre la historia clínica de las participantes. Tras el periodo de 8 semanas de intervención, ambos grupos fueron citados en el laboratorio para volver a realizar todas las pruebas de valoración a excepción del formulario de datos descriptivos.

Tabla 1
Descripción de la intervención utilizando la plantilla de lista de comprobación y la replicación de intervenciones (TIDier)

Nº del item	Ítem
Nombre abreviado	
1	Efectos de un programa de ejercicio físico combinado en mujeres con cáncer de mama.
Por qué	
2	Analizar los efectos de un programa de ejercicio físico combinado en la capacidad cardiovascular, composición corporal, presión arterial, prensión manual, funcionalidad del tren inferior y equilibrio en mujeres con cáncer de mama en cualquier momento de la enfermedad.
Qué	
3	El grupo de ejercicio tuvo acceso a los siguientes materiales: • Mancuernas de 2 a 14 kg • Barra olímpica de 20 kg • Esterillas • Discos de 1, 2.5, 5 y 10 kg • Gomas de baja, media y alta intensidad Ambos grupos recibieron recomendaciones de actividad física.
4	Programa de ejercicio físico combinado de 8 semanas, donde se combinan ejercicios de fuerza y aeróbico en la parte principal de la sesión.
Quién realiza la intervención	
5	Dos estudiantes de cuarto curso de Ciencias de la Actividad Física y del Deporte, con previa experiencia en el entrenamiento personal en el paciente oncológico.
Cómo	
6	Sesiones presenciales supervisadas en grupos de dos a tres personas.
Dónde	
7	• **Ejercicios de fuerza:** Gimnasio multiusos de la Facultad de Ciencias del Deporte de Toledo de la Universidad de Castilla-La Mancha para la parte de fuerza. • **Ejercicios aeróbicos:** En la Senda Ecológica en Toledo.
Cuándo y cuánto	
8	Dos sesiones semanales de 1 hora, con 48 horas de diferencia entre sesiones, durante 8 semanas **Ejercicios aeróbicos** • Semanas 1 a la 4: Entrenamiento interválico de 5 x 20 s a intensidad moderada (RPE 3-6) y aumentando 5 s en los intervalos cada semana. Descanso de 2 a 3 minutos. • Semanas 5 a la 8: Entrenamiento interválico de 5 x 20 s a intensidad vigorosa (RPE 7-8) y aumentando 5 s en los intervalos cada semana. Descanso de 2 a 3 minutos. **Ejercicios de fuerza** Entrenamientos full-body con los principales patrones de movimiento, realizando de trabajo dos series de 8-10 repeticiones. • **Semanas 1 a la 2**, "Ejercicios isométricos" (30 segundos cada repetición): Floor press isométrico, Remo isométrico, Press militar isométrico, Pull down isométrico, Sentadilla en pared, Peso muerto rumano isométrico. • **Semanas 3 a la 4,** "Ejercicios con autocarga": Floor press con goma, Remo con goma, Press militar con goma, Pull down con goma, Sentadilla, Peso muerto rumano con goma. • **Semanas 5 a la 6,** "Ejercicios con cargas externas ligeras" (RPE 4-5): Floor press con mancuernas, Remo con mancuernas, Press militar con mancuernas, Curl de bíceps con mancuernas, Sentadilla trasera con barra, Peso muerto rumano con barra. • **Semanas 7 a la 8,**"Ejercicios con cargas externas pesadas" (RPE 7-8): Floor press con mancuernas, Remo con mancuernas, Press militar con mancuernas, Curl de bíceps con mancuernas, Sentadilla trasera con barra, Peso muerto rumano con barra.
Adaptaciones	
9	El entrenamiento aeróbico se podía realizar andando o caminando, en función de las capacidades del sujeto.
Modificaciones	
10	Se añadió una tercera serie de fuerza a partir de la semana 3 para cumplir la duración de la sesión.
Cómo de bien	
11	Entrenadores formados en ejercicio físico en el paciente oncológico.
12	La asistencia al programa de ejercicio (%) fue del 90.00 ± 12.96.

Análisis Estadístico

Se utilizó el paquete estadístico SPSS ® V. 28.0 para Windows 10 (SPSS Inc., Chicago, IL, EE.UU.). Se realizó la prueba de Shapiro-Wilk, debido a que el tamaño de la muestra era inferior a 30 (n = 9), y con el fin de analizar la distribución y normalidad de los datos. Para las variables de edad, altura, y las referentes a datos demográficos e historia clínica, se calcularon lo estadísticos descriptivos (media, desviación estándar y error típico de la media). Todas las variables, excepto a las referentes al One-Leg Standing test, seguían distribución normal, por lo que se aplicó la prueba T de Student para muestras relacionadas (con un intervalo de confianza del 95%) con el fin de observar los cambios entre el Pre- y Post- de cada grupo. Se utilizó la Prueba T de Student para muestras independientes para las comparaciones entre grupos, estableciendo un nivel de significación de $p \leq .05$. Se utilizó la d de Cohen para estudiar el tamaño del efecto, en la que se consideró, valores inferiores a 0.2 un efecto pequeño, entre 0.5-0.7 un efecto medio, y valores superiores a 0.8 un efecto grande (Dominguez-Lara, 2018).

En las variables relacionadas al one-Leg Standing test, al ser no paramétricas, se utilizó la prueba de Wilcoxon con el fin de observar las diferentes entre el Pre- y Post- de cada grupo. Se aplicó la prueba de la U de Mann-Whitney, para analizar las diferencias entre ambos grupos, estableciendo un nivel de significación de $p \leq .05$. Se estudió el tamaño del efecto mediante la correlación biserial, considerando valores inferiores a .3 de efecto pequeño, entre .3 y .5 de efecto medio, y superiores a .5 de efecto grande (Dominguez-Lara, 2018).

Resultados

Características de la Muestra

Como se puede observar en la Tabla 2, en este estudio, se reclutaron nueve participantes, de las cuales ocho completaron la evaluación final después del programa de ejercicio. La edad promedio de las participantes fue de 51 ± 11.4 años.

En cuanto a la historia clínica, el 66.6% de las participantes habían sido diagnosticadas con el subtipo de cáncer Luminal A (33.3%) o Luminal B (33.3%). La mayoría (77.8%) estaba recibiendo tratamiento en el momento del estudio, y el 77.8% había sido diagnosticado con cáncer antes de la menopausia. Un 55.5% de las participantes habían sido diagnosticadas en el estadio II de la enfermedad, y el 66.7% no tenían metástasis. Al 88.9% se le había realizado cirugía. La quimioterapia había sido administrada al 77.8% de las participantes, pero en la actualidad solo el 33% continuaban con el tratamiento. El 77.8% había recibido radioterapia, y un número similar (77.8%) seguía con tratamiento hormonal.

Comparación Pre-Post Programa

De acuerdo con los datos presentados en la Tabla 3, se han encontrado diferencias en el grupo de control en la masa libre de grasa (kg) y en su respectivo porcentaje. Además, se encontraron diferencias en los valores de presión sistólica.

Referente al grupo de ejercicio, se encontraron diferencias en la distancia recorrida en el 6MWT, así como en el número de repeticiones realizadas en el 30STS.

Tabla 2
Datos descriptivos de la muestra

	Total
Edad en años, *M* (*DE*)	51 (11.48)
Altura en metros, *M* (*DE*)	156.73 (5.9)
Datos clínicos, *n* (%)	
Tipo de cáncer	
LUMINAL A	3 (33.3)
LUMINAL B	3 (33.3)
TRIPLE NEGATIVO	1 (11.1)
HER2+	2 (22.2)
Tipo de paciente	
En tratamiento	7 (77.8)
Superviviente	2 (22.2)
Menopausia	
Premenopausia	7 (77.8)
Postmenopausia	2 (22.2)
Estadio del cáncer	
I	1 (11.1)
II	5 (55.5)
III	3 (33.3)
Metástasis	
No	6 (66.7)
Ganglios	1 (11.1)
Huesos	1 (11.1)
Múltiple	1 (11.1)
Cirugía	
Sí	8 (88.9)
No	1 (11.1)
Tipo de cirugía	
No	1 (11.1)
Conservadora	4 (44.4)
Mastectomía parcial	1 (11.1)
Mastectomía radical	1 (11.1)
Mastectomía radical doble	2 (22.2)
Quimioterapia	
Sí	7 (77.8)
No	2 (22.2)
Quimioterapia en activo	
Sí	3 (33.3)
No	6 (66.7)
Radioterapia	
Sí	7 (77.8)
No	2 (22.2)
Tratamiento hormonal	
Sí	7 (77.8)
No	2 (22.2)

Tabla 3
Cambios en las variables evaluadas pre-post intervención de ejercicio físico combinado

	CG (*n* = 4), *M* ± *DE*				EG (*n* = 5), *M* ± *DE*					
Variables	**Pre**	**Post**	Δ	***p*[a]**	**Pre**	**Post**	Δ	***p*[a]**	***p*[b]**	***TE***
Capacidad cardiovascular										
Distancia alcanzada en el 6MWT (m)	530.63 ± 70.54	574.75 ± 42.23	44.13	.192	645.75 ± 76.86	769.25 ± 134.73	123.5	**.024***	**.033***	**-1.948[e]**
VO2max estimado (ml/kg/min)	26.15 ± 3.85	28.43 ± 2.32	2.28	.196	32.97 ± 7.76	36.80 ± 12.93	3.83	.197	.248	**-0.846[e]**
Composición corporal										
Peso (kg)	70.60 ± 17.28	70.50 ± 17.49	-0.10	.572	62.60 ± 14.14	63.38 ± 12.65	0.77	.383	.534	0.467
Masa grasa (kg)	25.90 ± 10.33	26.90 ± 9.79	1.00	.088	20.85 ± 8.81	20.20 ± 8.66	-0.65	.102	.345	0.725[d]
Masa grasa (%)	35.85 ± 6.91	37.53 ± 5.50	1.68	.144	32.40 ± 5.64	30.95 ± 6.50	-1.45	.071	.173	1.092[e]
Masa libre de grasa (kg)	44.18 ± 8.47	43.60 ± 8.62	-0.57	**.019***	41.75 ± 5.47	43.18 ± 4.32	1.43	.127	.933	0.062
Masa libre de grasa (%)	63.20 ± 5.33	62.48 ±5.50	-0.73	**.024***	67.63 ± 5.66	69.05 ± 6.50	1.43	.070	.173	**-1.092[e]**
Masa ósea (kg)	2.333 ± 0.47	2.333 ± 0.47	0.00	-[c]	2.13 ± 0.26	2.20 ± 0.22	0.08	.058	.839	0.150
IMC	28.88 ± 4.82	28.80 ± 4.92	-0.07	.391	24.93 ± 4.30	25.25 ± 3.73	0.32	.340	.294	**0.813[e]**
Perímetro de cadera (cm)	108.67 ± 7.57	103.25 ± 7.64	-5.42	**.001***	98.75 ± 4.19	105.38 ± 11.26	6.63	.204	.765	0.221
Perímetro de cintura (cm)	101.04 ± 12.51	95.75 ± 15.58	-5.29	.051	78.38 ± 8.75	77.00 ± 11.30	-1.38	.740	.099	**1.378[e]**
ICC	0.93 ± 0.05	0.92 ± 0.08	0.00	.836	0.79 ± 0.09	0.73 ± 0.04	-0.06	.166	**.006***	**2.902[e]**
Presión arterial										
Presión sistólica (mmHg)	125.75 ± 10.37	114.00 ± 5.60	-11.75	**.023***	114.75 ± 4.27	112.00 ± 4.83	-2.75	.382	.608	0.383
Presión diastólica (mmHg)	78.75 ± 6.24	82.25 ± 9.14	3.50	.544	76.25 ± 4.27	74.75 ± 3.30	-1.50	.620	.174	**1.091[e]**
Funcionalidad del tren inferior										
30STS	15.25 ± 1.71	18.25 ± 5.06	3.00	.199	16.25 ± 2.21	24.75 ± 5.05	8.5	**.014***	.119	**-1.285[e]**
Prensión manual										
Mano dominante (kg)	23.10 ± 5.84	25.63 ± 7.82	2.53	0.276	21.65 ± 4.94	23.75 ± 4.66	2.1	.391	.695	0.291
Mano no dominante (kg)	22.43 ± 9.54	23.38 ± 8.44	0.95	0.586	22.4 ± 4.16	24.62 ± 4.60	2.22	.236	.804	-0.184
Equilibrio										
Pierna dominante (s)	50.75 ± 18.5	51.75 ± 16.5	1	0.655	42.80 ± 19.15	60.00 ± 0.00	17.20	.180	.317	0.353[d]
Pierna no dominante (s)	45.5 ±22.51	40.75 ± 16.68	-4.75	0.593	54.00 ± 5.52	60.00 ± 0.00	6.00	.180	**.047***	**0.701[e]**

Nota: CG = Grupo control; EG = Grupo de ejercicio; 6MWT = test de los seis minutos andando; 30STS = 30 segundos sit to stand; Δ = diferencia entre pre y post.

a = Comparación entre base y post.

b = Diferencia en el post entre grupos.

c = *T* no se puede calcular porque el error estándar de la diferencia es 0.

d = *TE* medio.

e = *TE* grande.

* = $p \leq .05$.

Comparación entre Grupos

Se observaron diferencias significativas entre ambos grupos en la distancia recorrida (m) en el 6MWT, en el ICC y en el tiempo en equilibrio con la pierna no dominante.

Además, se observó un tamaño del efecto grande en las variables referentes a la capacidad cardiovascular, el porcentaje de masa grasa y masa libre de grasa, el IMC, perímetro de cintura y en el ICC. Asimismo, se observa un tamaño del efecto grande en la presión sistólica, en las repeticiones del 30STS y en el equilibrio de la pierna no dominante. Se observa un tamaño de efecto medio en la masa grasa (kg).

Discusión

El objetivo de este estudio fue analizar el efecto de un programa de ejercicio físico combinado en la capacidad cardiovascular de mujeres con cáncer de mama en cualquier momento de la enfermedad.

Nuestros hallazgos han mostrado que, tras 8 semanas de ejercicio físico combinado, el grupo de ejercicio fue capaz de recorrer mayor distancia en la prueba de 6MWT que el grupo control, siendo este aumento mayor a los 50 m, que se considera una diferencia clínica significativa en la mayoría de las poblaciones (Kirkham et al., 2016). La distancia alcanzada por el grupo de ejercicio fue similar a la alcanzada por el grupo de mujeres activas con cáncer de mama del estudio transversal de Gil-Herrero, Pollán, et al. (2022). Se ha demostrado que el aumento de la distancia no se ve influenciado por el estadio del cáncer, tipo de cirugía ni tratamiento hormonal (But-Hadzic et al., 2021), por lo que permite comparar a la población de este estudio, a pesar de encontrarse en momentos diferentes de la enfermedad.

En línea con lo anterior, las diferencias observadas entre los grupos podrían estar relacionadas con la inclusión de ejercicio cardiovascular de intensidad moderada-alta. En concordancia con otros estudios, se ha demostrado que las intervenciones de ejercicio físico con una duración entre 8-14 semanas, una frecuencia de entrenamiento de 2-3 veces por semana, que incluyan entre 20-45 minutos de ejercicio aeróbico de intensidad moderada a vigorosa son efectivas para mejorar la capacidad cardiovascular de pacientes con cáncer de mama durante y después de los tratamientos (Kirkham et al., 2016).

Por otro lado, otro de los objetivos planteados en este estudio fue evaluar el impacto del programa de ejercicio físico combinado en la composición corporal y la presión arterial de esta población.

Nuestros resultados mostraron que un programa de ejercicio físico de 8 semanas es eficaz para reducir el ICC de las mujeres con cáncer de mama, en concordancia con los resultados de otras intervenciones como las realizadas por Nuri et al. (2012) y por Rogers et al. (2009). La reducción del ICC, por debajo de 0.85 es indispensable en esta población, ya que valores altos de ICC aumentan el riesgo de muerte por cualquier causa, complicaciones metabólicas, así como un aumento del riesgo de recidiva (Chan & Norat, 2015).

Aunque nuestros resultados muestran un aumento en el porcentaje de la masa muscular y disminución de la masa grasa de las participantes del grupo de ejercicio, esta diferencia no es significativa, pero se observa un tamaño de efecto grande en estas variables. Esto pudo ser debido a la duración del programa, ya que algunas investigaciones no han mostrado mejoras en la composición corporal y en el peso corporal, hasta la semana 20 de la intervención (Kirkham et al., 2016). Sin embargo, existen múltiples estudios que muestran diferencias en estas variables con tan sólo 12 semanas de intervención (Casla-Barrio et al., 2021; Gil-Herrero, Courneya, et al., 2022; Lee & An, 2022). Estas mejoras son importantes ya que la pérdida de masa muscular en pacientes con cáncer está asociadas a una peor calidad de vida y mayor toxicidad en la quimioterapia; y la ganancia de masa grasa incrementa el riesgo de enfermedades metabólicas y cardiovasculares a largo plazo (Gil-Herrero, Courneya, et al., 2022). Referente al grupo de control, existen diferencias significativas en la masa libre de grasa y en su porcentaje. Esto es debido a que tanto el sedentarismo (Shur et al., 2021) como el tratamiento (Hojan et al., 2013; Mijwel, Cardinale, et al., 2018; Tram et al., 2022), reducen los niveles de masa muscular.

En cuanto a la presión arterial, no se han encontrado diferencias significativas, pero se aprecia un tamaño del efecto grande en la diastólica como un descenso de la presión sistólica (2.75 mmHg) y la diastólica (1.50 mmHg), que concuerda con los resultados obtenidos en la revisión de Kirkham et al. (2016) en pacientes de cáncer de mama durante y tras finalizar los tratamientos.

Otro de los objetivos planteados en este estudio fue observar el impacto del programa de ejercicio físico combinado sobre la prensión manual y funcionalidad del tren inferior en esta población. Tras el programa, las participantes del grupo de ejercicio fueron capaces de realizar un mayor número de repeticiones en el 30STS comparado con el grupo control. Estos resultados concuerdan con múltiples estudios realizados con este colectivo (Gavala-González et al., 2020; Herrero et al., 2006; Santagnello et al., 2020). Estas mejoras de fuerza están relacionadas con una mejor calidad de vida de las pacientes, debido a que muestran mayor satisfacción con su condición física, (Hojan et al., 2013) mejor funcionalidad y facilidad para desempeñar las actividades de la vida cotidiana.

Referente a la prensión manual, no se han observado diferencias entre ambos grupos. Como hemos comentado anteriormente, una de las principales limitaciones de estas diferencias es la duración del programa, ya que numerosos estudios muestran diferencias en estas variables al tener mayor duración del programa (Lee & An, 2022; Mijwel, Backman, et al., 2018). A su vez, esto pudo ser debido a que nuestras participantes tenían una mayor fuerza de prensión manual que los valores esperados para su edad, tal y como sucedió en el estudio de Parkinson et al. (2023), donde no hubo una mejora tras un año de intervención.

Por último, otro de los objetivos del estudio era examinar el efecto en el equilibrio de un programa de ejercicio físico combinado en pacientes de cáncer de mama en cualquier momento de la enfermedad. Nuestros resultados muestran

una mejora significativa en el equilibrio de la pierna no dominante del grupo de ejercicio comparado con el grupo control. Aunque no realizamos ejercicios específicos de equilibrio en el programa, la ganancia de fuerza obtenida en el tren inferior contribuye de forma clave en el equilibrio (McLay et al., 2019).

Limitaciones

Una de las principales limitaciones de este estudio es el tamaño de la muestra, debido a la especificidad de la población, además de ser un colectivo con un reducido interés en la práctica de ejercicio físico. Otra de las limitaciones es la heterogeneidad de la muestra, debida tanto a los tipos de cáncer de mama como al momento de la enfermedad que se encontraba cada una de ellas, lo que pudo afectar a los resultados obtenidos. Otra de las limitaciones del estudio es la división entre grupos, ya que no fue aleatorizada debido a que fue en base a la disponibilidad de las participantes para realizar el programa. Por otro lado, la duración del programa de ejercicio fue un factor limitante, ya que con un programa más largo se podrían haber observado más diferencias en las variables evaluadas.

Conclusiones

Los hallazgos en este estudio concluyen que un programa de ejercicio físico combinado y supervisado de 8 semanas produce mejoras en la capacidad cardiovascular, fuerza y funcionalidad del tren inferior, así como en el equilibrio de la pierna no dominante de pacientes con cáncer de mama en cualquier momento de la enfermedad. Además, este tipo de intervenciones también ha mostrado una reducción del índice cintura cadera en esta población.

Declaración del Comité de Ética

El estudio se realizó siguiendo la Declaración de Helsinki y las participantes firmaron un consentimiento informando antes de la participación del estudio.

Conflicto de Intereses

Los autores declaran no tener conflicto de intereses.

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Contribución de los Autores

Conceptualización: A.J. & M.C.; Conservación de datos: A.J. & H.A.; Análisis formal: A.J.; Investigación: A.J., E.M., H.A., & M.V.G.; Metodología: A.J., E.M., H.A. & M.C.; Administración de Proyectos: M.C.; Recursos: M.V.G.; Supervisión: M.C. & M.V.G.; Validación: M.C. & M.V.G.; Visualización: A.J.; Redacción - Borrador Original: A.J. & M.C; Redacción – Revisión y Edición: A.J., E.M., H.A., M.C. & M.V.G. Todos los autores han leído y aceptado la versión publicada del manuscrito.

Declaración de Disponibilidad de Datos

Datos disponibles bajo demanda al autor de correspondencia (alejandroj.m.01@gmail.com).

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Participatory Evaluation in Higher Education: Trends and Their Impact on Training in Sports Sciences

Evaluación Participativa en Educación Superior: Tendencias y su Impacto en la Formación en Ciencias del Deporte

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Abstract

This study investigates the impact of the Collaborative-Opposition Sports course on competency development within the Physical Activity and Sports Science degree in higher education. Utilizing a questionnaire based on a 1 to 5 Likert scale, student perceptions regarding competencies gained upon completing the course over three consecutive academic years: 2018-2019, 2019-2020, and 2020-2021 were assessed. The sample consisted of a total of 147 participants. Findings indicated significant variations in competency perceptions, with effect sizes ranging from moderate to very large. Teaching-learning strategies were implemented to enhance those competencies receiving less favourable evaluations. The results emphasize the importance of the learning process and the ability to learn effectively, particularly highlighting a positive impact on systemic competencies. It is concluded that the integration of methodologies combining teaching practice, reflection, collaboration, and experience is crucial for the development of skills and competencies in university students, thereby contributing to their preparedness to face the challenges of contemporary society.

Keywords: Peer assessment, university training center, competency-based education, active methodologies.

Resumen

El presente estudio examina la influencia de la asignatura de Deportes de colaboración-oposición en el desarrollo de competencias dentro del grado de Ciencias de la Actividad Física y el Deporte en la educación superior. A través de la aplicación de un cuestionario basado en una escala Likert de 1 a 5, se evaluaron las percepciones de los estudiantes respecto a las competencias adquiridas al concluir la asignatura durante tres años académicos consecutivos: 2018-2019, 2019-2020 y 2020-2021. La muestra estuvo compuesta por un total de 147 participantes. Los hallazgos revelaron variaciones significativas en la percepción de las competencias, registrando tamaños de efecto desde moderados a muy grandes. Se implementaron estrategias de enseñanza-aprendizaje dirigidas a fortalecer aquellas competencias con evaluaciones menos favorables. Los resultados subrayan la importancia del proceso de aprendizaje y la capacidad de aprender de manera efectiva, destacando un impacto positivo particularmente en las competencias sistémicas. Se concluye que la integración de metodologías que combinan la enseñanza-práctica, reflexión, colaboración y experiencia resulta fundamental para el desarrollo de habilidades y competencias en estudiantes universitarios, contribuyendo así a su preparación para afrontar los desafíos de la sociedad contemporánea.

Palabras clave: Evaluación por pares, centro universitario de formación, educación por competencias, metodologías activas.

Introduction

Today's global society has brought about a paradigm shift in university education, which is reflected in the creation of the European Higher Education Area, which establishes that the new teaching framework must focus on developing students' skills and competences that allow them to face the challenges of contemporary life (Bologna Declaration, 1999). It is necessary to train autonomous, participative students with cognitive flexibility, complex thinking, critical and reflective judgment, who become responsible citizens, as well as good professionals, capable of adapting and acting effectively in today's knowledge society subject to rapid and profound changes (Rodríguez-Gómez et al., 2018).

Royal Decree 1393/2007 on the Regulation of University Education, amended by various regulations (RD 861/2010, RD 96/2014, RD 43/2015) and the European Qualifications Framework for Higher Education (Royal Decree 1027/2011), incorporate references to two types of competences in university education: specific competences related to a specific disciplinary area and transversal competences transferable to other contexts related to the personal-social development of the individual, which do not depend on a specific thematic area but can be developed in different academic or professional disciplines (Rodríguez-Gómez et al., 2018). These skills are understood as an incipient social and professional need, bureaucratically accepted to manage and react to change and employability since they are closely linked to the social and labor demands of the current market (Martínez-Otero et al., 2018; Medina & Jaruta, 2013).

Transversal competences related to participatory assessment are those that students put into practice when they assess their own performances and productions (self-assessment), those of their peers (peer assessment, peer evaluation, small group evaluation, reciprocal evaluation), between two people (student-teacher co-assessment; student-student) or those of the teaching staff (hetero-assessment) (Rodríguez-Gómez et al., 2018).

The participation of students in the teaching-learning process and in their own assessment enhances the development of competencies through a series of elements such as reflection, collaboration, involvement, motivation and improves the results of the same if, together with teachers, they become responsible partners in learning and progressively assume responsibility for the processes and develop the ability to judge the quality of their own work, as well as that of others, according to agreed standards (Boude & Associates, 2010; Ibarra-Saiz, Rodríguez-Gómez, & Gómez-Ruíz, 2012; Thomas, Martin, & Pleasants, 2011).

The current concern of university professors in Higher Education to receive feedback from students that implies the improvement of teaching processes is reflected in different research on the acquisition and transfer of skills (Jarauta & Medina, 2013; Martínez-Clares & González-Morga, 2018; Muñoz-San Roque, Martín-Alonso, Prieto-Navarro, & Urosa-Sanz, 2016; Pérez-Vázquez & Vila-Lladosa, 2013; Salmerón, 2013; Villardón-Gallego, Yániz, Achurra, Iraurgi, & Aguilar, 2013).

Nowadays, society demands that students acquire knowledge and skills related to certain disciplines, on the one hand, but also transversal skills that ensure, firstly, the ability to continue learning and updating themselves throughout life, in line with new advances and discoveries, according to the needs that arise. It is not just about accumulating knowledge, but rather about transforming information into knowledge on which to base professional performance and which also allows it to be judged, assessed and used to transform reality (ANECA, 2011).

Thus, competencies, understood as the ability to put knowledge and skills into action, are, on the one hand, something that the student has to learn and, on the other, they allow an application of knowledge that brings us closer to other forms of learning in that they serve to contrast a way of understanding things; this way may be wrong or right and, in reality, this would not matter too much from the point of view of learning, as long as the student takes advantage of the opportunity, with the help of the teacher, to reflect on the results of his activity and learn from this feedback (ANECA, 2011).

The context of this work is carried out in the Degree of Physical Activity and Sports Sciences, a qualification in which one learns to be a competent professional in five profiles: teaching of physical activity and sports, sports training, physical activity and quality of life, sports management and recreation. The work developed is based on a teaching environment oriented to learning, central axis of the reform in which the Spanish university system is immersed, where a program must be judged in terms of its effectiveness to help teachers to maximize student learning, it must be a starting point for annual decision-making, thanks to the active participation and feedback obtained from the students' results, which help to improve the process (Gessa, 2011).

This work is the continuation of a process of continuous improvement within the subject of collaborative-opposition sports of the Degree in Physical Activity and Sports Sciences that has followed the following process:

1. Construction and validation of a questionnaire to evaluate the teaching process of sports techniques by peers in Higher Education (ETEPES) (Álvarez et al., 2019).
2. Student opinion on the peer-based sports technique teaching process in Higher Education (ETEPES) (Álvarez-Medina et al., 2022)

3. Inclusion of participatory assessment in higher education of team sports (Álvarez-Medina et al., 2020).

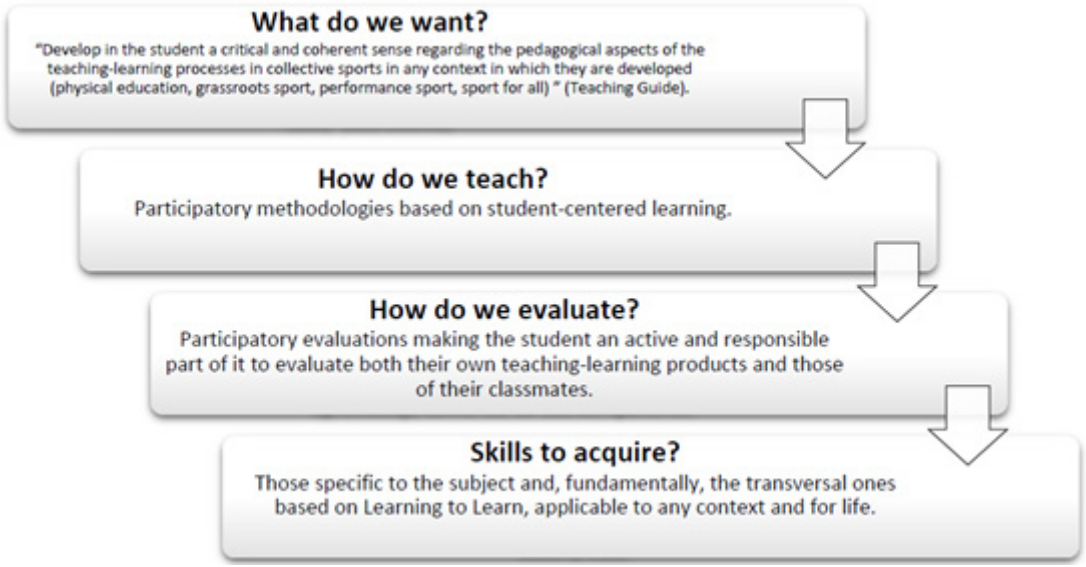
The results of previous publications on participatory assessments and methodologies show that students agree with the benefits they provide, confirming what other authors have established as one of the most effective ways to improve the development of interpersonal strategies, increase formative intentionality, encourage dialogue and the ability to make judgments with other classmates and even teachers to assess, improve the processes and products of learning specific subjects as well as the development of skills in general, producing an attitudinal change towards learning. All of this represents an undoubted formative value that helps to form more autonomous, responsible, critical students (Ibarra-Saiz, Rodríguez-Gómez, & Gómez-Ruíz, 2012; Moreno-Murcia, Aracil, & Reina, 2014; Prins, Sluijsmans, Kirschner, & Strijbos, 2005; Valdivieso et al., 2013), and as society demands, democratic citizens (Valdivieso et al., 2013), capable of entering the labor market and adapting to it throughout life.

Once, as suggested by Salmerón (2013), innovative proactive teaching methods with participatory assessments have been included to facilitate the development and attainment of the skills necessary to transfer knowledge and innovate in the workplace (Muñoz-San Roque et al., 2016), it is necessary to measure the degree of acquisition of the skills established in the Degree. Thus, this work shows a way of knowing the opinion of the students regarding the skills developed, and how within the subject under study work is done to improve those that are evaluated the worst.

The object of study of this research is to evaluate the students' assessment of the skills of the subject "Collaborative -opposition sports" and try to improve the acquisition of these skills, especially those in which the worst results are obtained.

The research hypothesis is that students participating in the subject of Collaborative -Opposition Sports perceive the evaluated competencies positively, although work on those that are less well evaluated can have a positive effect on their acquisition in later years.

Figure 1
Structure of the object of study



Material and Method

A selective longitudinal study was carried out on second-year students of the Degree in Physical Activity and Sports Sciences in the subject "Collaborative-opposition sports". The courses analysed were:

- 2018-2019, 47 participants.
- 2019-2020, 2nd semester, 54 participants.
- 2020-2021, 46 participants.

76.1 % of the students are male, while 23.8 % are female.

It should be noted that, starting in the second semester of the 2019-20 academic year, they were developed under the health restrictions caused by the COVID-19 pandemic.

Instrument

The general skills proposed for this subject are divided into:

- Instrumentals
- Personal and interpersonal relationships
- Systemic
- Others

In order to determine whether the competencies have been achieved, a questionnaire was prepared consisting of all those described in the teaching guide for the subject "Collaborative-opposition sports":

Table 1
List of Instrumental, Personal and interpersonal, Systemic and other competencies

Competencies
Instrumentals
CI1.-Ability to analyze and synthesize applied to the management and organization of physical and sports activities
CI2.- Use of appropriate oral and written communication techniques. both in academic contexts (in their different manifestations) and in informative situations
CI3.-Understanding of scientific literature on physical activity and sport in languages with a significant presence in this field. as well as correct expression in the aforementioned languages.
CI4.-Application of information and communication technologies (ICT) to the field of Physical Activity and Sports Sciences
CI5.-Organization and planning of own work. establishing guidelines and strategies appropriate to each situation
CI6.-Development of habits of excellence and quality in professional practice
CI7.-Application of knowledge on gender differences in AFE and sports in any professional field of the GCCAFD
CI8.-Application of knowledge to professionally care for any group or individual with special needs
Personal and interpersonal
CPEI.1.-Know and act within the ethical principles necessary for the correct professional practice referring both to the relations with users and to the organization and management of physical activity properly speaking.
CPEI.2.-Recognition of diversity and multiculturalism in professional performance
CPEI.3.-Commitment to the educational and social values of sport and physical activity as part of a culture of peace and democracy
CPEI.4.-Critical reasoning in the analysis and assessment of alternatives in all occupations related to professional performance
CPEI.5.-Develop management leadership interpersonal relationship and teamwork skills
CPEI.6.-Ability to integrate into multidisciplinary teams
Systemic
CS1.-Ability to adapt to new situations and changes in the environment
CS2.-Initiative and coherence in problem solving
CS3.- Positive attitude and sufficient aptitude for autonomous learning
CS4.- Ability to undertake improvements and propose innovations
Others
CO1.- Ability to understand each other in an international context
CO2.-Application of theory to practice
CO3.-Research skills
CO4.-Knowledge of other cultures
CO5.-Ability to work independently
CO6.-Project design and management
CO7.- Achievement motivation
CO8.-Environmental sensitivity

Note: CI (Instrumentals Competency); CPEI (Personal and interpersonal relationships Competency); CS (Systemic Competence); CO (Others Competency).

Quantitatively indicates the student's perception regarding general competences, using the Likert scale 1-5 where 1 corresponds to "I have not acquired it" and 5 "I have fully acquired it" and also regarding sub-competences, in which case it is necessary to mark whether they are considered to exist. In addition, qualitatively at the end of the questionnaire, it is possible to give an opinion on the competences and sub-competences raised.

Procedure

The questionnaires were collected through Google Platform Forms. Each participant was asked at the end of the course in each academic year, and in the presence of the professor responsible, to complete it and ask questions about any type of doubt they had regarding the items.

The inclusion criterion is that all students enrolled in the subject in each academic year participate in the study, while the only exclusion criterion established was not opting for continuous assessment of the subject based on what is established in the teaching guide, such as non-attendance in class.

Throughout each academic year, students progressively assimilate the learning processes in the cognitive, emotional and behavioural aspects, facilitating the assessment of the learning products (Muñoz-San Roque et al., 2016). Although all the competences must be acquired at the end of the degree, the obtaining and learning of the competences framed in this subject together with the contributions of the students through the final assessment, provide valuable feedback to help understand and improve the established process, highlighting the importance of knowing the opinion of the students as they are the main protagonists (Santos-Rego et al., 2017; Tejada & Ruiz, 2016) and the main ones affected by their pedagogical action (Dugas, 2006; Martínez-Otero et al., 2018).

Throughout the study, the anonymity of the responses was guaranteed in compliance with the ethical research standards of the Code of Good Practices in Research of the University of Zaragoza (2018), administering and being accepted by the participants the corresponding informed consent to participate in the study.

Intervention

The feedback obtained in the 2018-2019 academic year was considered and taken into account for the improvement of the subject in the following courses, both in the score of each competence and in the comments provided by the students. Some of these comments were:

- "I think that many of the skills mentioned here would be very good to acquire if it is really an objective proposed in this subject. I think that the way this subject has been developed has been by giving a lot of priority to some topics. The topic of the environment, curricular adaptations, gender equality, interculturality... I think that they have not been addressed at all, ..."
- "Knowledge of other cultures? Environmental sensitivity? I haven't heard a word about this."

With the aim of continuing to improve in all those skills especially related to "Learning to Learn", in the 2019-2020 and 2020-2021 academic years a series of activities-tasks were established to try to specifically improve those skills that obtained the worst results in the previous year. These were:

- Competence related to: Gender attention
  - Intervention: Work "Current role of women in sport".
- Competence related to: Other cultures and languages
  - Intervention: Searches for bibliographies in another language.
- Competence related to: Environmental care
  - Intervention: Reference to it in each assignment and in each class activity.
- Competence related to: Adaptive sport
  - Intervention: Monograph on adapted team sport.

The special situation experienced in the 2019-2020 academic year due to COVID-19 affected the acquisition of skills as it prevented the completion of some of the specific tasks planned for this purpose for the last months of the course, where both in theoretical class and in practice the student's intervention was even greater.

Statistical Method

SPSS v.21 program licensed by the University of Zaragoza. The results are given in descriptive form: frequency, percentages, mean and standard deviation. Inferential for the comparison of variables and to establish significant differences chi-square *(p < .05). Cronbach's alpha coefficient to establish the relationship between samples and Cohen's d* statistic to estimate the effect size.

Results

Table 2 shows the relationship between the different types of competencies and their scores in the 2018-2019, 2019-2020, and 2020-2021 academic years. The "Difference" column shows the difference in scores between two consecutive years, while the "p" column shows the p - *value* (probability) associated with that difference. The "Cohen's d" column shows the effect size.

It can be seen that in the instrumental competencies, there was an increase in 2019-2020 (.27) but a decrease in 2020-2021 (.08) with a *p-value* (.067) and a moderate Cohen effect size (.12). In personal and interpersonal competencies, there was an increase in 2019-2020 (.13) and a decrease in 2020-2021 (.02) with a *p-value* (451) and a Cohen effect size (03) estimated as small. In systemic competencies there was an increase in 2019-2020 (.40) but a decrease in 2020-2021 (.34) with a *p-value* (.000) and a very large Cohen effect size (.85). In the 'Other' competencies, there was an increase in 2019-2020 (.21) but a decrease in 2020-2021 (.11) with a *p-value* (.000) and a Cohen effect size (.28) considered as moderate.

Table 2
Acquisition of type of competences

Types of competencies	2018-19	2019-20	Difference	p	Cohen's d	2020'21	Difference	p	Cohen's d	Diff. 2018-19 vs 2020-21	p	Cohen's d
Instrumentals	3.57±.53	3.84±.53	+.27	.006	0.51	3.76±.08	- .08	.067	0.12	.19	.016	0.27
Personal and interpersonal	3.80±.63	3.93±.61	+.13	.298	0.21	3.91±.08	-.02	.451	0.03	.11	.882	0.15
Systemic	3.77±.64	4.17±.56	+.4	.001	0.67	3.83±.10	-.34	.000	0.85	.06	.000	0.13
Others	3.38±.70	3.59±.54	+.21	.132	0.34	3.70±.09	-.11	.000	0.28	.32	.000	0.65
Total	3.63±.19	3.88±.24	+.25			3.80±.09	-.08			.17		

Herein table 3 shows a slight improvement in skills for both genders in the period 2020-2021 compared to 2018-2019 (p = .04). However, assessing skill by skill, the differences between men and women in both periods are small and not statistically significant (p > .05), except for the 'Other' skill.

Table 3
Acquisition of skills by year and gender

	2018-2019				2020-2021				Diff. 2018-19 vs 2020-21		
Types of competencies	Masc.	Fem.	Diff.	p	Masc.	Fem.	Diff.	p	Masc.	Fem.	p
Instrumentals	3.6 ± 0.56	3.48 ± 0.49	+0.12	.635	4.08 ± 0.77	4 ± 1.15	+0.08	.720	0.48	0.52	0.132
Personal and interpersonal	3.89 ± 0.62	3.57 ± 0.54	+0.32	.359	3.81 ± 0.81	3.9 ± 0.83	-0.09	0.511	-0.08	0.33	0.753
Systemic	3.73 ± 0.7	3.86 ± 0.49	--0.13	.219	3.83 ± 0.775	3.7 ± 1.33	+0.13	0.975	0.1	-0.16	0.521
Others	3.42 ± 0.75	3.29 ± 0.59	+0.13	.145				0.365			0.04
Total	3.66 ± 0.65	3.55 ± 0.53	+0.11		3.91 ± 0.785	3.87 ± 1.10	+0.78		0.25	0.32	0.04

Analyzing competency by competency (table 4) we can see those that have obtained significant differences between the courses. In particular, a significant increase is observed in competencies 1, 2, 3, 4, 5, 6 and 8, with statistically significant differences (p < .05) in competencies 1, 2, 4, 5 and 6. On the other hand, a significant decrease is observed in competency 7, (p = .017).

In competencies 9, 10 and 11 an increase is also observed, but it is not significant.

As reflected in table 5, a positive trend is shown in the assessment of instrumental and personal and interpersonal competencies. If we look at the instrumental competencies, it is observed that the scores for sub-competence 1.c Generation of activities and experiences have been relatively stable over the three years, with a slight decrease in the year 2020-2021. Sub-competence 3.d Identification of errors and proposal of alternatives has shown a significant increase in scores over the three years. Sub-competence 3.a Conducting scientific searches has also shown an increase in the score in the year 2020-2021 compared to the year 2018-2019, but a decrease in the year 2019-2020. Finally, subcompetence 6.d Assessment and review of performances showed an increase in the score in 2019-2020 but decreased in 2020-2021.

Table 4
Acquisition of skills

Competency	2018-2019	2019-2020	Dif	p	2020-2021	Dif	p
Instrumentals							
C.I.1	3.89±.79	3.89±.82	=	.885	4.24±.79	+.35	.027
C.I.2	3.34±.81	3.70±.80	+.36	.034	3.8±.74	+.1	.542
C.I.3	3.62±.92	3.85±.82	+.23	.159	4.11±.70	+.26	.101
C.I.4	3.85±.95	4.23±.82	+.38	.040	4.02±1.02	-.21	.402
C.I.5	3.66±.89	4.02±.70	+.36	.030	3.8±.77	-.22	.130
C.I.6	3.91±.77	4.06±.79	+.15	.334	3.52±1.11	-.54	.018
C.I.7	3.23±1.07	3.68±.98	+.45	.039	3.85±.86	+.17	.443
C.I.8	3.02±1.19	3.30±.93	+.28	.269	3.26±1.06	-.04	1
Personal and interpersonal							
CPEI.1	4.26±.82	4.23±.87	-.03	.943	4.07±.85	-.16	.122
CPEI.2	3.43±1.12	3.72±.95	+.29	.205	3.89±1.04	+.17	.087
CPEI.3	3.98±.70	4.08±.94	+.1	.318	4.2±.80	+.12	.010
CPEI.4	3.91±.93	4.15±.72	+.24	.263	4.04±.72	-.11	.570
CPEI.5	3.77±1.00	4.08±.78	+.31	.141	4.04±.84	-.04	.594
CPEI.6	3.43±.95	3.32±.99	-.11	.693	3.41±1.00	+.09	.001
Systemic							
C.S.1	3.49±.93	3.92±.76	+.43	.008	3.89±.82	-.03	.003
C.S.2	3.74±.99	4.04±.76	+.3	.162	3.83±.82	-.21	.474
C.S.3	4.06±.96	4.49±.75	+.43	.012	4.26±.88	-.23	.011
C.S.4	3.79±.88	4.21±.74	+.42	.010	3.87±1.00	+.34	.530
Others							
C.O.1	3.09±1.16	3.13±1.06	+.04	.852	3.17±1.06	+.04	.000
C.O.2	3.96±.83	4.13±.71	+.17	.331	4.07±.8	-.06	.354
C.O.3	3.43±.97	3.43±.89	=	.855	3.8±.91	+.37	.017
C.O.4	2.30±.93	2.57±.93	+.27	.157	2.98±1.14	+.41	.482
C.O.5	4.13±.80	4.28±.70	+.15	.357	4.39±.64	+.11	.064
C.O.6	3.57±1.02	3.83±.83	+.26	.170	3.85±.86	+.02	.017
C.O.7	3.74±1.13	4.17±.80	+.43	.067	4.07±.92	-.1	.000
C.O.8	2.81±1.34	3.19±1.18	+.38	.162	3.22±1.19	+.03	.000

Note: C.I. (Instrumentals Competency); C.P.E.I. (Personal and interpersonal relationships Competency); C.S. (Systemic Competence; C.O. (Others Competency).

Table 5
Summary of the evolution of the sub-competencies worked on throughout the 3 academic years analyzed 2018-19; 2019-20; 2020-21 expressed in percentage value

COMPETENCE	2018-19	2019-20	2020-21
Instrumental skills			
1.c Generation of activities and experiences	82.98%	84.91%	84.78%
3.d Identifying errors and proposing alternatives	78.72%	86.79%	89.13%
3.a Conducting scientific research	85.11%	83.02%	89.13%
6.d Assessment and review of actions	80.85%	92.45%	80.43%
Personal and interpersonal skills			
9.a Respect for the integrity of people. both from a physical. emotional and social point of view	82.98%	86.79%	82.61%
9.c Respect for rules and regulations in interaction situations	82.98%	86.79%	82.61%
11.a Understanding physical activity practice situations that can be treated from the culture of peace and fair play	82.98%	86.79%	86.96%

As for personal and interpersonal competencies, a similar trend is observed in sub- competencies 9.a and 11.a. Both scores have remained stable over the three years, with a small increase in the year 2020-2021. However, sub-competency 9.c Respect for rules and regulations in interaction situations has shown a significant increase in score between 2018-2019 and 2019-2020, but a decrease in the year 2020-2021.

Discussion

This study analyses the extent to which the competencies established in the Degree are being acquired. All the opinions obtained in the 2018-2019 academic year were considered and taken into account for the 2019-20 and 2020-21 academic years and a series of activities-tasks were established to try to specifically improve those competencies that obtained the worst results without ceasing to work on them in order to try to continue improving in all those competencies, especially those related to 'Learning to Learn'.

At first glance, it can be seen that scores have increased between 2018-19 and 2019-20 in all categories, except for the 'Other' category, which remains stable. However, between 2019-20 and 2020-21, a decrease in skills is observed in all categories, except for the 'Other' category, which increases. In addition, the effect size (Coh's d) is moderate or large in most comparisons, suggesting a significant impact.

Specifically, all types of competencies after the intervention have improved their scores in the 2019-2020 academic year compared to the previous one, being higher than 3.5, obtaining an improvement of .25 on average, going from 3,63 ± .19 to .3,88 ± .24 ± and dropping minimally in the 2020-2021 academic year to 3.86 ±.19 ± The greatest increase (0.4) has occurred in the systemic ones, going from 3,77 ± .64 in the 2018-2019 academic year to 4,17 ± .56 .in the 2019-2020 academic year, going from the second best rating to the first before the intervention. The personal ones obtain the smallest increase (.13) in the year 2019-2020, going from first place before the intervention to second after it, in the year 2020-2021 they increase slightly (.01). After the intervention, the instrumental ones continue to occupy the third best average and 'Others', despite suffering the second largest increase post-intervention (.21) in the 2019-2020 academic year, continues to obtain the worst average of all. Significant differences have been obtained in the instrumental (.006) and systemic (.001) in the 2019-2020 academic year.

If we look at the overall differences between the first and last year (2018-19 and 2020-21), there are significant differences in the values of the systemic competencies *(p* = .016), as well as in the Systemic *(p* = .000) and 'Other' *(p* = .000) competencies. It can be said that all of them are worked on within the subject for their full acquisition at the end of the degree.

It is worth noting that various investigations have shown that the combination of different types of educational experiences, including practical teaching and collaboration, are effective for the development of competencies in university students. In addition, it has also been shown that academic support and guidance are important to improve the development of personal and interpersonal competencies (Biggs, 2003; Popovic, 2013).

Evaluating the acquisition of skills by year and gender (table 3), a subtle increase in performance has been observed in both genders during the period between 2020 and 2021 compared to the period between 2018 and 2019. However, the variations between genders in both periods are insubstantial and do not reach statistical significance *(p* > .05). There are several studies that have examined the relationship between gender and skills at the university level in the degrees of physical activity and sports, and some of these studies have also concluded that there are no significant differences between the gender variable in terms of the acquisition of skills, considering the works of Gómez Ruiz et al. (2013), Rodríguez-Gómez et al. (2018), or in Bustamante-Ara et al. (2022).

Going deeper into the analysis of the acquisition of sub-competencies (table 4), we want to assess how in the instrumental competencies it is seen that the average scores between men and women are similar in the three years, with an average difference between genders of only .12 in the first year, .16 in the second year, and .0.8 in the third year. In the personal and interpersonal competencies, it is seen that the average scores are slightly higher in men than in women in the three years, with an average difference between genders of .32 in the first year, .0.2 in the second year, and .-0.9 in the third year. In the first and second year, the difference is significant *(p* < .0.5), but the value in the third year is not significant.

Regarding systemic competencies, it can be seen that the average scores are similar between men and women in the three years, with an average difference between genders of -13 in the first year, .,04 in the second year and .13 in the third year. The p values indicate that there is no significant difference between the average scores of men and women in systemic competencies.

Regarding the effectiveness of the specific measures implemented in the 2019-20 and 2020-21 academic years, all have improved, except for "Application of knowledge to professionally care for any group or individual with special needs" which decreased slightly in the 2020-21 academic year.

Breaking these down, we highlight the following considerations:

Attention to Gender:

Application of knowledge on gender differences in AFE and sports in any professional field of the GCCAFD 3.23 ± 1.07/3.68 ± .98 (+.,45) / 3.85 ± .86 (+.17). It is important to highlight the importance of developing this skill given that there are studies that highlight that there is still ongoing discrimination based on gender in our society but that students positively highlight the approach to these issues in university education. An aspect that we should overcome and address through this degree (Bas-Peña et al., 2017).

Other cultures and languages:

Understanding of scientific literature on physical activity and sport in languages with a significant presence in this field, as well as correct expression in the aforementioned languages 3.62 ± .92/3.85 ± .82 (+.23) / 4.11 ± .70 (+.26)

Ability to understand oneself in an international context 3.09 ± 1.16/3.13 ± 1.06 (+.04) / 3.17 ± 1. 06 (+.04)

Knowledge of other cultures 2.30 ± .93/2.57 ± .93 (++.27) / 2.98 ± 1.14 (+.41)

One of the most characteristic features of the university in the 21st century is its great linguistic, cultural and academic diversity. This is why studies such as those by Dafouz (2015) and Oyarzún et al. (2012) suggest the need to develop, in the university environment, a multidimensional linguistic competence that contributes to students being able to understand the professional needs that they may encounter in current times. Hence the importance of the results of our study where these competences register a relevant consideration by the students.

Caring for the environment:

Environmental sensitivity 2.81 ± 1. 34/3.19 ± 1.18 (+.38) / 3.22 ± ± 1.19 (+.03)

Adaptive sport:

Application of knowledge to professionally care for any group or individual with special needs 3.02 ± 1.19/3.30 ± .93 (+.28) / 3.26 ± 1.06 (-.04)

And with respect to the skills that will most promote 'Learning to Learn', we can highlight those that favor:

Ability to change, self-improvement, critical thinking:

Within the instrumentals (CI):

Application of information and communication technologies (ICT) to the field of Physical Activity Sciences 3.85 ± .95/4.23 ± .82 (+.38). As can be seen in table 4, in the 2019-20 academic year, the percentage of students who consider that work is being done increases compared to the 2018-19 academic year, although in the 2020-21 academic year the results decrease 4.02 ± 1.02 (-.21).

Organization and planning of one's own work, establishing guidelines and strategies appropriate to each situation 3.66 ± .89/4.02 ± .70 (+.36). As can be seen in table 4, in the 2019-20 academic year, the percentage of students who consider that they work increases compared to the 2018-19 academic year, although in the 2020-21 academic year the results decrease 3.80 ± .77 (-.22).

Within the personal ones (CP):

Critical reasoning in the analysis and assessment of alternatives in all those occupations specific to professional performance 3.91 ± .93/4.15 ± .72 (+.24). As can be seen in table 4, in the 2019-20 academic year the percentage of students who consider that they work increases compared to the 2018-19 academic year, although in the 2020-21 academic year the results decrease 4.04 ± .72 (-.11).

Within the systemic ones (CS):

Ability to adapt to new situations and changes in the environment improves in the 2019-20 academic year compared to the previous one 3,49 ± .93 / 3,92 ± .76 (+.43) but worsens in the 2020-21 academic year 3 .89 ± .82 (-.03)

Initiative and coherence in problem solving improved in the 2019-20 academic year compared to the previous one 3,74 ± .99 / 4,04 ± .76 (+.3) but worsened in the 2020-21 academic year 3,83 ± .82 (-.21).

Positive attitude and sufficient aptitude for autonomous learning improves in the 2019-20 academic year compared to the previous one 4.06 ± .96/4,49 ± .75 (+.43) but worsens in the 2020-21 academic year 4,26 ± .88 (-.23).

Capacity to undertake improvements and propose innovations improved in 2019-20 compared to the previous year 3 .79 ± .88 / 4,21 ± .74 (+.42) but worsened in the 2020-21 academic year 3 .87 ± 1,0 (-.34).

Within 'Other' (CO):

Ability to work independently improved in both years, in 2019-20 4 .13 ± .80 / 4 .28 ± .70 (+.15) and in 2020-21 4 .39 ± .64 (+.11).

Achievement motivation improves in the 2019-20 academic year compared to the previous one 3,74 ± 1,13 / 4,17 ± .80 (+.43) but worsens in the 2020-21 academic year 4,07 ± .92 (-.11)

These results coincide with the assessments of Ribas et al. (2022) or Douglas and Gammie (2019) both in that learning and the ability to learn are considered fundamental by the respondents, and a high assessment is also observed in terms of their performance in the Degree, which indicates that it is not only considered an important aspect, but that it is also being effectively developed through the participatory methodology applied in this study.

Likewise, in this table 5, several sub-competencies are highlighted that in the three courses analyzed the students consider that they are always worked on, which obtain percentages of approximately 80% of choice in all cases. Within the instrumental competence "Ability to analyze and synthesize applied to the management and organization of physical and sports activities", two sub-competencies stand out: "Generation of activities and experiences" and "Identification of errors and proposal of alternatives ". Within the instrumental competence "Understanding of scientific literature referring to physical activity and sport in languages with a significant presence in this field, as well as correct expression in the aforementioned languages", the sub- competency "Conducting scientific searches" stands out. Within the instrumental competence "Development of habits of excellence and quality in professional practice", the sub-competency "Assessment and review of actions" stands out. Within the personal and interpersonal competence "Knowing and acting within the ethical principles necessary for the correct professional practice, referring both to relations with users and to the organization and management of physical activity itself", the sub-competence "Respect for the integrity of people, both from a physical, emotional and social point of view" and "Respect for the rules and regulations in interaction situations" stand out. Within the personal and interpersonal competence "Commitment to the educational and social values of sport and physical activity as part of a culture of peace and democracy", the sub-competence "Understanding situations of physical activity practice that can be treated from a culture of peace and fair play" stands out.

Due to the special situation experienced, COVID-19, it should be noted that although this subject and the methodologies and evaluations section were not excessively affected because it was annual and in the second semester there were less weekly teaching sessions, it did affect the acquisition of skills to a greater extent since it prevented some of the specific tasks planned for this purpose from being carried out for the last months of the course, where both in the theoretical and practical classes the student's intervention was even greater, so it may fundamentally affect the results obtained in the competitions and in the methodology applied in football because it is the last of all (González-Arévalo et al., 2022).

These values can be related to those obtained in the work of Amor-Almedina and Serrano-Rodríguez (2018), in which the levels of development of general skills in university studies were evaluated. The results show that there are significant differences between groups, but In general, the ability to work in a team is the best perceived by all participants, compared to the ability to communicate in a language and technological ability.

Cooperative peer assessment on a group of high school students. The results of the study suggest that this strategy can significantly improve students' academic performance. Furthermore, students who participated in cooperative peer assessment showed a higher level of confidence and a more positive attitude towards learning in general (González-Arévalo et al., 2022).

Cooperative pair assessment is carried out as follows: students are divided into pairs and assigned a specific topic to study. Each student then makes his or her own assessment of the topic, and then they meet with their partner to discuss their assessments and come to an agreement on their level of understanding of the topic. This technique allows students to improve their understanding of the material and also gives them the opportunity to teach their partners what they have learned.

In summary, cooperative peer assessment is an effective pedagogical strategy that can improve students' academic performance and increase their confidence and positive attitude toward learning.

It is important to note that these results must be interpreted with caution, as they depend on the methodology used to carry out the assessments and surveys, as well as the size and representativeness of the sample of students assessed. In addition, it is necessary to know the context in which these assessments were carried out in order to understand why certain improvements or decreases in the results have occurred.

Conclusions

The main conclusions regarding competences are:

- All skills are worked on throughout the subject, obtaining values greater than 3.5.

- The intervention has been effective, going from an average of 3.63 ±.19 to 3.80 ± .009, obtaining an improvement of .27.
- Highlighting the systemic ones, focused on 'Learning to Learn', going from 3,77 ±.64 to 3,83 ±.10 with an increase of .06.
- Despite the measures adopted, some skills are difficult to work on due to the characteristics of the subject.

The main general conclusions of the study were:

- The entire teaching-learning process is coherent, with the methodologies and assessments used aligned with the acquisition of skills and the objective of the subject.
- Student feedback is effective in improving the process and should be a starting point for annual decision making.

The intervention had a positive impact on students' competencies, with a significant improvement in systemic competencies and a smaller but significant increase in instrumental competencies. However, the ' Other' category continued to have the worst average of all. Likewise, we consider that further research is needed in the application of this type of participatory methodology to identify possible solutions and improve the acquisition of students' competencies in these subjects. The combination of different types of educational experiences, including practical teaching, reflection, collaboration and experience, are effective for the development of competencies in university students.

Ethics Committee Statement

Not applicable due to the nature of the study, as it does not involve sensitive people or data that require approval from an Ethics Committee.

Conflict of Interest

The authors declare that this research has been carried out without any commercial or financial relationships that could be interpreted as a potential conflict of interest.

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Authors' Contribution

CRediT taxonomy, the individual contributions of the authors in this article are as follows: Interpretation of results: Javier Álvarez Medina, Jaime Casterad Seral, Víctor Murillo Lorente, Luis Pueyo Romeo; Methodology: Javier Álvarez Medina, Jaime Casterad Seral, Víctor Murillo Lorente, José Antonio Poblador Vallés; Data collection: Javier Álvarez Medina, Jaime Casterad Seral, Víctor Murillo Lorente, José Antonio Poblador Vallés; Literature review: Javier Álvarez Medina, Víctor Murillo Lorente, José Antonio Poblador Vallés, Luis Pueyo Romeo; Review and editing: Jaime Casterad Seral, Luis Pueyo Romeo. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data derived from this work are available upon request from the author (jcaster@unizar.es) without any undue restrictions.

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Evaluación Participativa en Educación Superior: Tendencias y su Impacto en la Formación en Ciencias del Deporte

Participatory Evaluation in Higher Education: Trends and Their Impact on Training in Sports Sciences

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Resumen

El presente estudio examina la influencia de la asignatura de Deportes de colaboración-oposición en el desarrollo de competencias dentro del grado de Ciencias de la Actividad Física y el Deporte en la educación superior. A través de la aplicación de un cuestionario basado en una escala Likert de 1 a 5, se evaluaron las percepciones de los estudiantes respecto a las competencias adquiridas al concluir la asignatura durante tres años académicos consecutivos: 2018-2019, 2019-2020 y 2020-2021. La muestra estuvo compuesta por un total de 147 participantes. Los hallazgos revelaron variaciones significativas en la percepción de las competencias, registrando tamaños de efecto desde moderados a muy grandes. Se implementaron estrategias de enseñanza-aprendizaje dirigidas a fortalecer aquellas competencias con evaluaciones menos favorables. Los resultados subrayan la importancia del proceso de aprendizaje y la capacidad de aprender de manera efectiva, destacando un impacto positivo particularmente en las competencias sistémicas. Se concluye que la integración de metodologías que combinan la enseñanza práctica, reflexión, colaboración y experiencia resulta fundamental para el desarrollo de habilidades y competencias en estudiantes universitarios, contribuyendo así a su preparación para afrontar los desafíos de la sociedad contemporánea.

Palabras clave: Evaluación por pares, centro universitario de formación, educación por competencias, metodologías activas.

Abstract

This study investigates the impact of the Collaborative-Opposition Sports course on competency development within the Physical Activity and Sports Science degree in higher education. Utilizing a questionnaire based on a 1 to 5 Likert scale, student perceptions regarding competencies gained upon completing the course over three consecutive academic years: 2018-2019, 2019-2020, and 2020-2021 were assessed. The sample consisted of a total of 147 participants. Findings indicated significant variations in competency perceptions, with effect sizes ranging from moderate to very large. Teaching-learning strategies were implemented to enhance those competencies receiving less favourable evaluations. The results emphasize the importance of the learning process and the ability to learn effectively, particularly highlighting a positive impact on systemic competencies. It is concluded that the integration of methodologies combining teaching-practice, reflection, collaboration, and experience is crucial for the development of skills and competencies in university students, thereby contributing to their preparedness to face the challenges of contemporary society.

Keywords: Peer assessment, university training center, competency-based education, active methodologies.

Introducción

La sociedad global actual ha supuesto un cambio de paradigma en la educación universitaria, que se refleja en la creación del Espacio Europeo de Educación Superior, donde se establece que el nuevo marco de enseñanza debe poner el acento en desarrollar las habilidades y competencias de los estudiantes que les permita enfrentarse a los desafíos de la vida contemporánea (Declaración de Bolonia, 1999). Hay que formar estudiantes autónomos, participativos con flexibilidad cognoscitiva, pensamiento complejo, juicio crítico y reflexivo, que se conviertan en ciudadanos responsables, además de buenos profesionales, capaces de adaptarse y actuar de manera eficaz en la sociedad actual del conocimiento sometida a rápidos y profundos cambios (Rodríguez-Gómez et al., 2018).

El Real Decreto 1393/2007 de Ordenación de las Enseñanza Universitarias modificado por distintas normativas (RD 861/2010, RD 96/2014, RD 43/2015) y el Marco Europeo de Cualificaciones de la Educación Superior (Real Decreto 1027/2011), incorporan referencias a dos tipos de competencias en la enseñanza universitaria, las competencias específicas relativas a un ámbito disciplinar concreto y las competencias transversales transferibles a otros contextos relacionadas con el desarrollo personal-social del individuo, que no dependen de un ámbito temático específico sino que pueden desarrollarse en distintas disciplinas académicas o profesionales (Rodríguez-Gómez et al., 2018). Estas competencias se entienden como una necesidad social y profesional incipiente, burocráticamente aceptada para gestionar y reaccionar ante el cambio y la empleabilidad ya que están estrechamente ligadas a las demandas sociales y laborales del mercado actual (Martínez-Otero et al., 2018; Medina & Jaruta, 2013).

Las competencias transversales relacionadas con la evaluación participativa son aquellas que los estudiantes ponen en práctica cuando valoran sus actuaciones y producciones (autoevaluación), las de sus compañeros (evaluación entre iguales, por pares, pequeños grupos, recíproca), entre dos personas (coevaluación alumno-profesor; alumno-alumno) o las del profesorado (heteroevaluación) (Rodríguez-Gómez et al., 2018).

La participación de los estudiantes en el proceso de enseñanza-aprendizaje y en su propia evaluación potencia el desarrollo de las competencias a través de una serie de elementos como la reflexión, colaboración, implicación, motivación y mejora los resultados de los mismos si junto a los profesores, se convierten en socios responsables del aprendizaje y progresivamente van asumiendo la responsabilidad de los procesos y desarrollando la capacidad para juzgar la calidad de su propio trabajo, así como el de los otros, según unas normas acordadas (Boude & Associates, 2010; Ibarra-Saiz, Rodríguez-Gómez, & Gómez-Ruíz, 2012; Thomas, Martin, & Pleasants, 2011).

La inquietud actual del profesorado universitario en la Enseñanza Superior por recibir el feedback de los alumnos que impliquen la mejora de los procesos de enseñanza queda reflejada en diferentes investigaciones sobre la adquisición y transferencia de competencias (Jarauta & Medina, 2013; Martínez-Clares & González-Morga, 2018; Muñoz-San Roque, Martín-Alonso, Prieto-Navarro, & Urosa-Sanz, 2016; Pérez-Vázquez & Vila-Lladosa, 2013; Salmerón, 2013; Villardón-Gallego, Yániz, Achurra, Iraurgi, & Aguilar, 2013).

Actualmente la sociedad nos demanda alumnos y alumnas que aprendan conocimientos y competencias ligados a ciertas disciplinas, por una parte, pero también competencias transversales que aseguren, en primer lugar, la capacidad de seguir aprendiendo y actualizarse a lo largo de la vida, de la mano de los nuevos avances y descubrimientos, según las necesidades que vayan surgiendo. No se trata sólo de acumular conocimientos, sino más bien de transformar la información en conocimientos en los que basar la actuación profesional y permitan, además, juzgarla, valorarla y utilizarla para transformar la realidad (ANECA, 2011).

Así, las competencias, entendidas como la capacidad de poner en acción conocimientos y habilidades, son, por una parte, algo que el estudiante tiene que aprender y, por otra, permiten una aplicación del conocimiento que nos acerca a otras formas de aprendizaje en cuanto que sirven para contrastar una forma de entender las cosas; esta forma puede ser errónea o acertada y, en realidad, esto no importaría demasiado desde el punto de vista del aprendizaje, siempre que el estudiante aproveche la oportunidad, con ayuda del profesor, de reflexionar sobre los resultados de su actividad y aprenda de esta retroalimentación. (ANECA, 2011).

El contexto de este trabajo se realiza en el Grado de Ciencias de la Actividad Física y el Deporte, titulación en la que se aprende a ser profesional competente en cinco perfiles: enseñanza de la actividad física y el deporte, entrenamiento deportivo, actividad física y calidad de vida, gestión y recreación deportiva. El trabajo desarrollado se basa en un entorno de enseñanza orientada al aprendizaje, eje central de la reforma en la que se encuentra inmerso el sistema universitario español, donde un programa se debe juzgar en términos de su efectividad para ayudar al profesorado a maximizar el aprendizaje del alumnado, debe ser un punto de partida para la toma de decisiones anuales, gracias a la participación activa y retroalimentación obtenida a partir de los resultados de los alumnos, que ayuden a mejorar el proceso (Gessa, 2011).

Este trabajo es la continuación de un proceso de mejora continua dentro de la asignatura deportes de colaboración-oposición del Grado de Ciencias de la Actividad Física y del Deporte que ha seguido el siguiente proceso:

1. Construcción y validación cuestionario para evaluar el proceso de enseñanza de la técnica deportiva por pares en la Enseñanza Superior (ETEPES) (Álvarez et al., 2019).
2. Opinión del alumnado proceso de enseñanza de la técnica deportiva por pares en la Enseñanza Superior (ETEPES) (Álvarez-Medina et al., 2022)
3. Inclusión de la evaluación participativa en la enseñanza superior de los deportes colectivos (Álvarez-Medina et al., 2020).

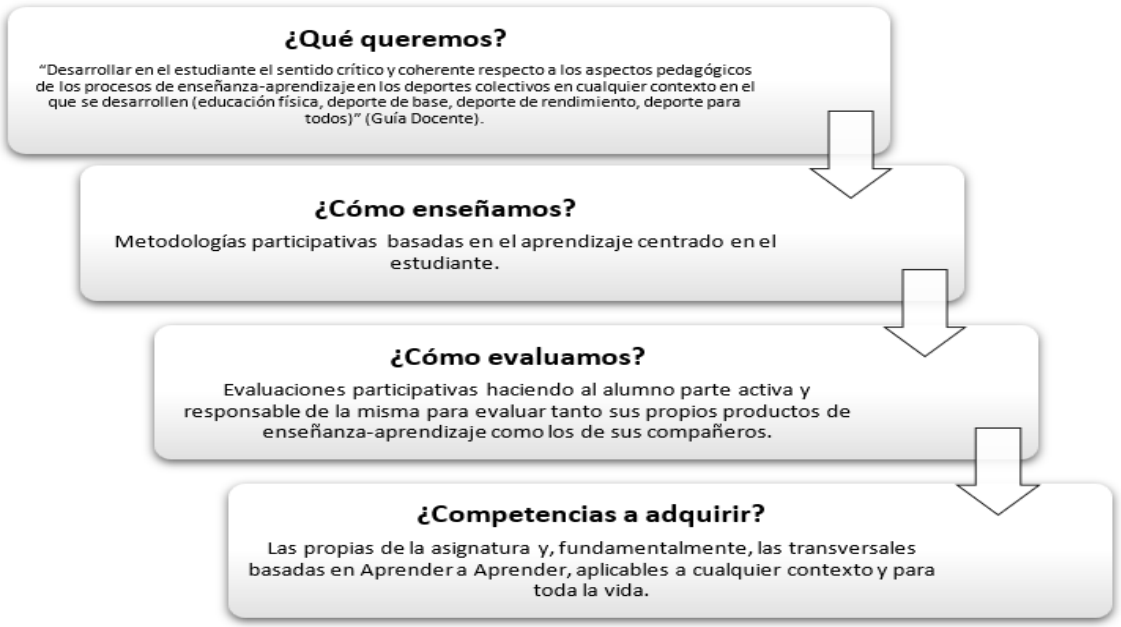
Los resultados de las publicaciones anteriores sobre evaluaciones y metodologías participativas muestran como los estudiantes están de acuerdo con los beneficios que estas aportan, confirmando lo establecido por otros autores como una de las formas más efectivas para mejorar el desarrollo de estrategias interpersonales, incrementar la intencionalidad formativa, fomentar el diálogo y la capacidad de realizar juicios con los otros compañeros e incluso docentes para evaluar, mejora los procesos y productos del aprendizaje de las materias específicas así como el desarrollo de competencias en general, produciendo un cambio actitudinal hacia el aprendizaje. Todo ello, supone un indudable valor formativo que ayuda a formar alumnos más autónomos, responsables, críticos (Ibarra-Saiz, Rodríguez-Gómez, & Gómez-Ruíz, 2012; Moreno-Murcia, Aracil, & Reina, 2014; Prins, Sluijsmans, Kirschner, & Strijbos, 2005) y como la sociedad demanda, ciudadanos democráticos (Valdivieso et al., 2013), capaces de insertarse en el mercado laboral y adaptarse al mismo a lo largo de la vida.

Una vez incluidos, como sugiere Salmerón (2013), métodos innovadores docentes proactivos con evaluaciones participativas para facilitar el desarrollo y la consecución de las competencias necesarias para transferir conocimiento e innovar en el puesto de trabajo (Muñoz-San Roque et al., 2016), falta medir el grado de adquisición de las competencias establecidas en el Grado. De esta manera, en el presente trabajo se muestra una manera de conocer la opinión de los alumnos en cuanto a las competencias desarrolladas, y como dentro de la asignatura objeto de estudio se trabaja para la mejora de aquellas peor evaluadas.

El objeto de estudio de esta investigación es evaluar la valoración del alumnado acerca de las competencias de la asignatura de "Deportes de colaboración-oposición" y tratar de mejorar la adquisición de dichas competencias, especialmente aquellas en las que se obtienen peores resultados.

La hipótesis de investigación responde a que los estudiantes participantes en la asignatura de Deportes de colaboración-oposición perciben de forma positiva las competencias evaluadas, si bien el trabajo en aquellas peor evaluadas puede provocar un efecto positivo en su adquisición en años posteriores.

Figura 1
Estructura del objeto de estudio



Material y Método

Se llevó a cabo un estudio longitudinal selectivo en estudiantes de 2º curso del Grado en Ciencias de la Actividad Física y del Deporte en la asignatura "Deportes de colaboración-oposición". Los cursos analizados fueron:

- 2018-2019, 47 participantes.

- 2019-2020, 2º semestre, 54 participantes.
- 2020-2021, 46 participantes.

El 76.1% de los estudiantes son del género masculino, mientras que el 23.8% son del género femenino.

Cabe destacar que a partir del 2º semestre del curso 2019-20 se desarrollaron bajo las restricciones sanitarias motivadas por la pandemia del COVID-19.

Instrumento

Las competencias generales que se plantean para esta asignatura se dividen en:

- Instrumentales
- Personales y de relación interpersonales
- Sistémicas
- Otras

Para poder saber si se han conseguido las competencias, se elaboró un cuestionario formado por todas las descritas en la guía docente de la asignatura de "Deportes de colaboración-oposición".

Tabla 1
Listado de competencias Instrumentales. Personales e interpersonales. Sistémicas y otras

Competencias
Instrumentales
C.I.1.-Capacidad de análisis y síntesis aplicadas a la gestión y organización de las actividades físicas y deportivas
C.I.2.-Utilización de técnicas de comunicación oral y escrita adecuadas. tanto en contextos académicos (en sus distintas manifestaciones) como en situaciones de carácter divulgativo
C.I.3.-Comprensión de la literatura científica referente a la actividad física y el deporte en lenguas de presencia significativa en dicho ámbito. así como correcta expresión en las citadas lenguas
C.I.4.-Aplicación de las tecnologías de la información y comunicación (TIC) al ámbito de las Ciencias de la Actividad Física y del deporte
C.I.5.-Organización y planificación del trabajo propio estableciendo pautas y estrategias apropiadas a cada situación
C.I.6.-Desarrollo de hábitos de excelencia y calidad en el ejercicio profesional
C.I.7.-Aplicación de los conocimientos sobre las diferencias de género en las AFE y deportivas en cualquier ámbito profesional del GCCAFD
C.I.8.-Aplicación de los conocimientos para atender profesionalmente a cualquier colectivo o individuo con necesidades especiales
Personales e interpersonales
CPEI.1.-Conocer y actuar dentro de los principios éticos necesarios para el correcto ejercicio profesional referido tanto a las relaciones con los usuarios como a la organización y gestión de la actividad física propiamente dicha
CPEI.2.-Reconocimiento de la diversidad y la multiculturalidad en el desempeño profesional
CPEI.3.-Compromiso con los valores educativos y sociales del deporte y la actividad física como propios de una cultura de paz y democracia
CPEI.4.-Razonamiento crítico en el análisis y la valoración de alternativas en todas aquellas ocupaciones propias del desempeño profesional
CPEI.5.-Desarrollar habilidades de dirección liderazgo relación interpersonal y trabajo en equipo
CPEI.6.-Capacidad de integración en equipos multidisciplinares
Sistémicas
C.S.1.-Capacidad para la adaptación a nuevas situaciones y a cambios en el entorno
C.S.2.-Iniciativa y coherencia en la resolución de problemas
C.S.3.-Actitud positiva y aptitud suficiente para el aprendizaje autónomo
C.S.4.-Capacidad para emprender mejoras y proponer innovaciones
Otras
C.O.1.-Capacidad para entenderse en un contexto internacional
C.O.2.-Aplicación de la teoría a la práctica
C.O.3.-Habilidades de investigación
C.O.4.-Conocimiento de otras culturas
C.O.5.-Habilidad para trabajar de forma autónoma
C.O.6.-Diseño y gestión de proyectos
C.O.7.-Motivación de logro
C.O.8.-Sensibilidad medioambiental

Nota: CI (Competencia Instrumental); CPEI (Competencias Personales e Interpersonales); CS (Competencias Sistémicas); CO (Competencias Otras).

En dicho cuestionario se indica de forma cuantitativa la percepción del alumno en cuanto a las competencias generales, utilizando la escala Likert 1-5 donde 1 corresponde "no la he adquirido" y 5 "la he adquirido totalmente" y también en cuanto a las subcompetencias, en cuyo caso hay que marcar si se consideran que se dan. Además de forma cualitativa al final del cuestionario se permite dar la opinión sobre las competencias y subcompetencias planteada.

Procedimiento

La recogida de los cuestionarios se realizó a través de la plataforma Google Forms. Se solicitó a cada uno de los participantes a la finalización de la asignatura en cada uno de los años académicos, y en presencia del profesor responsable, que lo cumplimentaran y consultaran cualquier tipo de duda que tuvieran con los ítems.

El criterio de inclusión es que participarán en el estudio todos los alumnos y alumnas matriculados en la asignatura en cada año académico, mientras que el único criterio de exclusión establecido fue el no optar a la evaluación continua de la asignatura en función de lo establecido en la guía docente, como puede ser la falta de asistencia a clase.

A lo largo de cada año académico los alumnos van asimilando progresivamente los procesos de aprendizaje en lo cognitivo, emocional y conductual, facilitando la valoración de los productos de aprendizaje (Muñoz-San Roque et al., 2016). Aunque el total de las competencias deben adquirirse al final del grado, la obtención y el aprendizaje de las competencias enmarcadas en esta asignatura unidas a las aportaciones de los alumnos a través de la valoración final, aportan una retroalimentación valiosa para ayudar a entender y mejorar el proceso establecido, resaltando la importancia de conocer la opinión de los alumnos al ser los principales protagonistas (Santos-Rego et al., 2017; Tejada & Ruiz, 2016) y los principales afectados de su acción pedagógica (Dugas, 2006; Martínez-Otero et al., 2018).

Durante todo el estudio se garantizó el anonimato de las respuestas en cumplimiento de las normas éticas de investigación del Código de Buenas Prácticas en Investigación de la Universidad de Zaragoza (2018), administrando y siendo aceptado por los participantes el correspondiente consentimiento informado para participar en el estudio.

Intervención

El feedback obtenido en el curso 2018-2019 se consideró y se tuvo en cuenta para la mejora de la asignatura en los siguientes cursos, tanto en la puntuación de cada competencia, como en los comentarios aportados por los alumnos. Algunos de estos comentarios fueron:

- "Creo que muchas de las competencias aquí nombradas estaría muy bien adquirirlas si realmente es un objetivo propuesto en esta asignatura, creo que la manera que se ha desarrollado esta asignatura ha sido dando mucha prioridad a algunos temas. El tema del medioambiente, de las adaptaciones curriculares, la igualdad de género, la interculturalidad... creo que para nada se han tratado, ...".
- "¿Conocimiento de otras culturas? ¿Sensibilidad medioambiental? No he oído ni una palabra sobre esto".

Con el objetivo de seguir mejorando en todas aquellas competencias especialmente relacionadas con "Aprender a Aprender", en el curso 2019-2020 y en el curso 2020-2021 se establecieron una serie de actividades-tareas para intentar mejorar específicamente aquellas competencias que obtuvieron peores resultados en el curso previo. Estas fueron:

- Competencia relacionada con: Atención al género
  - Intervención: Trabajo "Papel actual de la mujer en el deporte".
- Competencia relacionada con: Otras culturas e idiomas
  - Intervención: Búsquedas bibliografías en otro idioma.
- Competencia relacionada con: Cuidado del medioambiente
  - Intervención: Referencia al mismo en cada trabajo y en cada actividad de clase.
- Competencia relacionada con: Deporte adaptado
  - Intervención: Trabajo y exposición monográfico del deporte colectivo adaptado.

La situación especial vivida en el curso 2019-2020 por el COVID-19 afectó a la adquisición de competencias ya que impidió realizar algunas de las tareas concretas planificadas a tal efecto para los últimos meses del curso, donde tanto en la clase teórica como en la práctica la intervención del alumno era aún mayor.

Método Estadístico

Programa SPSS v.21 con licencia de la Universidad de Zaragoza. Los resultados se dan en descriptivos: frecuencia, porcentajes, media y desviación estándar. Inferencial para la comparación de variables y establecer diferencias significativas chi-cuadrado ($p < .05$). Coeficiente alfa de Cronbach para establecer la relación entre muestras y el estadístico *d* de Cohen para estimar el tamaño del efecto.

Resultados

La tabla 2 muestra la relación entre los diferentes tipos de competencias y su puntuación en los cursos 2018-2019, 2019-2020 y 2020-2021. En la columna "Diferencia" se muestra la diferencia en la puntuación entre dos años consecutivos, mientras que la columna "p" muestra el *p-valor* (probabilidad) asociado a esa diferencia. La columna "d de Cohen" muestra el tamaño del efecto.

Tabla 2
Adquisición tipo de competencias

Tipos de competencias	2018-19	2019-20	Dife-rencia	p	d de Cohen	2020-21	Diferencia	p	d de Cohen	Dif. 2018-19 vs 2020-21	p	d de Cohen
Instrumentales	3.57 ± .53	3.84 ± .53	+.27	.006	.51	3.76 ± .08	- .08	.067	.12	.19	.016	.27
Personales e interpersonales	3.80 ± .63	3.93 ± .61	+.13	.298	.21	3.91 ± .08	-.02	.451	.03	.11	.882	.15
Sistémicas	3.77 ± .64	4.17 ± .56	+.40	.001	.67	3.83 ± .10	-.34	.000	.85	.06	.000	.13
Otras	3.38 ± .70	3.59 ± .54	+.21	.132	.34	3.70 ± .09	-.11	.000	.28	.32	.000	.65
Total	3.63 ± .19	3.88 ± .24	+.25			3.80 ± .09	-.08			.17		

Se puede apreciar como en las competencias instrumentales, hubo un aumento en 2019-2020 (.27) pero una disminución en 2020-2021 (.08) con un *p-valor* (.067) y un tamaño del efecto de Cohen (.12) moderado. En las competencias personales e interpersonales, hubo un aumento en 2019-2020 (.13) y una disminución en 2020-2021 (.02) con un *p-valor* (.451) y un tamaño del efecto de Cohen (.03) estimado como pequeño. En las competencias sistémicas hubo un aumento en 2019-2020 (.40) pero una disminución en 2020-2021 (.34) con un *p-valor* (.000) y un tamaño del efecto de Cohen (.85) muy grande. En las competencias 'Otras', hubo un aumento en 2019-2020 (.21) pero una disminución en 2020-2021 (.11) con un *p-valor* (.000) y un tamaño del efecto de Cohen (.28) considerado como moderado.

En esta tabla 3, se observa una ligera mejora en las competencias en ambos géneros en el período 2020-2021 en comparación con 2018-2019. *(p* = .04). Sin embargo, valorando competencia por competencia, las diferencias entre hombres y mujeres en ambos períodos son pequeñas y no son estadísticamente significativas *(p* > .05), si exceptuamos la competencia 'Otras'.

Tabla 3
Adquisición de competencias por año y género

	2018-2019				2020-2021				Dif. 2018-19 vs 2020-21		
Tipos de competencias	Masc.	Fem.	Dif.	p	Masc.	Fem.	Dif.	p	Masc.	Fem.	p
Instrumentales	3.6 ± .56	3.48 ± .49	+.12	.635	4.08 ± .77	4 ± 1.15	+.08	.720	.48	.52	.132
Personales e interpersonales	3.89 ± .62	3.57 ± .54	+.32	.359	3.81 ± .81	3.9 ± .83	-.09	.511	-.08	.33	.753
Sistémicas	3.73 ± .7	3.86 ± .49	-.13	.219	3.83 ± .775	3.7 ± 1.33	+.13	.975	.1	-.16	.521
Otras	3.42 ± .75	3.29 ± .59	+.13	.145				.365			.04
Total	3.66 ± .65	3.55 ± .53	+.11		3.91 ± .785	3.87 ± 1.10	+.78		.25	.32	.04

Analizando competencia por competencia (tabla 4) se pueden ver aquellas que han obtenido diferencias significativas entre los cursos. En particular, se observa un incremento significativo en las competencias 1, 2, 3, 4, 5, 6 y 8, con diferencias estadísticamente significativas *(p* < .05) en las competencias 1, 2, 4, 5 y 6. Por otro lado, se aprecia una disminución significativa en la competencia 7, *(p* = .017).

En las competencias 9, 10 y 11 también se observa un incremento, pero no es significativo.

Tabla 4
Adquisición de competencias

Competencias	2018-2019	2019-2020	Dif	p	2020-2021	Dif	p
Instrumentales							
C.I.1	3.89±.79	3.89±.82	=	.885	4.24±.79	+.35	.027
C.I.2	3.34±.81	3.70±.80	+.36	.034	3.8±.74	+.1	.542
C.I.3	3.62±.92	3.85±.82	+.23	.159	4.11±.70	+.26	.101
C.I.4	3.85±.95	4.23±.82	+.38	.040	4.02±1.02	-.21	.402
C.I.5	3.66±.89	4.02±.70	+.36	.030	3.8±.77	-.22	.130
C.I.6	3.91±.77	4.06±.79	+.15	.334	3.52±1.11	-.54	.018
C.I.7	3.23±1.07	3.68±.98	+.45	.039	3.85±.86	+.17	.443
C.I.8	3.02±1.19	3.30±.93	+.28	.269	3.26±1.06	-.04	1
Personales e interpersonales							
CPEI.1	4.26±.82	4.23±.87	-.03	.943	4.07±.85	-.16	.122
CPEI.2	3.43±1.12	3.72±.95	+.29	.205	3.89±1.04	+.17	.087
CPEI.3	3.98±.70	4.08±.94	+.1	.318	4.2±.80	+.12	.010
CPEI.4	3.91±.93	4.15±.72	+.24	.263	4.04±.72	-.11	.570
CPEI.5	3.77±1.00	4.08±.78	+.31	.141	4.04±.84	-.04	.594
CPEI.6	3.43±.95	3.32±.99	-.11	.693	3.41±1.00	+.09	.001
Sistémicas							
C.S.1	3.49±.93	3.92±.76	+.43	.008	3.89±.82	-.03	.003
C.S.2	3.74±.99	4.04±.76	+.3	.162	3.83±.82	-.21	.474
C.S.3	4.06±.96	4.49±.75	+.43	.012	4.26±.88	-.23	.011
C.S.4	3.79±.88	4.21±.74	+.42	.010	3.87±1.00	+.34	.530
Otras							
C.O.1	3.09±1.16	3.13±1.06	+.04	.852	3.17±1.06	+.04	.000
C.O.2	3.96±.83	4.13±.71	+.17	.331	4.07±.8	-.06	.354
C.O.3	3.43±.97	3.43±.89	=	.855	3.8±.91	+.37	.017
C.O.4	2.30±.93	2.57±.93	+.27	.157	2.98±1.14	+.41	.482
C.O.5	4.13±.80	4.28±.70	+.15	.357	4.39±.64	+.11	.064
C.O.6	3.57±1.02	3.83±.83	+.26	.170	3.85±.86	+.02	.017
C.O.7	3.74±1.13	4.17±.80	+.43	.067	4.07±.92	-.1	.000
C.O.8	2.81±1.34	3.19±1.18	+.38	.162	3.22±1.19	+.03	.000

Nota: C.I. (Competencia Instrumental); C.P.E.I. (Competencias Personales e Interpersonales); C.S. Competencias Sistémicas; C.O. (Competencias Otras).

Tal y como se refleja en la tabla 5, se muestran una tendencia positiva en la evaluación de las competencias instrumentales y personales e interpersonales. Si atendemos a las competencias instrumentales, se observa que los puntajes para la subcompetencia 1.c Generación de actividades y experiencias han sido relativamente estables a lo largo de los tres años, con una ligera disminución en el año 2020-2021. La subcompetencia 3.d Identificación de errores y propuesta de alternativas ha mostrado un aumento significativo en los puntajes a lo largo de los tres años. La subcompetencia 3.a Realización de búsquedas científicas también ha mostrado un aumento en el puntaje en el año 2020-2021 en comparación con el año 2018-2019, pero una disminución en el año 2019-2020. Por último, la subcompetencia 6.d Valoración y revisión de las actuaciones mostró un aumento en el puntaje en el año 2019-2020 pero disminuyó en el año 2020-2021.

En cuanto a las competencias personales e interpersonales, se observa una tendencia similar en las subcompetencias 9.a y 11.a. Ambas puntuaciones se han mantenido estables a lo largo de los tres años, con un pequeño aumento en el año 2020-2021. Sin embargo, la subcompetencia 9.c Respeto a las normas y reglamentos en situaciones de interacción ha mostrado un aumento significativo en el puntaje entre 2018-2019 y 2019-2020, pero una disminución en el año 2020-2021.

Tabla 5
Resumen de la evolución de las subcompetencias trabajadas a lo largo de los 3 cursos académicos analizados 2018-19; 2019-20; 2020-21 expresado en valor porcentual

COMPETENCIA	2018-19	2019-20	2020-21
Competencias instrumentales			
1.c_Generación de actividades y experiencias	82.98%	84.91%	84.78%
3.d_Identificación de errores y propuesta de alternativas	78.72%	86.79%	89.13%
3.a_Realización de búsquedas científicas	85.11%	83.02%	89.13%
6.d_Valoración y revisión de las actuaciones	8.85%	92.45%	8.43%
Competencias personales e interpersonales			
9.a_ Respeto a la integridad de las personas. tanto desde el punto de vista físico. como emocional y social	82.98%	86.79%	82.61%
9.c_ Respeto a las normas y reglamentos en situaciones de interacción	82.98%	86.79%	82.61%
11.a_ Comprensión de situaciones de práctica de actividad física susceptibles de ser tratadas desde la cultura de la paz y el fair-play	82.98%	86.79%	86.96%

Discusión

En este estudio se analiza en qué medida se van adquiriendo las competencias establecidas en el Grado. Todas las opiniones obtenidas en el curso 2018-2019 se consideraron y tuvieron en cuenta para el curso 2019-20 y 2020-21 y se establecieron una serie de actividades-tareas para intentar mejorar específicamente aquellas competencias que obtuvieron peores resultados sin dejar de trabajarlas para intentar así seguir mejorando en todas aquellas competencias, especialmente las relacionadas con 'Aprender a Aprender'.

En una primera valoración, se observa que las puntuaciones han aumentado entre el año 2018-19 y el 2019-20 en todas las categorías con excepción de la categoría de 'Otras' que se mantiene estable. Sin embargo, entre el año 2019-20 y 2020-21 se observa un descenso en las competencias en todas las categorías, salvo en la categoría 'Otras', que aumenta. Además, el tamaño del efecto (d de Cohen) es moderado o grande en la mayoría de las comparaciones sugiriendo un impacto importante.

Concretamente, todos los tipos de competencias después de la intervención han mejorado sus puntuaciones en el curso 2019-2020 respecto al anterior, siendo superiores a 3.5, obteniendo una mejora de .25 como media, pasando de 3.63 ± .19 a 3.88 ± .24 y bajando mínimamente en el curso 2020-2021 pasando a 3.86 ±.19 .El mayor aumento (0,4) se ha producido en las sistémicas pasando de 3.77 ± .64 en el curso 2018-2019 a 4.17 ± .56 en el curso 2019-2020, pasando antes de la intervención de la segunda mejor valoración a la primera. Las personales obtienen el menor aumento (.13) en el año 2019-2020, pasando del primer lugar antes de la intervención al segundo después de la misma, en el año 2020-2021 aumentan ligeramente (.01). Las instrumentales siguen ocupando después de la intervención la tercera mejor media y 'Otras', a pesar de sufrir el segundo mayor aumento postintervención (.21) en el curso 2019-2020, sigue obteniendo la peor media de todas. Se han obtenido diferencias significativas en las instrumentales (.006) y sistémicas (.001) en el curso 2019-2020.

Si atendemos a las diferencias globales entre el primer y el último curso, (2018-19 y 2020-21), se encuentran diferencias significativas en los valores de las competencias sistémicas (p = .016), así como en las Sistémicas (p = .000) y 'Otras' (p =.000). Se puede decir que todas se trabajan dentro de la asignatura para su adquisición total al final del grado.

Cabe destacar que son diversas las investigaciones han demostrado que la combinación de diferentes tipos de experiencias educativas, incluyendo la enseñanza práctica y la colaboración, son efectivas para el desarrollo de competencias en estudiantes universitarios. Además, también se ha demostrado que el apoyo académico y la orientación son importantes para mejorar el desarrollo de las competencias personales e interpersonales (Biggs, 2003; Popovic, 2013).

Evaluando la adquisición de las competencias atendiendo al año y al género (tabla 3), se ha observado un incremento sutil en el desempeño en ambos géneros durante el período comprendido entre 2020 y 2021 en comparación con el período comprendido entre 2018 y 2019. No obstante, las variaciones entre los géneros en ambos períodos son insustanciales y no alcanzan significancia estadística (p > .05). Existen varios estudios que han examinado la relación entre género y competencias en el ámbito universitario en los grados de actividad física y deportiva, y algunos de estos estudios han concluido igualmente que no hay diferencias significativas entre la variable género en términos de adquisición de competencias, considerando los trabajos de Gómez Ruiz et al. (2013), Rodríguez-Gómez et al. (2018), o en Bustamante-Ara et al. (2022).

Adentrándonos en el análisis de la adquisición de las subcompetencias (tabla 4), queremos llegar a valorar como en las competencias instrumentales se ve que las puntuaciones promedio entre hombres y mujeres son similares en los tres

años, con una diferencia promedio entre géneros de solo .12 en el primer año, .16 en el segundo año, y .08 en el tercer año. En las competencias personales e interpersonales, se ve que las puntuaciones promedio son ligeramente más altas en hombres que en mujeres en los tres años, con una diferencia promedio entre géneros de .32 en el primer año, .02 en el segundo año y -.09 en el tercer año. En el primer y segundo año, la diferencia es significativa *(p < .05)*, pero el valor en el tercer año no es significativo.

En cuanto a las competencias sistémicas, se puede apreciar que las puntuaciones promedio son similares entre hombres y mujeres en los tres años, con una diferencia promedio entre géneros de -.13 en el primer año, .,04 en el segundo año y .13 en el tercer año. Los valores de p indican que no hay una diferencia significativa entre las puntuaciones promedio de hombres y mujeres en las competencias sistémicas.

Con respecto a la efectividad de las medidas concretas realizadas en el curso 2019-20 y 2020-21, todas han mejorado, excepto "Aplicación de los conocimientos para atender profesionalmente a cualquier colectivo o individuo con necesidades especiales" que baja ligeramente en el curso 2020-21.

Desglosando éstas, destacamos las siguientes consideraciones:

Atención al Género:

Aplicación de los conocimientos sobre las diferencias de género en las AFE y deportivas en cualquier ámbito profesional del GCCAFD 3.23 ± 1.07/3.68 ± .98 (+.,45) / 3.85 ± .86 (+.,17). Es importante destacar la importancia del desarrollo de esta competencia dado que hay estudios que resaltan que todavía permanece de forma continua en nuestra sociedad una discriminación en función del género pero que el alumnado, destaca positivamente el abordaje de estas cuestiones en la formación universitaria. aspecto que deberíamos superar y abordar a través de este grado (Bas-Peña et al., 2017).

Otras culturas e idiomas:

Comprensión de la literatura científica referente a la actividad física y el deporte en lenguas de presencia significativa en dicho ámbito, así como correcta expresión en las citadas lenguas 3.62 ± .92/3.85 ± .82 (+.23) / 4.11 ± .70 (+.26)

Capacidad para entenderse en un contexto internacional 3.09 ± 1.16/3.13 ± 1.06 (+.04) / 3.17 ± 1.06 (+.04)

Conocimiento de otras culturas 2.30 ± .93/2.57 ± .93 (+.27) / 2.98 ± 1.14 (+.41)

Uno de los rasgos más característicos de la universidad en el siglo XXI es su gran diversidad lingüística, cultural y académica. Es por ello por lo que estudios como los de Dafouz (2015) y Oyarzún et al. (2012) planteen la necesidad de desarrollar, en el ámbito universitario, una competencia lingüística multidimensional que contribuya a que los estudiantes puedan comprender las necesidades profesionales que en los tiempos actuales pueden llegar a encontrarse. De ahí la importancia de los resultados de nuestro estudio donde estas competencias registran una consideración relevante por parte de los estudiantes.

Cuidado del medioambiente:

Sensibilidad medioambiental 2.81 ± 1.34/3.19 ± 1.18 (+.38) / 3.22 ± 1.19 (+.03)

Deporte adaptado:

Aplicación de los conocimientos para atender profesionalmente a cualquier colectivo o individuo con necesidades especiales 3.02 ± 1.19/3.30 ± .93 (+.28) / 3.26 ± 1.06 (-.04)

Y con respecto a las competencias que más van a fomentar 'Aprender a Aprender' se puede destacar las que favorecen:

Capacidad de cambio, automejora, pensamiento crítico:

Dentro de las instrumentales (CI):

Aplicación de las tecnologías de la información y comunicación (TIC) al ámbito de las Ciencias de la Actividad Física 3.85 ± .95/4.23 ± .82 (+.38). Como se puede observar en la tabla 4 en el curso 2019-20 aumenta el porcentaje de los alumnos que consideran que se trabajan con respecto al curso 2018-19 aunque en el curso 2020-21 los resultados disminuyen 4.02 ± 1.02 (-.21).

Organización y planificación del trabajo propio, estableciendo pautas y estrategias apropiadas a cada situación 3.66 ± .89/4.02 ± .70 (+.36). Como se puede observar en la tabla 4 en el curso 2019-20 aumenta el porcentaje los alumnos que consideran que se trabajan con respecto al curso 2018-19 aunque en el curso 2020-21 los resultados disminuyen 3.80 ± .77(-.22).

Dentro de las personales (CP):

Razonamiento crítico en el análisis y la valoración de alternativas en todas aquellas ocupaciones propias del desempeño profesional 3.91 ± .93/4.15 ± .72 (+.24). Como se puede observar en la tabla 4 en el curso 2019-20 aumenta el porcentaje los alumnos que consideran que se trabajan con respecto al curso 2018-19 aunque en el curso 2020-21 los resultados disminuyen 4.04 ± .72 (-.11).

Dentro de las sistémicas (CS):

Capacidad para la adaptación a nuevas situaciones y a cambios en el entorno mejora en el curso 2019-20 respecto al anterior 3,49 ± .93 / 3,92 ± .76 (+.43) pero empeora en el curso 2020-21 3.89 ± .82 (-.03)

Iniciativa y coherencia en la resolución de problemas mejora en el curso 2019-20 respecto al anterior 3,74 ± .99 / 4,04 ± .76 (+.3) pero empeora en el curso 2020-21 3,83 ± .82 (-.21)

Actitud positiva y aptitud suficiente para el aprendizaje autónomo mejora en el curso 2019-20 respecto al anterior 4.06 ± .96/4,49 ± .75 (+.43) pero empeora en el curso 2020-21 4,26 ± .88 (-.23)

Capacidad para emprender mejoras y proponer innovaciones mejora en el año 2019-20 respecto al anterior 3.79 ± .88 / 4,21 ± .74 (+.42) pero empeora en el curso 2020-21 3.87 ± 1,0 (-.34)

Dentro de 'Otras' (CO):

Habilidad para trabajar de forma autónoma mejora en ambos años, en el año 2019-20 4.13 ± .80 / 4.28 ± .70 (+.15) y en el año 2020-21 4.39 ± .64 (+.11).

Motivación de logro mejora en el curso 2019-20 respecto al anterior 3,74 ± 1,13 / 4,17 ± .80 (+.43) pero empeora en el curso 2020-21 4,07 ± .92 (-.1)

Estos resultados coinciden con las valoraciones de Ribas et al. (2022) o Douglas y Gammie (2019) tanto en cuanto que el aprendizaje y la capacidad de aprender son considerados como fundamentales por los encuestados, y también se observa una alta valoración en cuanto a su desempeño en el Grado, lo que indica que no solo es considerado como un aspecto importante, sino que también se está desarrollando efectivamente a través de la metodología participativa aplicada en este estudio.

Así mismo, en esta tabla 5 se destacan varias subcompetencias que en los tres cursos analizados los alumnos consideran que se trabajan siempre, las cuales obtienen porcentajes aproximados al 80% de elección en todos los casos. Dentro de la competencia instrumental "Capacidad de análisis y síntesis aplicadas a la gestión y organización de las actividades físicas y deportivas", destacan dos subcompetencias "Generación de actividades y experiencias" e "Identificación de errores y propuesta de alternativas". Dentro de la competencia instrumental "Comprensión de la literatura científica referente a la actividad física y el deporte en lenguas de presencia significativa en dicho ámbito, así como correcta expresión en las citadas lenguas", destaca la subcompetencia "Realización de búsquedas científicas". Dentro de la competencia instrumental "Desarrollo de hábitos de excelencia y calidad en el ejercicio profesional", destaca la subcompetencia "Valoración y revisión de las actuaciones". Dentro de la competencia personal e interpersonal "Conocer y actuar dentro de los principios éticos necesarios para el correcto ejercicio profesional, referido tanto a las relaciones con los usuarios como a la organización y gestión de la actividad física, propiamente dicha", destaca la subcompetencia "Respeto a la integridad de las personas, tanto desde el punto de vista físico, como emocional y social" y "Respeto a las normas y reglamentos en situaciones de interacción". Dentro de la competencia personal e interpersonal "Compromiso con los valores educativos y sociales del deporte y la actividad física como propios de una cultura de paz y democracia" destaca la subcompetencia "Comprensión de situaciones de práctica de actividad física susceptibles de ser tratadas desde la cultura de la paz y el fair-play".

Debido a la situación especial vivida, COVID-19, señalar que si bien a esta asignatura y en el apartado metodologías y evaluaciones no afectó en demasía por ser anual y en el segundo semestre tener menos docencia semanal, sí que afectó en mayor medida a la adquisición de competencias ya que impidió realizar algunas de las tareas concretas planificadas a tal efecto para los últimos meses del curso, donde tanto en la clase teórica como en la práctica la intervención del alumno era aún mayor, por lo que puede afectar, fundamentalmente, en los resultados obtenidos en las competencias y en la metodología aplicada en el fútbol por ser la última de todas (González-Arévalo et al., 2022).

Estos valores pueden relacionarse con los obtenidos en el trabajo de Amor-Almedina y Serrano-Rodríguez (2018), en el que se evaluaron los niveles de desarrollo de las habilidades generales en los estudios universitarios Los resultados muestran que existen diferencias significativas entre grupos, pero en general, la habilidad para trabajar en equipo es la mejor percibida por todos los participantes, en comparación a la capacidad de comunicación en un idioma y la habilidad tecnológica.

Un estudio reciente ha investigado los efectos de la evaluación cooperativa por parejas en un grupo de estudiantes de secundaria. Los resultados del estudio sugieren que esta estrategia puede mejorar significativamente el rendimiento aca-

démico de los estudiantes. Además, los estudiantes que participaron en la evaluación cooperativa por parejas mostraron un mayor nivel de confianza y una actitud más positiva hacia el aprendizaje en general (González-Arévalo et al., 2022).

La evaluación cooperativa por parejas se lleva a cabo de la siguiente manera: los estudiantes se dividen en parejas y se les asigna un tema específico para estudiar. Cada estudiante luego realiza su propia evaluación del tema, y luego se reúnen con su compañero de pareja para discutir sus evaluaciones y llegar a un acuerdo sobre el nivel de comprensión del tema. Esta técnica permite a los estudiantes mejorar su comprensión del material y también les da la oportunidad de enseñar a sus compañeros lo que han aprendido.

En resumen, la evaluación cooperativa por parejas es una estrategia pedagógica efectiva que puede mejorar el rendimiento académico de los estudiantes y aumentar su confianza y actitud positiva hacia el aprendizaje.

Es importante tener en cuenta que estos resultados deben interpretarse con precaución, ya que dependen de la metodología utilizada para realizar las evaluaciones y encuestas, así como del tamaño y representatividad de la muestra de estudiantes evaluados. Además, es necesario conocer el contexto en el que se han realizado estas evaluaciones para poder entender por qué se han producido ciertas mejoras o disminuciones en los resultados.

Conclusiones

Las principales conclusiones en cuanto a competencias son:

- Todas las competencias se trabajan a lo largo de la asignatura obteniendo valores superiores a 3.5.
- La intervención ha sido efectiva pasando de una media de 3,63 ± .19 a 3.80 ± .009 obteniendo una mejora de .27.
- Las medidas específicas han sido efectivas destacando por tipos las sistémicas, enfocadas a 'Aprender a Aprender', pasando de 3.77 ± .64 a 3.83 ± .10 con un aumento de .06.
- A pesar de las medidas adoptadas algunas competencias son difíciles de trabajar por las características de la asignatura.

Las principales conclusiones generales del estudio han sido:

- Todo el proceso de enseñanza-aprendizaje es coherente estando alineadas las metodologías y evaluaciones utilizadas con la adquisición de competencias y objetivo de la asignatura.
- La retroalimentación de los alumnos es efectiva para mejorar el proceso y debe ser un punto de partida para la toma de decisiones anuales.

La intervención tuvo un impacto positivo en las competencias de los estudiantes, con una mejora significativa en las competencias sistémicas y un aumento menor pero significativo en las competencias instrumentales. Sin embargo, la categoría de 'Otras' siguieron obteniendo la peor media de todas. De la misma manera, consideramos que es necesario seguir investigando en la aplicación de este tipo de metodología participativas para identificar posibles soluciones y mejorar la adquisición de las competencias de los estudiantes en estas materias. La combinación de diferentes tipos de experiencias educativas, incluyendo la enseñanza práctica, la reflexión, la colaboración y la experiencia, son efectivas para el desarrollo de competencias en estudiantes universitario.

Declaración del Comité de Ética

No aplica debido a la naturaleza del estudio, ya que no involucra a personas ni datos sensibles que requieran aprobación de un Comité de Ética.

Conflicto de Intereses

Los autores manifiestan que la presente investigación se ha llevado a cabo sin la existencia de relaciones comerciales o financieras que pudieran interpretarse como un posible conflicto de interés.

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Según la taxonomía CRediT, las contribuciones individuales de los autores en este artículo son las siguientes: Interpretación de resultados: Javier Álvarez Medina, Jaime Casterad Seral, Víctor Murillo Lorente, Luis Pueyo Romeo; Metodología: Javier Álvarez Medina, Jaime Casterad Seral, Víctor Murillo Lorente, José Antonio Poblador Vallés; Recolección de datos: Javier Álvarez Medina, Jaime Casterad Seral, Víctor Murillo Lorente, José Antonio Poblador Vallés; Revisión de literatura: Javier

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Declaración de Disponibilidad de Datos

Los datos derivados del presente trabajo se encuentran disponibles bajo demanda al autor (jcaster@unizar.es) sin ninguna restricción indebida.

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The Relative age Effect in Spanish High-Level Rink Hockey

El Efecto de la Edad Relativa en el Hockey Patines de Alto Nivel en España

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Abstract

The influence of athletes' birth distribution across different year periods on sports performance is called the relative age effect. The present research aims to identify this bias in the top male and female national rink hockey competitions in Spain, as well as to assess this effect on variables such as level of competition, gender playing position, nationality, team standings, individual performance (goals scored), and international player status. The relative age of athletes in the first and second top Spanish national male (n = 499) and female (n = 358) competitions in the 2022-23 season was analysed. The results reveal the absence of a relative age effect in any of the analysed variables, indicating the independence of this variable from gender and competitive level. The nature of the sport, its organization, and the competitive structure designed in rink hockey indicate that athletes achieving higher performance were not selected based on biological maturation criteria.

Keywords: Relative age, roller hockey, talent identification, sports performance.

Resumen

La influencia de la distribución de los nacimientos de los deportistas en los diferentes períodos del año sobre el rendimiento deportivo se llama efecto de la edad relativa. La presente investigación tiene como objetivo identificar el efecto de la edad relativa en las máximas competiciones nacionales masculinas y femeninas de hockey patines en España, así como valorar este efecto sobre las variables: competición, género, posición en pista, nacionalidad, clasificación del equipo, rendimiento individual (goles marcados) y condición de jugador internacional. Se analiza la edad relativa de deportistas de la primera y segunda máxima competición nacional española masculina (n = 499) y femenina (n = 358) en la temporada 2022-23. Los resultados revelan la no existencia de efecto de la edad relativa en ninguna de las variables analizadas, mostrando independencia de esta variable del género y el nivel competitivo. La naturaleza del deporte, su organización y la estructura competitiva diseñada en el hockey patines muestra que en este deporte los deportistas que obtienen mayor rendimiento no han sido seleccionados teniendo en cuenta criterios madurativos de tipo biológico.

Palabras Clave: Edad relativa, hockey sobre patines, identificación de talento, rendimiento deportivo.

Introduction

In order to organise and balance the formative competitions of rink hockey (RH), in Spain the categories are structured and divided according to the athletes' birth age of the, typically grouping two different and consecutive birth years into each category. Despite this age-based structuring to bring together athletes with similar capabilities and skills, there are conditions of inequality that affect athletes' performance and participation, which is described by the concept of the relative age effect (RAE) (Barnsley et al., 1992). The concept of RAE in the sports field is described as the advantage in the performance of athletes born at the beginning of the year, after the cut-off date of the structure of the categories organized by age (Barnsley et al., 1985; Lovell et al., 2015). This RAE translates into a more significant presence of athletes born in the first quarters of the year compared to those born at the end of the year in teams and categories linked to performance (Barnsley et al., 1985; Prieto et al., 2015; Rodríguez-Lorenzo & Martín-Acero, 2019).

The age distribution of the sports regulations generates positive and negative effects on athletes' chances of success, favoring those born at the beginning of the year and disadvantaging those born later. During their developmental phase, athletes born early in the year tend to exhibit greater physical and cognitive development, which translates into better immediate performance. This advantage makes them more likely to be identified as talented early on, leading to better experiences and learning opportunities throughout their sporting careers. These favorable conditions increase the likelihood of achieving higher performance compared to those born later in the year (Delorme & Raspaud, 2009; Helsen et al., 1998; Yague et al., 2018). Late-developing players are often excluded from talent selection processes, and in some cases, this leads to dropout from sports due to perceived lack of competitiveness and lower self-confidence (Helsen et al., 1998; Thompson et al., 2004). The practice and competition environment surrounding young athletes plays a crucial role in shaping their development and performance. Positive and high-quality external reinforcements from parents and coaches (Helsen et al., 2005), along with greater training and competition volume (Barnsley et al., 1992; Helsen et al., 1998, 2005), contribute to this. Despite widespread agreement on these factors, the influence of RAE is not consistently observed across all contexts and disciplines, and authors such as Sæther (2016) have not found a relationship between participation time in youth competitions and long-term performance outcomes in sports like football.

Studies that have addressed RAE confirm that this impact is present in a variety of sports, taking into account different characteristics and demands (Cobley et al., 2009; De la Rubia et al., 2020), and is more pronounced in lower categories, decreasing as the age of the athletes and the qualitative and competitive level of the competition increases (Cobley et al., 2009; Doncaster et al., 2020; Rodríguez-Lorenzo &Martín-Acero, 2019; Sierra-Díaz et al., 2017). The adolescence stage generates the most suitable conditions for the RAE to be more significant due to the differences in the physical and cognitive development of the athletes (Cobley et al., 2009).

Despite the evidence of widespread RAE in various high-level sports and competitions, the opposite has also been observed, where RAE is absent or even reversed, showing a greater presence of athletes born later in the year. This reversed RAE, particularly in non-youth categories, is often a result of the challenges faced by athletes born at the end of the year during their development. In many cases, their later maturation has been an obstacle in early developmental stages, and their resilience has made them more capable of performing well in the long term (Cobley et al., 2009; Lago-Fuentes et al., 2019).

A comprehensive review of the literature reveals a wide range of contextual and personal variables associated with RAE, including: a) the player's position and role (De la Rubia et al., 2021; Prieto et al., 2015; Sierra-Díaz et al., 2017; Yague et al., 2018), b) the level of the club and the competition (Cobley et al., 2009; Salinero et al., 2013), c) selection competition, with teams having a larger pool of athletes to choose from showing a greater prevalence of early-year athletes (Lesma et al., 2011), d) the popularity of the sport (Cobley et al., 2009; Doncaster et al., 2020), e) the country of competition (Sierra-Díaz et al., 2017) and the athletes' nationality, with no conclusive results but indicating that RAE may occur in athletes from various countries (Lesma et al., 2011; Sánchez-Rodríguez et al., 2012), f) the characteristics of the sport, showing that in sports where physical abilities are not as critical for performance, RAE may not be identified (Sierra-Díaz et al., 2017), or a reversed RAE may appear, with an overrepresentation of late-year athletes when technical skills are more important than physical abilities (Delorme & Raspaud, 2009; Fumarco et al., 2017), g) the gender of the athletes, with RAE being less frequent and less studied in female sports (Helsen et al., 2005; Sierra-Díaz et al., 2017; Vincent & Glamser, 2006), h) birthplace characteristics, such as the population size of the city or country (Ribeiro-Junior et al., 2023; Sierra-Díaz et al., 2017), i) team and individual performance, or specific performance metrics per game (De la Rubia et al., 2021; Fumarco et al., 2017), j) athletes' economic income (Fumarco et al., 2017), and k) the various stages and ages of the athletes (Doncaster et al., 2020).

In Spain, RAE has been researched for years, demonstrating its impact across various sports (De la Rubia et al., 2021; Lesma et al., 2011; Rodríguez-Lorenzo & Martín-Acero, 2019; Salinero et al., 2013; Sánchez-Rodríguez et al., 2012; Sierra-Díaz et al., 2017; Yague et al., 2018). In RH, and to our knowledge, only one study has examined the influence of RAE. This study analyzed the professional and youth categories of FC Barcelona (Spain), revealing a greater presence of early-born players in all of the club's youth categories, with a significant effect in the U14 and U16 categories. However, this influence was no longer present in the senior professional team (Doncaster et al., 2020).

Given the growing interest in RH within the research field in recent years (Arboix-Alió et al., 2023; Fernández et al., 2023; Ferraz et al., 2024), and the lack of studies investigating the RAE effect in the top national men's and women's competitions in this sport, the objective of this study is to identify the influence of RAE on men's and women's teams in Spanish top RH based on: a) team competitive level; b) player position; c) team final ranking; d) player nationality; e) individual performance (goals scored), and f) international player status.

Material and Methods

Participants

The sample consisted of all participants in the two top men's and women's RH competitions in Spain in the 2022-23 season (*n* = 857): *OK Liga Masculina* (14 teams), *OK Liga Plata Masculina* (24 teams), *OK Liga Feminina* (14 teams) and *OK Liga Plata Feminina* (14 teams) (Table 1). The sample selection was done for convenience, using as a reference the best national women's championship and the second-best men's championship in the world (Arboix-Alió et al., 2023).

Table 1
Sample distribution by category and gender

Competition	Male	Female	Total
OK Liga Masculine (1st category)	*n* = 181		
OK Liga Plata Masculine (2n category)	*n* = 318		
OK Liga Feminine (1st category)		*n* = 184	
OK Liga Plata Femenine (2n category)		*n* = 174	
Total	*n* = 499	*n* = 358	*n* = 857

Instruments

The observation instrument consisted of the following variables: a quarter of the year of birth, player position, athlete nationality, competition, final team classification, individual performance (goals scored), and international player status (Table 2). The recording instrument was created using an Excel table with each variable.

Table 2
Description of the variables analyzed

Variable	Category and description
Birth quarter	Q1: first trimester born Q2: second trimester born Q3: third trimester born Q4: fourth trimester born
Player position	Goalkeeper Forward / defender
Nationality	Spanish Foreign
International player status [a]	International No international OK Liga Masculine
Competition	OK Liga Plata Masculine OK Liga Feminine OK Liga Plata Feminine
Final team classification	G1: 1t to 4th G2: 5th to 8th G3: 9th to 11th G4: 12th to 14th
Individual performance (goals scored)	First 20 top scored players No first 20 top scored players

Note: a The absolute international variable has only been analyzed in the highest national male and female categories: OK Liga Masculine and OK Liga Feminine.

Procedure

The data was provided by the Royal Spanish Skating Federation, which owns the competition and is responsible for incorporating the licenses of all participants. The Federation gave written permission to use this data, which is public and available on its website.

Statistical Analysis

The SPSS v29.0 statistical package was used to perform the statistical analysis. Frequencies and percentages of the different variables were obtained. To analyze the homogeneity of the distribution across the four quarters (Q1, Q2, Q3 and Q4), a chi-square test was performed to compare the differences between the observed and expected distributions. Statistical significance was set at $p < .05$. Statistical analysis of the four grouped competitions was performed. All analyses have been performed accepting a sample distribution of 25% for each quarter (Yague et al., 2018). The odds ratio was calculated for the different quarters to evaluate potential differences in the distribution of dates between subgroups, with Q4 as a reference. A higher odds ratio value indicates a greater probability of members of this group belonging to this category than the reference group.

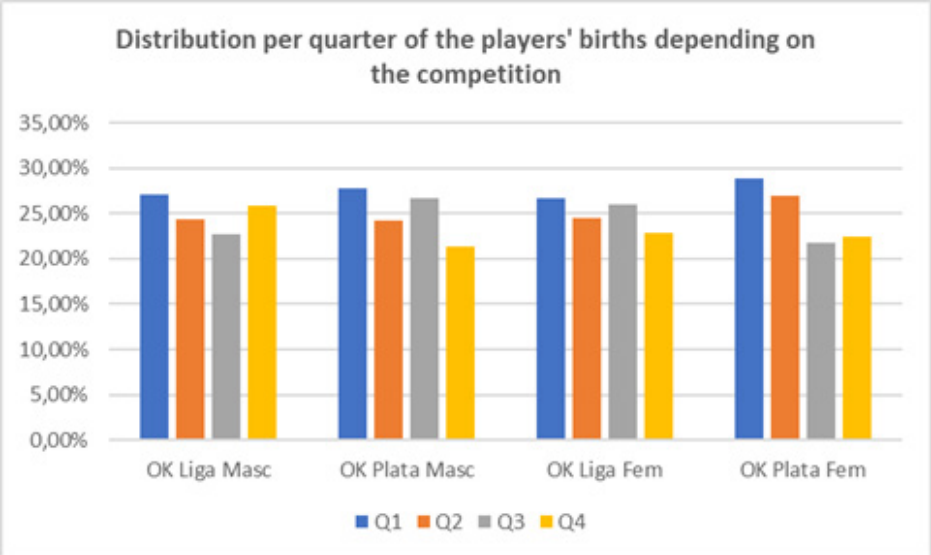
Results

The sample comparison does not show significantly different distributions in the births' quarters in relation to the expected uniform distribution (Table 3 and Figure 1), so no RAE is observed in the top national RH competitions. Despite this lack of significance, there is a percentage greater than 25% of births in Q1 in all competitions. The comparison between groups shows in practically all cases odds ratio values very close to 1, and it can be established that there is no effect with practical significance of the RAE in any of the categories or quartiles compared (Table 3).

Table 3
Frequency distribution and percentages of player distribution per quarter depending on the competition

	Number and y % of players per trimester							Odds ratio (CI 95%)		
Competition	Q1	Q2	Q3	Q4	Total	χ^2	p	Q1-Q4	Q2-Q4	Q3-Q4
OK Liga Masc	49 (27.1%)	44 (24.3%)	41 (22.7%)	47 (25.9%)	181	0.812	.817	1.04 (0.53-2.04)	.94 (0.47-1.87)	.87 (0.43-1.76)
OK Plata Masc	88 (27.8%)	77 (24.2%)	85 (26.7%)	68 (21.4%)	318	3.031	.387	1.29 (0.68-2,47)	1.13 (0.51-2.21)	1.25 (0.65-2.41)
OK Liga Fem	49 (26.7%)	45 (24.5%)	48 (26%)	42 (22.8%)	184	0.652	.884	1.17 (0.58-2.34)	1.07 (0.53-2.18)	1.14 (0.57-2.33)
OK Plata Fem	50 (28.8%)	47 (27%)	38 (21.8%)	39 (22.4%)	174	2.414	.491	1.28 (0.64-2.56)	1.21 (0.6-2.43)	.97 (0.46-2.04)
Total	236 (27.5%)	213 (24.8%)	212 (24.7%)	196 (22.8%)	857					

Figure 1
Chart showing the percentage distribution of players by birth quarter



Detailed analyses of the variables in the top competition of Spanish RH: player position, nationality, final team classification, individual performance (goals scored), and international status confirm the non-existence of RAE in Spanish RH, as homogeneous distributions of athletes are observed in the four quarters of birth (Table 4). A detailed analysis of the different distributions by quarter allows us to observe a tendency towards a greater number of athletes in Q1, even though this has not presented statistically significant differences in the distributions. The comparison between groups again shows, in practically all cases, odds ratio values close to 1, and it can be established that there is no effect on the practical significance of the RAE in any of the categories or quartiles compared (Table 4).

Table 4

*Distribution, frequency and percentage of the distribution of players per quarter based on the player position, the nationality of the athletes, the final team classification, the individual performance of the players and the international player status * in the four top national competitions of Spanish RH*

		Number and % of player per trimester							Odds ratio (CI 95%)		
		Q1	Q2	Q3	Q4	Total	χ^2	*p*	Q1-Q4	Q2-Q4	Q3-Q4
Player's position	Goalkeeper	47 (25.8%)	47 (25.8%)	38 (20.8%)	50 (27.55)	182	1.780	.619	.94 (0.48-1.83)	,94 (0.48-1,.3)	.76 (0.37-1.54)
	Forward / defender	189 (28%)	166 (24.6%)	174 (25.8%)	146 (21.6%)	675	5.705	.127	1.29 (0.71-2.36)	1.14 (0.61-2.11)	1.19 (0.65-2.20)
Nationality	Spanish	219 (27.8%)	192 (24.4%)	197 (25%)	179 (22.8%)	787	4.233	.237	1.22 (0.68-2.20)	1.07 (0.58-1.97)	1.10 (0.60-2.01)
	Foreign	17 (24.2%)	21 (30%)	15 (21.4%)	17 (24.3%)	70	1.086	.781	1 (0.42-2.40)	1.24 (0.54-2.84)	.88 (0.36-2.18)
Final team classification	G1	70 (30%)	53 (22.7%)	60 (25.7%)	50 (21.4%)	233	4.064	.255	1.40 (0.72-2.72)	1.06 (0.52-2.15)	1.20 (0.60-2.38)
	G2	57 (25.4%)	60 (26.9%)	56 (25%)	51 (22.8%)	224	0.750	.861	1.12 (0.57-2.21)	1.18 (0.60-2.30)	1.10 (0.55-2.17)
	G3	52 (25.2%)	55 (26.7%)	49 (23.8%)	50 (24.3%)	206	0.408	.939	1.04 (0.53-2.05)	1.10 (0.56-2.15)	.98 (0.49-1.95)
	G4	57 (29.5%)	45 (23.3%)	46 (23.8%)	45 (23.3%)	193	2.130	.546	1.27 (0.65-2.47)	1 (0.49-2.03)	1.02 (0.51-2.07)
Individual performance of the players	Top scorer	26 (28.9%)	14 (15.5%)	30 (33.3%)	20 (22.2%)	90	6.533	.088	1.30 (0.58-2.90)	.75 (0.30-1.91)	1.50 (0.69-3.27)
	Non top scorer	212 (27.3%)	202 (26%)	184 (23.7%)	178 (22.9%)	776	3.835	.280	1.19 (0.66-2.15)	1.13 (0.62-2.06)	1.03 (0.56-1.90)
International player status *	Internacional	20 (29.5%)	14 (20.9%)	18 (26.8%)	15 (22.4%)	67	1.358	.715	1.33 (0.56-3.17)	.93 (0.36-2.39)	1.20 (0.49-2.91)
	Non international	80 (26.4%)	75 (24.8%)	73 (24.2%)	74 (24.5%)	302	0.384	.944	1.08 (0.57-2.04)	1.01 (0.53-1.93)	.99 (0.52-1.89)

Note: * Analyzed in the highest national category for men (OK Liga Masculine) and women (OK Liga Female).

Discussion

The main objective of this study was to identify the existence of the RAE in the top-tier Spanish men's and women's RH teams. The results obtained allow us to affirm the non-existence of the RAE neither in the top national competitions nor in any of the variables analyzed in the athletes: track position, nationality, the final team classification of the teams, individual performance (goals scored,) and international status. The novelty of this research and the limited number of studies for RAE in RH requires comparing our results with other sports.

The main result of our research has been that no RAE effect was observed in any of the top national RH competitions in Spain, which has also been evidenced in the top national competitions of other sports (Cobley et al., 2009; De la Rubia et al., 2020; Smith et al., 2018).

Our results in top-level RH are similar to those of Doncaster et al. (2020) who also found no RAE effect in a top-tier Spanish RH club. The absence of RAE in in RH may be due to multiple factors, one of t which is the sport's high technical complexity (Trabal, 2016) meaning that athletes' and teams' performance is not exclusively dependent on physical abilities but rather on a complex response that integrates various skills and abilities (Trabal, Daza, & Arboix-Alió, 2020; Trabal, Daza,

& Riera, 2020). This phenomenon has been observed in other sports, where, when technical and tactical demands are predominant, RAE is either not identified or a reverse RAE is observed, with an overrepresentation of athletes born later in the year (Delorme & Raspaud, 2009). It is possible that in the talent identification process, RH coaches and experts, who are aware of these individual characteristics related to performance, do not favor players who may initially stand out solely due to their greater physical development, which can be advantageous in the early stages of training (Larkin & O'Connor, 2017). This differs from talent identification in other sports where anthropometric characteristics can play a more prominent role (Lovell et al., 2015).

Another possible explanation is related to the popularity of the sport. RH is not one of the most popular sports in Spain, and this lack of interest translates into a lower number of federation licenses compared to other more popular sports with higher participation and viewership, particularly in female RH (Consejo Superior de Deportes, 2023). The greater the popularity and practice of a sport, the greater the number of practitioners and, consequently, an increase in competitiveness to be part of the main teams and competitions, directly related to the appearance of the RAE (Doncaster et al., 2020).

The initiation process in RH in Spain is characterized by early hyper-specialization, with athletes starting the sport at ages ranging from three to five years. We believe this factor directly influences RAE because, prior to talent identification, there is an extended period for developing technical skills, allowing young athletes to compensate for physical limitations.

RAE and Gender

Neither the male nor female competitions showed an RAE effect. Regarding female RH, our results follow a general trend in the relationship between RAE and gender since the latter is less present and has a smaller impact in women's sports (Figueiredo et al., 2021; Helsen et al., 2005; Sierra-Díaz et al., 2017; Smith et al., 2018) or is even non-existent (Orozco et al., 2022; Smith et al., 2018; Vincent & Glamser, 2006). Despite the limited scientific evidence in female RH (Arboix-Alió et al., 2023), the lower influence of physical attributes on performance, combined with the smaller numberof girls participating in the sport, may reduce the level of competition for reaching the elite level, a fact also observed in other sports (Vincent & Glamser, 2006). This may help explain the absence of RAE when analyzedby gender. In Catalonia, the region of Spain with the most RH licenses, 76% of these are processed to boys and 24% to girls (Consejo Superior de Deportes, 2023).

RAE and Player Position

Our research has also focused on the study of variables that are likely to be influenced by the RAE playing position, nationality, team ranking, individual performance measured by goals scored, and international player status. Regarding the playing position, several sports have shown the existence of the RAE about the player position or court of the athletes, although no conclusive results are determining which positions are most affected in these sports: goalkeepers (Ferragut et al., 2021), goalkeepers, midfielders and defenders (Lesma et al., 2011), defenders and forwards (Lago-Fuentes et al., 2019; Prieto et al., 2015; Salinero et al., 2013), or the absence of RAE (Salim de Souza et al., 2020). One reason that may explain the lack of influence in RH could be the less pronounced differences in the physical condition of the athletes, depending on the role and the technical and tactical complexity required in all positions. Studies in RH have only shown differences in physical demands between goalkeepers and outfield players, and between outside and inside players, with inside players, who have a more static role near the opposing goal, representing less than 20% of the team's positions (Fernández et al., 2023; Trabal, 2016). Another possible explanation is the limited specialization in positions in RH, except for goalkeepers and a few specific inside players or defenders, who tend to hold these defensive positions more consistently. For this reason, no role differences are observed among outfield players, who take on various roles and positions within the same match, a concept known as "universal" or "mixed" players in this sport. Even in the case of goalkeepers, who exhibit clear differences in their physical demands (Trabal, Daza, & Arboix-Alió, 2020), no effect of the RAE has been observed either, results in line with other research (De la Rubia et al., 2021; Prieto et al., 2015; Salim de Souza et al., 2020; Salinero et al., 2013; Yague et al., 2018).

RAE and Nationality

Regarding the nationality of the athletes, we have not observed any difference in the influence of the RAE on this variable. Our results are in line with existing research that does not show significant RAE differences based on the origin of the athletes (Lesma et al., 2011; Orozco et al., 2022; Sánchez-Rodríguez et al., 2012). The lack of an effect based on nationality may be explained by the fact that the requirements for participation in Spain's top national competitions are the same for all athletes, regardless of nationality, even though the recruitment of foreign players is uncommon due to the high costs involved. RH clubs usually recruit foreign players only when they are exceptionally skilled and can make a significant impact, which is not a frequent occurrence in Spain's national competitions.

RAE and Individual Performance

The individual performance variable, analyzed through goals scored, has not shown any effect of the RAE either, a finding that contrasts with results from the top ice hockey competition (NHL), where an inverse RAE (underdog effect) has been

observed, with Q4-born players scoring more goals (Fumarco et al., 2017). This effect is justified by the fact that these athletes born in Q4 and who have reached elite competitions have had to overcome greater adversity, which has favored their development and learning. In RH, the top scorers tend to be the forward players, and as has been observed, there is no RAE by playing position to differentiate these players from the rest.

RAE and International Player Status and Final Team Classification

The last two variables analyzed and those that have not observed an effect of the RAE on the RH are team ranking and the international player status. These results align with those observed by Fonseca et al. (2019) in handball and the international status of the player, with results opposite to those observed by Ferragut et al. (2021) who showed an RAE in high-level female handball players on national teams. The absence of RAE in both variables may be due to the same argument previously presented regarding the inherent characteristics of RH, which require athletes whose physical condition is important but also integrated with other skills and abilities, a factor that may reduce the influence of RAE compared to talent selection in other sports.

Despite these results indicating the absence RAE in this specific context of the Spanish RH, several limitations of this study must be acknowledged. First, the sample was focused only on top-level competitions, possibly excluding other categories where RAE might be more pronounced. Furthermore, the analysis was limited to a single season and the evolution of RAE over time was not considered. To further understand RAE in RH, other dimensions and variables such as the relationship between previous experience in lower categories and performance at the top level, could be explored. Moreover, extending this type of research to other geographic regions and age categories would help determine the generalizability of the results and provide a better understanding of RAE dynamics in RH globally. Finally, it would be interesting to analyze the influence of RAE in relation to the physical demands and conditional requirements of RH, particularly considering the high intensity of the sport.

Conclusions

This research shows that there is no RAE in Spanish national RH competitions in any of the variables studied: playing position, athlete nationality, competition, team ranking, individual performance (goals scored), and international player status. This research allows us to lay the foundations on which RAE research in RH can evolve and and provides valuable data for federations and organizations responsible for structuring and organizing national RH, as the current competitive structure and talent identification process do not discriminate players based on their birth date.

Ethics Committee Statement

It has not been necessary due to the public nature of the data.

Conflict of Interest Statement

We declare that there is no conflict of interest, including any personal situation or interest that may be perceived as influencing the presentation or interpretation of the results.

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Authors' Contribution

Conceptualization Guillem Trabal, Vasco Vaz, Hugo Sarmento & Jordi Arboix-Alió; Methodology Guillem Trabal, Jordi Arboix-Alió & Javier Peña.; Software Guillem Trabal; Validation Vasco Vaz & Hugo Sarmento; Formal Analysis Guillem Trabal & Javier Peña; Investigation Guillem Trabal & Jordi Arboix-Alió; Resources Guillem Trabal & Dani Moreno; Data Curation Javier Peña & Hugo Sarmento; Writing – Original Draft Guillem Trabal & Jordi Arboix-Alió; Writing – Review & Editing Hugo Sarmento, Vasco Vaz & Javier Peña; Visualization Dani Moreno & Guillem Trabal.; Supervision Hugo Sarmento & Guillem Trabal.; Project Administration Guillem Trabal. All authors have read and agree with the published version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding autor (guillem.trabal@uvic.cat).

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El Efecto de la Edad Relativa en el Hockey Patines de Alto Nivel en España

The Relative age Effect in Spanish High-Level Rink Hockey

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Resumen

La influencia de la distribución de los nacimientos de los deportistas en los diferentes períodos del año sobre el rendimiento deportivo se llama efecto de la edad relativa. La presente investigación tiene como objetivo identificar el efecto de la edad relativa en las máximas competiciones nacionales masculinas y femeninas de hockey patines en España, así como valorar este efecto sobre las variables: competición, género, posición en pista, nacionalidad, clasificación del equipo, rendimiento individual (goles marcados) y condición de jugador internacional. Se analiza la edad relativa de deportistas de la primera y segunda máxima competición nacional española masculina (n = 499) y femenina (n = 358) en la temporada 2022-23. Los resultados revelan la no existencia de efecto de la edad relativa en ninguna de las variables analizadas, mostrando independencia de esta variable del género y el nivel competitivo. La naturaleza del deporte, su organización y la estructura competitiva diseñada en el hockey patines muestra que en este deporte los deportistas que obtienen mayor rendimiento no han sido seleccionados teniendo en cuenta criterios madurativos de tipo biológico.

Palabras Clave: Edad relativa, hockey sobre patines, identificación de talento, rendimiento deportivo.

Abstract

The influence of athletes' birth distribution across different year periods on sports performance is called the relative age effect. The present research aims to identify this bias in the top male and female national rink hockey competitions in Spain, as well as to assess this effect on variables such as level of competition, gender playing position, nationality, team standings, individual performance (goals scored), and international player status. The relative age of athletes in the first and second top Spanish national male (n = 499) and female (n = 358) competitions in the 2022-23 season was analysed. The results reveal the absence of a relative age effect in any of the analysed variables, indicating the independence of this variable from gender and competitive level. The nature of the sport, its organization, and the competitive structure designed in rink hockey indicate that athletes achieving higher performance were not selected based on biological maturation criteria.

Keywords: Relative age, roller hockey, talent identification, sports performance.

Introducción

Con el objetivo de ordenar y equilibrar las competiciones formativas de hockey patines (HP), en España se estructuran y dividen las categorías atendiendo a la edad de nacimiento de los deportistas, habitualmente por categorías que incluyen dos años diferentes y consecutivos de nacimiento. A pesar de esta estructuración por edades próximas con la voluntad de agrupar a deportistas con similares capacidades y habilidades, existen unas condiciones de desigualdad que influyen sobre el rendimiento y la participación de los deportistas que se describe con el concepto del efecto de la edad relativa (RAE) (Barnsley et al., 1992). El concepto del RAE en el ámbito deportivo está descrito como la ventaja en el rendimiento de los deportistas nacidos a principios de año, con posterioridad a la fecha de corte de la estructura de las categorías organizadas por edades (Barnsley et al., 1985; Lovell et al., 2015). Este RAE se traduce en una mayor presencia de deportistas nacidos en los primeros trimestres del año respecto a los nacidos a final de año en los equipos y categorías vinculadas al rendimiento (Barnsley et al., 1985; Prieto et al., 2015; Rodríguez-Lorenzo & Martín-Acero, 2019).

La distribución por edades del reglamento deportivo genera efectos positivos y negativos sobre las posibilidades de éxito, siendo beneficiados los nacidos a principios de año y viceversa. Los nacidos a principios de año, durante su etapa formativa, están más predispuestos a presentar un mayor desarrollo físico y cognitivo que se traduce en un mejor rendimiento inmediato, facilitando que sean identificados desde un inicio como más talentosos y haciendo que su trayectoria deportiva tenga mejores experiencias y situaciones de aprendizaje, generando unas condiciones de práctica que aumentan la posibilidad de obtener un mayor rendimiento respecto a los nacidos a final de año (Delorme & Raspaud, 2009; Helsen et al., 1998; Yague et al., 2018). Los jugadores con desarrollo más tardío son habitualmente descartados en los procesos de selección de talentos. Incluso, en algunos casos, ocasionando que abandonen la práctica deportiva por la falta de competencia observada y la baja autoconfianza (Helsen et al., 1998; Thompson et al., 2004). El contexto de práctica y de competición que se genera y que enmarca la práctica deportiva de los jóvenes determina que se generen unas relaciones adecuadas y propicias entre deportista y un ambiente que condiciona y determina el rendimiento, como puede ser obtener refuerzos externos de padres y entrenadores positivos y de mayor calidad (Helsen et al., 2005) y disponer de mayor volumen de entrenamiento y de competición (Barnsley et al., 1992; Helsen et al., 1998, 2005). Pese a un acuerdo generalizado, esta última causa del RAE no está evidenciada en todas las situaciones y disciplinas, y autores como Sæther (2016) no han encontrado relación entre el tiempo de participación en competición en etapas formativas y su rendimiento final en deportes como fútbol.

Los diferentes estudios que han abordado el RAE confirman que este impacto está presente en diversidad de deportes atendiendo a características y exigencias diversas (Cobley et al., 2009; De la Rubia et al., 2020), y es más acusado en categorías inferiores, decreciendo a medida que aumenta la edad de los deportistas y el nivel cualitativo y competitivo de la competición (Cobley et al., 2009; Doncaster et al., 2020; Rodríguez-Lorenzo & Martín-Acero, 2019; Sierra-Díaz et al., 2017). La etapa de la adolescencia es la que genera las condiciones más adecuadas para que el RAE sea más significativo debido a las diferencias en el desarrollo físico y cognitivo de los deportistas (Cobley et al., 2009).

A pesar de las evidencias de la presencia generalizada del RAE en diferentes deportes y competiciones de máximo nivel, también se ha observado la situación contraria en la que no existe el RAE e incluso, con la presencia de un RAE inverso con mayor cantidad de deportistas nacidos a final de año. Este RAE inverso, especialmente en categorías no formativas, es consecuencia de las adversidades que los deportistas nacidos a final de año han confrontado en el transcurso de su formación y desarrollo. En muchos casos, su desarrollo ha sido un obstáculo en etapas formativas iniciales y su capacidad de resiliencia los ha convertido en deportistas con mayor capacidad de rendir a largo plazo (Cobley et al., 2009; Lago-Fuentes et al., 2019).

Una revisión exhaustiva de los antecedentes permite observar una gran cantidad de variables contextuales y personales asociadas al RAE: a) la posición y el rol del deportista (De la Rubia et al., 2021; Prieto et al., 2015; Sierra-Díaz et al., 2017; Yague et al., 2018), b) el nivel del club y de la competición (Cobley et al., 2009; Salinero et al., 2013) c) la competencia para ser elegido, siendo los equipos que tienen mayor cantidad de deportistas a elegir los que incluyen mayor de ellos de principio de año (Lesma et al., 2011), d) la popularidad del deporte (Cobley et al., 2009; Doncaster et al., 2020), e) el país de la competición (Sierra-Díaz et al., 2017) y la nacionalidad de los deportistas, sin mostrar resultado concluyentes y afirmando que el RAE puede generarse en diversidad de países de procedencia de los deportistas (Lesma et al., 2011; Sánchez-Rodríguez et al., 2012), f) las características del deporte, demostrándose en los deportes en los que las capacidades físicas de los sujetos no son tan determinantes en el rendimiento, el RAE puede llegar a no ser identificado (Sierra-Díaz et al., 2017), e incluso, aparecer un RAE inverso, con sobrerrepresentación de deportistas de fin de año cuando las características técnicas del sujeto son demandadas por encima de las capacidades físicas (Delorme & Raspaud, 2009; Fumarco et al., 2017), g) el género de los deportistas, con RAE menos frecuente y menos investigado en el deporte femenino (Helsen et al., 2005; Sierra-Díaz et al., 2017; Vincent & Glamser, 2006), h) características del lugar de nacimiento tales como la cantidad de habitantes de la ciudad o país de nacimiento (Ribeiro-Junior et al., 2023; Sierra-Díaz et al., 2017), i) el rendimiento de los equipos y depor-

tistas o las características de acciones o rendimiento individual por partido (De la Rubia et al., 2021; Fumarco et al., 2017), j) los ingresos económicos de los deportistas (Fumarco et al., 2017) y k) las diferentes etapas y edades de los deportistas (Doncaster et al., 2020).

En España el RAE lleva años siendo investigado y demostrando su impacto en diferentes deportes (De la Rubia et al., 2021; Lesma et al., 2011; Rodríguez-Lorenzo & Martín-Acero, 2019; Salinero et al., 2013; Sánchez-Rodríguez et al., 2012; Sierra-Díaz et al., 2017; Yague et al., 2018). En HP, y dentro de nuestro conocimiento, únicamente se ha encontrado una sola investigación que haya estudiado la influencia del RAE. En esta se analizan el equipo profesional y todas las categorías de formación del FC Barcelona (España) (Doncaster et al., 2020) observándose una mayor presencia de jugadores nacidos a inicio de año en todas las categorías formativas del club, y de forma significativa en sub-14 y sub-16. En el equipo sénior y profesional de la sección esta influencia ya no está presente.

Por el enorme interés que el HP ha despertado en los últimos años en el ámbito de la investigación (Arboix-Alió et al., 2023; Fernández et al., 2023; Ferraz et al., 2024), y por la falta de estudios del efecto del RAE en las máximas competiciones nacionales masculinas y femeninas de este deporte, el objetivo de esta investigación es identificar la influencia del RAE en los equipos masculinos y femeninos de la máxima categoría española de 'HP en función de: a) nivel competitivo de los equipos; b) posición en la pista; c) clasificación final de los equipos; d) nacionalidad de los deportistas; e) rendimiento individual (goles marcados) y f) condición de jugador internacional.

Material y Métodos

Participantes

La muestra estuvo formada por todos los participantes de las dos máximas competiciones masculinas y femeninas de HP en España en la temporada 2022-23 (n = 857): OK Liga Masculina (14 equipos), OK Liga Plata Masculina (24 equipos), OK Liga Femenina (14 equipos) y OK Liga Plata Femenina (14 equipos) (Tabla 1). La selección de la muestra fue por conveniencia para tener como referencia el mejor campeonato nacional femenino y el segundo mejor campeonato masculino del mundo (Arboix-Alió et al., 2023).

Tabla 1
Distribución de la muestra por categoría y género

Competición	Masculina	Femenina	Total
OK Liga Masculina (1a categoría)	n = 181		
OK Liga Plata Masculina (2a categoría)	n = 318		
OK Liga Femenina (1a categoría)		n = 184	
OK Liga Plata Femenina (2a categoría)		n = 174	
Total	n = 499	n = 358	n = 857

Instrumentos

El instrumento de observación estaba formado por las variables: trimestre del año de nacimiento, posición en pista, nacionalidad del deportista, competición, clasificación final del equipo, rendimiento individual (goles marcados) y condición de jugador internacional (Tabla 2). El instrumento de registro fue creado mediante una tabla de Excel con cada una de las variables.

Procedimiento

Los datos fueron aportados por la Real Federación Española de Patinaje, propietaria de la competición y encargada de incorporar las licencias de todos los participantes en la misma. La propia Federación dio permiso por escrito para utilizar estos datos que son públicos y disponibles en su portal web.

Análisis Estadístico

Para realizar el análisis estadístico se utilizó el paquete estadístico SPSS v29.0. Se obtuvieron frecuencias y porcentajes de las distintas variables. Para analizar la homogeneidad de la distribución a través de los cuatro trimestres (Q1, Q2, Q3 y Q4) se realizó una prueba de chi cuadrado para comparar las diferencias entre las distribuciones observadas y esperadas. Se estableció la significación estadística en $p < .05$. Se realizó el análisis estadístico de las cuatro competiciones agrupadas. Todos los análisis se han realizado aceptando una distribución de la muestra del 25% por cada trimestre (Yague et al., 2018). Para evaluar las diferencias potenciales en la distribución de las fechas entre subgrupos, se calculó la odds ratio por

los distintos trimestres, con el Q4 como referencia. Un valor de odds ratio más alto indica que una mayor probabilidad de miembros de este grupo pertenezca a esta categoría en comparación con el grupo de referencia.

Tabla 2
Descripción de les variables analizadas

Variable	Categoría y descripción
Trimestre del año de nacimiento	Q1: nacidos primer trimestre
	Q2: nacidos segundo trimestre
	Q3: nacidos tercero trimestre
	Q4: nacidos cuarto trimestre
Posición a la pista	Portero
	Jugador de pista
Nacionalidad	Española
	Extranjera
Internacionalidad[a]	Internacional absoluto con la selección nacional
	No internacional absoluto con la selección nacional
Competición	OK Liga Masculina
	OK Liga Plata Masculina
	OK Liga Femenina
	OK Liga Plata Femenina
Clasificación final del equipo	G1: 1o a 4o clasificado
	G2: 5o a 8o clasificado
	G3: 9o a 11o clasificado
	G4: 12o a 14o clasificado
Rendimiento individual (goles marcados)	Primeros 20 máximos goleadores de la competición
	No 20 máximos goleadores de la competición

Nota: a La variable internacional absoluto únicamente ha estado analizada en la máxima categoría nacional masculina y femenina: OK Liga Masculina y OK Liga Femenina.

Resultados

La comparación de la muestra no presenta distribuciones en los trimestres de nacimientos significativamente diferentes en relación con la distribución uniforme esperada (Tabla 3 y Figura 1) por lo que en las máximas competiciones nacionales de hockey patines no se observa RAE. A pesar de esta falta de significación, sí que existe un porcentaje superior al 25% de nacidos en el Q1 en todas las competiciones. La comparación entre grupos muestra en prácticamente todos los casos valores de odds ratio muy cercanos a 1, pudiendo establecerse que no existe un efecto con significación práctica del RAE en ninguna de las categorías ni cuartiles comparados (Tabla 3).

Tabla 3
Distribución frecuencia y porcentajes de la distribución de jugadores por trimestre en función de la competición

	Nombre y % de jugadores por trimestre							Odds ratio (*CI* 95%)		
Competición	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**χ^2**	***p***	**Q1-Q4**	**Q2-Q4**	**Q3-Q4**
OK Liga Masc	49 (27.1%)	44 (24.3%)	41 (22.7%)	47 (25.9%)	181	0.812	.817	1.04 (0.53-2.04)	.94 (0.47-1.87)	.87 (0.43-1.76)
OK Plata Masc	88 (27.8%)	77 (24.2%)	85 (26.7%)	68 (21.4%)	318	3.031	.387	1.29 (0.68-2,47)	1.13 (0.51-2.21)	1.25 (0.65-2.41)
OK Liga Fem	49 (26.7%)	45 (24.5%)	48 (26%)	42 (22.8%)	184	0.652	.884	1.17 (0.58-2.34)	1.07 (0.53-2.18)	1.14 (0.57-2.33)
OK Plata Fem	50 (28.8%)	47 (27%)	38 (21.8%)	39 (22.4%)	174	2.414	.491	1.28 (0.64-2.56)	1.21 (0.6-2.43)	.97 (0.46-2.04)
Total	236 (27.5%)	213 (24.8%)	212 (24.7%)	196 (22.8%)	857					

Figura 1
Gráfica con la distribución porcentual de jugadores por trimestre de nacimiento

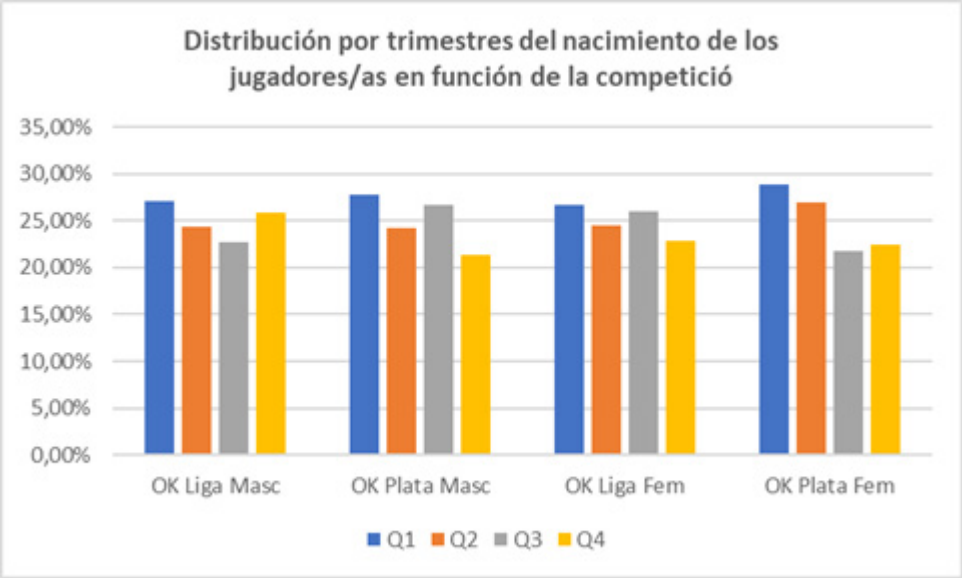

Tabla 4
Distribución, frecuencia y porcentaje de la distribución de jugadores por trimestre en función de la posición en la pista, la nacionalidad de los deportistas, la clasificación final de los equipos, el rendimiento individual de los jugadores y la condición de internacional de los jugadores en las cuatro máximas competiciones nacionales de hockey patines español*

		Nombre y % de jugadores por trimestre							Odds ratio (*CI* 95%)		
		Q1	Q2	Q3	Q4	Total	χ^2	*p*	Q1-Q4	Q2-Q4	Q3-Q4
Posición en la pista	Portero	47 (25.8%)	47 (25.8%)	38 (20.8%)	50 (27.55)	182	1.780	.619	.94 (0.48-1.83)	,94 (0.48-1,.3)	.76 (0.37-1.54)
	Jugador de pista	189 (28%)	166 (24.6%)	174 (25.8%)	146 (21.6%)	675	5.705	.127	1.29 (0.71-2.36)	1.14 (0.61-2.11)	1.19 (0.65-2.20)
Nacionalidad	Española	219 (27.8%)	192 (24.4%)	197 (25%)	179 (22.8%)	787	4.233	.237	1.22 (0.68-2.20)	1.07 (0.58-1.97)	1.10 (0.60-2.01)
	Extranjera	17 (24.2%)	21 (30%)	15 (21.4%)	17 (24.3%)	70	1.086	.781	1 (0.42-2.40)	1.24 (0.54-2.84)	.88 (0.36-2.18)
Clasificación final de los equipos	G1	70 (30%)	53 (22.7%)	60 (25.7%)	50 (21.4%)	233	4.064	.255	1.40 (0.72-2.72)	1.06 (0.52-2.15)	1.20 (0.60-2.38)
	G2	57 (25.4%)	60 (26.9%)	56 (25%)	51 (22.8%)	224	0.750	.861	1.12 (0.57-2.21)	1.18 (0.60-2.30)	1.10 (0.55-2.17)
	G3	52 (25.2%)	55 (26.7%)	49 (23.8%)	50 (24.3%)	206	0.408	.939	1.04 (0.53-2.05)	1.10 (0.56-2.15)	.98 (0.49-1.95)
	G4	57 (29.5%)	45 (23.3%)	46 (23.8%)	45 (23.3%)	193	2.130	.546	1.27 (0.65-2.47)	1 (0.49-2.03)	1.02 (0.51-2.07)
Rendimiento individual de los jugadores	Máximo goleador	26 (28.9%)	14 (15.5%)	30 (33.3%)	20 (22.2%)	90	6.533	.088	1.30 (0.58-2.90)	.75 (0.30-1.91)	1.50 (0.69-3.27)
	No Máximo goleador	212 (27.3%)	202 (26%)	184 (23.7%)	178 (22.9%)	776	3.835	.280	1.19 (0.66-2.15)	1.13 (0.62-2.06)	1.03 (0.56-1.90)
Internacional[a]	Internacional absoluto	20 (29.5%)	14 (20.9%)	18 (26.8%)	15 (22.4%)	67	1.358	.715	1.33 (0.56-3.17)	.93 (0.36-2.39)	1.20 (0.49-2.91)
	No internacional absoluto	80 (26.4%)	75 (24.8%)	73 (24.2%)	74 (24.5%)	302	0.384	.944	1.08 (0.57-2.04)	1.01 (0.53-1.93)	.99 (0.52-1.89)

Nota: a Analizado en la máxima categoría nacional masculina (OK Liga Masculina) y femenina (OK Liga Femenina).

Los análisis detallados en el hockey patines español de la máxima competición de las variables: posición en pista, nacionalidad, clasificación final, rendimiento individual (goles marcados) y condición de internacional, confirman la no existencia de RAE en el hockey patines español al observarse distribuciones homogéneas de los deportistas en los cuatro trimestres de nacimiento (Tabla 4). Un análisis detallado de las diferentes distribuciones por trimestres permite observar una tendencia de mayor cantidad de deportistas en el Q1 a pesar de que ésta no haya presentado diferencias estadísticamente significativas en las distribuciones. La comparación entre grupos de nuevo muestra en prácticamente todos los casos valores de odds ratio cercanos a 1, pudiéndose establecer que no existe un efecto con significación práctica del RAE en ninguna de las categorías ni cuartiles comparados (Tabla 4).

Discusión

El principal objetivo de este estudio fue identificar la existencia del RAE en los equipos de la máxima categoría española de HP masculino y femenino. Los resultados obtenidos permiten afirmar la no existencia del RAE ni en las máximas competiciones nacionales ni en ninguna de las variables analizadas en los deportistas: la posición de pista, la nacionalidad, la clasificación final de los equipos, el rendimiento individual (goles marcados) y la condición de internacional. La novedad de esta investigación y la limitada cantidad de búsquedas de RAE en HP exige comparar nuestros resultados respecto a otros deportes.

El principal resultado de nuestra investigación ha sido que no se observa efecto del RAE en ninguna de las máximas competiciones nacionales de HP en España, algo que también ha sido evidenciado en las máximas competiciones nacionales de otras disciplinas (Cobley et al., 2009; De la Rubia et al., 2020; Smith et al., 2018).

Nuestros resultados en el HP de máximo nivel son similares a los de Doncaster et al. (2020) que tampoco encontró efecto del RAE en un club de HP de la máxima categoría nacional española. El no efecto del RAE en el HP puede deberse a múltiples causas, siendo una de ellas la gran complejidad técnica de este deporte (Trabal, 2016) que determina que el rendimiento de los deportistas y equipos no está exclusivamente supeditado a las capacidades físicas y es dependiente de una respuesta compleja, integrando diferentes habilidades y capacidades (Trabal, Daza, & Arboix-Alió, 2020; Trabal, Daza, & Riera, 2020). Este hecho se ha observado en otros deportes cuando las exigencias técnicas y tácticas tienen gran preponderancia, el RAE no ha sido identificado o, incluso, se ha observado un RAE inverso, con sobrerrepresentación de deportistas de final de año (Delorme & Raspaud, 2009). Puede darse el caso de que en el proceso de detección de talentos, los entrenadores y los expertos en HP que son conocedores de estas características individuales asociadas al rendimiento, no contemplen la selección de aquellos jugadores que pueden destacar en unos inicios como consecuencia exclusiva de su mayor desarrollo físico y que les puede favorecer en las primeras etapas formativas (Larkin & O'Connor, 2017), a diferencias de la detección de talentos observadas en otros deportes cuyas características antropométricas pueden tener un papel destacado (Lovell et al., 2015).

Otra posible explicación está relacionada con la popularidad del deporte. El HP no es de los deportes con mayor popularidad en España, traduciéndose esta carencia de interés con una menor cantidad de licencias federativas en comparación con otros deportes más populares y de mayor práctica y seguimiento, especialmente acentuado en el HP femenino (Consejo Superior de Deportes, 2023). A mayor popularidad y práctica de un deporte implica mayor cantidad de practicantes y consiguientemente, un aumento de la competitividad por formar parte de los principales equipos y competiciones que se relaciona directamente con la aparición del RAE (Doncaster et al., 2020).

El proceso de iniciación en el HP en España se caracteriza por una hiperespecialización temprana que implica que el inicio en este deporte a edades oscila entre los tres y los cinco años. Creemos que este factor tiene una influencia directa sobre el RAE ya que previamente a la detección de talentos existe un amplio período de aprendizaje de las habilidades técnicas del deporte que favorece poder compensar las limitaciones en las capacidades físicas que puedan presentar los jóvenes deportistas.

RAE y Género

Ambas competiciones, masculinas y femeninas, no han mostrado ese efecto. Atendiendo al HP femenino, nuestros resultados siguen una tendencia generalizada en la relación RAE y género ya que este está menos presente y con menor impacto en el deporte femenino (Figueiredo et al., 2021; Helsen et al., 2005; Sierra-Díaz et al., 2017; Smith et al., 2018) o inexistente (Orozco et al., 2022; Smith et al., 2018; Vincent & Glamser, 2006). Pese a la poca evidencia científica en el HP femenino (Arboix-Alió et al., 2023), la menor influencia de las características físicas sobre el rendimiento, junto con una menor cantidad de chicas que practican este deporte, puede disminuir la competitividad para alcanzar el alto nivel, un hecho también observado en otros deportes (Vincent & Glamser, 2006). Esto puede ayudar a explicar el porqué de este no RAE analizando por género. En Cataluña, región de España con más licencias federativas en el HP, un 76% de éstas son tramitadas a chicos, y un 24% a chicas (Consejo Superior de Deportes, 2023).

RAE y Posición de Pista

Nuestra investigación también ha concretado el estudio sobre variables que son susceptibles de ser influenciadas por el RAE: la posición en la pista, la nacionalidad de los deportistas, la clasificación final de los equipos, el rendimiento individual medido por los goles marcados y la condición de internacional del jugador. En cuanto a la posición de la pista, varios deportes han evidenciado la existencia del RAE en relación con la posición en el campo o pista de los deportistas, aunque no hay resultados concluyentes determinando qué posiciones son las más afectadas en estos deportes: porteros (Ferragut et al., 2021), porteros, mediocampistas y defensas (Lesma et al., 2011), defensas y delanteros (Lago-Fuentes et al., 2019; Prieto et al., 2015; Salinero et al., 2013), o la no presencia de RAE (Salim de Souza et al., 2020). Una de las razones que puede explicar esta carencia de influencia en el HP puede recaer en diferencias menos acentuadas en la condición física de los deportistas en función del rol y en la complejidad técnica y táctica exigidas en todas y cada una de las posiciones en la pista. Los estudios en HP únicamente han evidenciado diferencias en la condición física y la exigencia condicional entre porteros y jugadores, y entre jugadores exteriores e interiores, siendo los jugadores interiores quienes tienen un rol más estático y cercano al portero rival, pero representando un porcentaje del total de posiciones de juego que no llega al 20% en los equipos (Fernández et al., 2023; Trabal, 2016). Otra causa puede ser la poca especialización que existe en las posiciones en el HP, a excepción de los porteros, y algunos pocos jugadores interiores o algunos defensas exclusivos, que tienden a ocupar estas posiciones muy defensivas de forma más estable. Por este motivo, no se observan diferencias de rol en los jugadores de pista, que adquieren diferentes roles y posiciones en un mismo partido de forma indiferenciada, haciéndose evidente en que existen una gran cantidad de jugadores universales o mixtos, como son llamados en este deporte. En el caso concreto de los porteros, quienes sí presentan diferencias evidentes en sus características condicionales (Trabal, Daza, & Arboix-Alió, 2020), tampoco se ha observado efecto del RAE, unos resultados en consonancia con otras investigaciones (De la Rubia et al., 2021; Prieto et al., 2015; Salim de Souza et al., 2020; Salinero et al., 2013; Yague et al., 2018).

RAE y Nacionalidad

En relación con la nacionalidad de los deportistas, no hemos observado diferencia alguna en la influencia del RAE sobre esta variable. Nuestros resultados están en consonancia con las investigaciones existentes al respecto que no determinan diferencias del RAE sobre el origen de los deportistas (Lesma et al., 2011; Orozco et al., 2022; Sánchez-Rodríguez et al., 2012). La explicación al no efecto según la nacionalidad de los deportistas puede explicarse porque la exigencia para participar en las máximas competiciones nacionales españolas es común a todos los deportistas y no hace diferencias por nacionalidades, a pesar de que la contratación de jugadores extranjeros habitualmente es un hecho poco habitual por el alto coste económico. Los clubs de HP incorporan a jugadores foráneos cuando éstos tienen un nivel destacado y ayudan a marcar diferencias, siendo un hecho poco recurrente en las competiciones nacionales españolas.

RAE y Rendimiento Individual

La variable del rendimiento individual, analizada a través de los goles marcados, tampoco ha evidenciado ningún efecto del RAE, unos resultados contradictorios a los observados en la máxima competición de hockey hielo (NHL) en la que por el contrario se ha observado un RAE inverso (*underdog effect*), siendo los nacidos Q4 los que marcan más goles (Fumarco et al., 2017). Este efecto queda justificado por el hecho de que estos deportistas nacidos en el Q4 y que han acabado llegando a las competiciones de élite han tenido que superar una mayor adversidad y eso ha favorecido su desarrollo y aprendizaje. En el HP, los máximos goleadores tienden a ser los jugadores delanteros, y tal y como se ha podido observar, no existe RAE por posición de pista que ayude a diferenciar a los jugadores que adquieren este rol respecto al resto.

RAE y Rendimiento de los equipos y Condición de Internacional

Las dos últimas variables analizadas y las que tampoco han observado efecto del RAE en el HP son la clasificación final de los equipos, resultados en consonancia con los observados por Fonseca et al. (2019) en balonmano y la condición de internacional del jugador, con resultados opuestos a los observados por Ferragut et al. (2021) los cuales evidenciaron un RAE en las jugadoras de balonmano de alto nivel que forman parte de las selecciones nacionales. La no existencia del RAE en ambas variables creemos que se sustenta sobre el mismo argumento ya presentado de las propias características inherentes del HP, las cuales exigen una tipología de deportista en la que la condición física es demandada pero supeditada o integrada junto con otras habilidades y capacidades, y que pueden escapar de la tendencia de selección de talentos de otros deportes que de forma más fácil puede verse afectada por el RAE.

A pesar de los resultados que indican la inexistencia del RAE en este contexto específico del HP español, es necesario reconocer algunas limitaciones en el presente estudio. En primer lugar, la muestra se centró únicamente en las competiciones de máxima categoría, pudiendo excluir otras categorías en las que el RAE podría ser más pronunciado. Además, el análisis se limitó a una sola temporada y la evolución del RAE a lo largo del tiempo no fue considerada. Para mejorar la comprensión del RAE en el hockey patines, podrían explorarse otras dimensiones y variables como la relación entre la experiencia previa en categorías inferiores y el rendimiento en la máxima categoría. Además, podría

extenderse este tipo de estudios a otras regiones geográficas y categorías de edad para determinar la generalización de los resultados y comprender mejor las dinámicas del RAE en el HP a nivel mundial. Finalmente, la influencia del RAE sería interesante analizarla en relación con las exigencias físicas y demandas condicionales del HP, destacando la alta intensidad de este deporte.

Conclusiones

Los resultados de esta investigación evidencian la no existencia de RAE en las competiciones nacionales españolas de HP en ninguna de las variables estudiadas: posición en la pista, nacionalidad del deportista, competición, clasificación del equipo, rendimiento individual (goles marcados) y condición de jugador internacional. Esta investigación permite poner los fundamentos sobre los que la investigación del RAE en el HP pueda evolucionar y aportan unos datos de gran valor para las Federaciones y entidades encargadas de estructurar y organizar el HP nacionales ya que la actual estructura competitiva y el proceso de detección de talentos no discrimina a los jugadores en función de la fecha de nacimiento.

Declaración del Comité de Ética

No ha sido necesario por el carácter público de los datos.

Conflicto de Intereses

Declaramos que no existe cualquier conflicto de interés, incluyendo cualquier situación personal o interés que pueda ser percibido como una influencia en la presentación o interpretación de los resultados.

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Contribución de los Autores

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Declaración de Disponibilidad de Datos

Datos disponibles bajo demanda al autor de correspondencia (guillem.trabal@uvic.cat).

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The Predictive Role of age, Gender, and Body Mass Index on Motor Proficiency of Preschool Children

El Papel Predictivo de la Edad, el Género y el Índice de Masa Corporal en la Competencia Motora de los Niños en Edad Preescolar

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Abstract

It is expected that basic motor skills will be able to perform correctly at the end of the preschool period. The fundamental motor skills that children masterfully perform will lead them to an active life & will increase their likelihood of participating in physical activity in their lifetime. It is known that motor skills are influenced by many factors such as age, gender, & BMI. The purposes of this study were to determine the motor proficiency level of preschool children & to examine the role of age, gender, & BMI. Participants of this study were 103 preschool children (MAge=61.10±8.75month) from a public preschool of Denizli in Turkey. The Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) was used to assess children's motor proficiency. A multiple linear regression was conducted to test whether the participant's age, gender, & BMI predicted the participant's motor proficiency levels. The results of the study show that all the sub-tests & BOT-2 total scores have significant increases with age. In addition, the results indicated that girls have significantly higher scores than boys on the fine-motor precision, the fine-motor integration, manual dexterity, & BOT-total scores. When the sub-tests, which girls had a higher score, were examined, it can be realized that all are related to fine motor skills. Future studies are needed to determine whether these explanations are to generalize.

Keywords: Motor Proficiency, preschool, age, gender, BMI.

Resumen

Se espera que las habilidades motoras básicas puedan desempeñarse correctamente al finalizar el periodo preescolar. Las habilidades motoras fundamentales que los niños desempeñan con maestría los llevarán a una vida activa y aumentarán su probabilidad de participar en actividades físicas a lo largo de su vida. Se sabe que las habilidades motoras están influenciadas por muchos factores, como la edad, el sexo y el IMC. Los objetivos de este estudio fueron determinar el nivel de competencia motora de los niños en edad preescolar y examinar el papel de la edad, el sexo y el IMC. Los participantes de este estudio fueron 103 niños en edad preescolar (Medad=61,10±8,75meses) de una escuela preescolar pública de Denizli en Turquía. Se utilizó la prueba de competencia motora Bruininks-Oseretsky, segunda edición (BOT-2) para evaluar la competencia motora de los niños. Se realizó una regresión lineal múltiple para probar si la edad, el sexo y el IMC del participante predecían los niveles de competencia motora del participante. Los resultados del estudio muestran que todas las subpruebas y las puntuaciones totales de BOT-2 tienen aumentos significativos con la edad. Además, los resultados indicaron que las niñas tienen puntuaciones significativamente más altas que los niños en precisión motora fina, integración motora fina, destreza manual y puntuaciones totales BOT. Cuando se examinaron las subpruebas en las que las niñas obtuvieron una puntuación más alta, se pudo comprobar que todas están relacionadas con la motricidad fina. Se necesitan estudios futuros para determinar si estas explicaciones deben generalizarse.

Palabras clave: Competencia motora, preescolar, edad, género, IMC

Introduction

A child's motor skill development is important aspects of their growth and maturity. Not only do they contribute to the child's overall physical and cognitive development, but they also foster self-confidence and social interaction. Motor skill development is influenced by a variety of factors that can be categorized as requirements of the movement task (e.g., a target's height or the size of a ball), the biology of the child (e.g., sex and heredity), and the environment (e.g., the surfaces of floors and walls, or socioeconomic status) (Iivonen, & Sääkslahti, 2014). These factors shape the movements individually and/or mutually either encouraging or discouraging skill achievement (Gallahue et al., 2012). Fundamental motor skills (FMS), which constitute motor development milestones for children from kindergarten to 2nd grade and include locomotor, manipulative and stability movements that children skillfully perform (Gallahue et al., 2012), will lead them to active development. It will increase their chances of living and participating in physical activity (Stodden et al. 2008).

The effects of age, gender, and BMI on motor skill have been studied extensively. A study by Bruininks, (1978), well-renowned for developing the Bruininks-Oseretsky Test of Motor Proficiency, revealed that older children performed better on tests of motor proficiency than younger children, clearly highlighting the role of age. Similarly, Livesey et al (2006) found that older children performed motor skills better than younger children. Bellows et al. (2013) reported a positive correlation between age and motor proficiency during the early childhood years. In their study investigating age and balance skills in preschool children, Venetsanou and Kambas (2011) found that age had a significant effect on both sub-test and item scores on balance skills. More recently, Venetsanou and Kambas (2016) found that age significantly affected motor proficeincy in children before the age of 6, with older children performing better in motor tests than their younger peers. Additionally, studies have found that older children had better balance, motor coordination, locomotor, and object control skills than their younger peers (Smits-Engelsman, & Hill 2012; Westendorp et al. 2012). Therefore, age plays a pivotal role in the development of motor proficiency as it influences the biological and environmental aspects of growth in children.

Also, gender plays a significant role in the child motor development. It seems that there are different opinions regarding the evaluation of biological factors in motor problems in terms of gender. Among the studies examining the gender relationship, an Australian study conducted with preschool students revealed the gender difference in locomotor and manipulative skills (Hardy et al., 2010). Boys generally had higher mastery of object control skills, while girls generally had higher mastery of locomotor skills. However, Piek et al. (2008) reported that girls had better hand-eye coordination and fine motor dexterity than boys. This aptitude often manifests in tasks that require precision and detail, such as drawing, writing, or manipulating small objects. In addition, Morley et al. (2015) stated that boys were often more proficient in gross motor skills, like running and jumping. On the other hand, Chow and Lily (2011) found that there was no gender difference in Hong Kong preschool children's gross motor skills when adjusted for the age effect. However, when analyzes were performed without adjusting for age, gender differences in favor of boys were found in all motor skill measurements. These different findings indicate that the effects of gender on motor skills should continue to be investigated.

Body Mass Index (BMI), an indicator of body fatness calculated from an individual's weight and height, can influence a child's motor proficiency. The findings of studies on the relationship between motor competence and BMI in preschool children report different results. Some studies show a negative correlation between children's motor skill proficiency and BMI (D'Hondt et al., 2009; Graf et al., 2004; Lopes et al., 2012; Siahkouhian et al., 2011). For instance, a study by Nervik et al. (2011) showed that increased BMI could lead to decreased physical performance, including functional tasks such as hopping, jumping, and balance. Another study found that excess body weight may negatively impact a child's ability to perform certain physical tasks, potentially due to reduced balance, flexibility, and coordination (D'Hondt et al., 2013). On the other hand, other studies have found no significant relationship between BMI and preschool children's motor proficiency level (Chow, & Lily, 2011; Logan, Scrabis-Fletcher, Modlesky, & Getchell, 2011). Logan et al. (2011) discussed the relationship between preschool children's motor skill proficiency and BMI in two different ways. First, no significant relationship was found between BMI and motor skill proficiency percentile rankings. Second, it was found that preschool children classified as overweight or obese had lower motor competence than their normal weight and thin peers. These equivocal results indicate that the effects of age, gender and BMI on motor skills should continue to be investigated.

Developing fundamental motor skills in preschool age helps to lay the foundation for a physically active lifestyle. Studies have shown that children who possess greater motor skills tend to engage in more physical activity and have better physical fitness levels later in life (Barnett at al., 2016; Stodden et al., 2008). It is expected that children will have properly attained the fundamental motor skills (locomotor, manipulative, and stability skills) by the end of the preschool education period, which is a critical and sensitive period for learning fundamental movement skills. In addition, fundamental motor skills provide a repertoire of movements that empower children to engage in various physical activities and sports. Research suggests that

children who are proficient in fundamental motor skills are more likely to participate in organized sports and recreational activities as they age (Clark, and Metcalfe, 2002; Holfelder, and Schott, 2014). Although the literature generally states that mastering motor competence increases with age, there are different results regarding the relationship between gender, BMI and motor competence. The existence of different results regarding the relationship between motor competence and age and gender, and especially the scarcity of studies conducted with preschool children in the national literature, brought the following questions to mind in this study. First, how are the motor proficiency levels of preschool children and secondly what is the role of age, gender and BMI in children's motor proficiency levels?*

Method

Participants

Participants were 103 preschool children (MAge = 61.10 ± 8.75 months) from a public preschool in Denizli, Turkey. Of this sample, forty five (43.7%) were girls (M_{Age} = 61.60±8.22 months) and 58 (56.3%) were boys (M_{Age} = 60.71. ± 9.19 months). Twenty-eight were 4 years old classes (M_{Age} = 50.25 ± 2.49month), 40 in 5 years old classes (M_{Age} = 59.95 ± 3.43) and 35 in 6 years old classes (M_{Age} = 71.09 ± 3.18month). The preschool's management approved the objectives and procedure of the study. Each child's parents and/or guardians were required to give permission for their child to participate. Children were informed that they could end the study at any time during the implementation.

Instruments

Motor Proficiency Measurement: To assess children's motor proficiency, the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) was used. Individually administered BOT-2 uses engaging, goal-directed activities to measure a wide array of motor skills in children aged 4 through 21 (Bruininks & Bruininks, 2005). The BOT-2 has 8 subtests with 53 items, which are categorized into four motor domains: fine motor control, manual coordination, body coordination, and strength and agility. The fine-motor-control domain comprises the fine-motor-precision (FMP, 7 items, 41 points) and fine-motor-integration (FMI, 8 items, 40 points) subtests. Manual coordination includes manual dexterity (MD, 5 items, 45 points) and upper-limb coordination (ULC, 7 items, 39 points) subtests. Body coordination includes bilateral coordination (BLC, 7 items, 24 points) and balance (BAL, 9 items, 37 points) subtests. Strength and agility include running speed and agility (RSA, 5 items, 52 points) and strength (STR, 5 items, 42 points) subtests. The scores of these four motor domains are combined into total composite score of motor proficiency (320 points). BOT-2 for the subtests, motor domains, and total composite score internal consistency (for 5, 6 & 7 years old) ranged from 0.73–0.90, test–retest coefficients over an interval of 7–42 days (for 4–7 ages) ranged from 0.47 to 0.91, and inter-rater reliability coefficients (for 4–7 ages) ranged from 0.84 to 0.99 (Bruininks & Bruininks, 2005).

The raw scores for each of the BOT-2 test items were converted into point scores according to procedure described in the the BOT-2 test manual. These point scores allow a participant's item performances to be evaluated on a graded scale. Adding these individual point scores together, a subtest total point score is obtained. Point scores from all subtest items are added to obtain the total point score (total BOT-2).

Body Mass Index: Body mass index (BMI) is a widely utilized and reliable indicator of body fat percentage for most children and teens. It is determined based on body weight and height based on using the following formula: BMI = Weight (kg) / Height^2 (m) (Centers for Disease Control and Prevention, 2014). The participants' height in meters and weight in kilograms were measured using standardized procedures (Malina et al., 2004).

Procedure

Receiving approval from the school administration for the study, written permission was obtained from each child's parents. All participants were tested individually in a quiet room and completed the tests in one session. The participants were advised at the beginning of the testing session that they could opt out of participating for any reason. First, the participants' height and weight measurements were taken by researcher. After that, BOT-2 application started, which takes approximately 40-60 minutes. Before each test item was administered, the researcher explained verbally how it would be done using the visual materials of the test. It was then demonstrated by the researcher and participants were given a trial opportunity before the actual application. For each of the BOT-2 items, the researcher observed the child's performance and determined a raw score according to the procedure described in the test manual.

Statistical Analysis

Using the G*Power program, the total number of samples to be taken was determined as 99 according to the 95% confidence (1-α), 90% test power (1-β), f2=0.5 effect size, two-tailed and 3-predictor multiple linear regression analysis. For each subtest and total BOT-2 scores, descriptive statistics, Pearson correlations, and a multiple linear regression were conducted to test whether the participants' age, gender, and BMI predicted motor proficiency. The univariate

and multivariate normal distributions of the data were examined by calculating the skewness and kurtosis values and the Mahalonobis distance. In correlation and regression analyses, it was decided whether the relationship between the variables showed a linear relationship or not by examining the scatter diagram. In the study, type 1 error rate was set at .05.

Results

Table 1 provides descriptive statistics for the BOT-2 subtests and BOT-2 total score, by gender.

Table 1
Descriptive statistics for BOT-2 subtests, BOT-2 total score, and BMI, by gender

Variables	Girl (*n* = 45)		Boy (*n* = 58)		Total (*n* = 103)	
	M	***SD***	***M***	***SD***	***M***	***SD***
Fine motor precision (range: 0–41)	25.53	8.32	20.83	7.91	22.88	8.39
Fine motor integration (range: 0–40)	21.09	9.64	15.91	10.16	18.17	10.22
Manual dexterity (range: 0–45)	12.04	3.61	9.33	3.17	10.51	3.61
Bilateral coordination (range: 0–24)	11.59	4.64	10.68	4.64	11.08	4.64
Balance (range: 0–37)	24.78	7.91	23.28	7.46	23.93	7.66
Running Speed and Agility (range: 0–52)	19.13	6.97	17.95	7.17	18.47	7.07
Upper-Limb Coordination (range: 0–39)	9.89	5.61	11.59	8.27	10.85	7.26
Strength (range: 0–42)	8.53	3.29	8.47	4.04	8.50	3.72
BOT2 Total (range: 0–320)	132.11	37.88	117.66	40.95	123.97	40.10
BMI	15.82	1.93	15.63	1.82	15.71	1.86

Note: Range refers to the lowest to highest possible score for each test.

Nine separate multiple linear regressions were conducted to see if age, gender, and BMI predicted the eight BOT-2 subtest scores and the BOT-2 total scores. Model assumptions were checked including normality, linearity, and multicollinearity. No violations in model assumptions were diagnosed. The results of the multiple linear regression analyses are shown in Table 2.

The results of the multiple linear regression analyses revealed that the three-predictor (age, gender and BMI) model explain a significant amount of the variance in the fine motor precision scores ($F_{(3, 99)}$ = 25.132, p < .001, R^2 = .432) equation of FMP = -15.665 + .575Age + 4.172Gender + .103BMI, fine motor integration scores ($F_{(3, 99)}$ = 28.214, p < .001, R^2 = .461) equation of FMI = -33.889 + .745Age + 4.452Gender + .291BMI, manual dexterity scores ($F_{(3, 99)}$ = .271, p < .001, R^2 = .237) equation of MD = -.325 + .131Age + 2.579Gender + .110BMI, bilateral coordination scores ($F_{(3, 99)}$ = 10.185, p < .001, R^2 = .241) equation of BC = -10.650 + .261Age + .572Gender + .352BMI, balance scores ($F_{(3, 99)}$ = 22.025, p < .001, R^2 = .400) equation of B = -12.761 + .553Age + .977Gender + .159BMI, running speed and agility scores ($F_{(3, 99)}$ = 17.102, p < .001, R^2 = .341) equation of RSA = -9.368 + .466Age + .781Gender + -.061BMI, upper-limb coordination scores ($F_{(3, 99)}$ = 17.558, p < .001, R^2 = .350) equation of ULC = -11.494 + .464Age + -2.117Gender + -.324BMI, strength scores ($F_{(3, 99)}$ = 7.276, p < .001, R^2 = .181) equation of S = -.995+ .177Age + -.074Gender + -.082BMI, and BOT-2 total scores ($F_{(3, 99)}$ = 43.404, p < .001, R^2 = .568) equation of BOT-2 total = -95.327 + 3.377Age + 11.340Gender + .512BMI.

Age was found to be the major determinant of children's motor proficiency. As shown in Table 2, age was a significant predictor in all the regression analyses, with older participants having higher motor proficiency scores. Gender was a significant predictor only in the fine motor precision, fine motor integration, manual dexterity, and BOT-2 total score analyses. The predicted fine motor precision scores for girls are 4.172 points higher than for boys, after controlling for age and BMI. The predicted fine motor integration scores for girls are 4.452 points higher than for boys, after controlling for age and BMI. The predicted fine manual dexterity scores for girls are 2.579 points higher than for boys, after controlling for age and BMI. Finally, the predicted BOT-2 total scores for girls are 11.340 points higher than for boys, after controlling for age and BMI. However, BMI has no significant effect on any of the subtests and BOT-2 total scores.

Table 2
Multiple Linear Regression Results

Variables:	Predictors:	*B*	*SE*	*β*	*t*	*p*
Fine motor precision:	Constant	-15.665	7.662		-2.044	.044
	Age	.575	.074	.599	7.785	.000
	Gender	4.172	1.278	.248	3.264	.002
	BMI	.103	.347	.023	.297	.767
Fine motor integration:	Constant	-33.889	9.099		-3.724	.000
	Age	.745	.088	.638	8.505	.000
	Gender	4.452	1.518	.217	2.933	.004
	BMI	.291	.413	.053	.705	.482
Manual dexterity:	Constant	-.325	3.826		-.085	.932
	Age	.131	.037	.317	3.547	.001
	Gender	2.579	.638	.356	4.040	.000
	BMI	.110	.173	.057	.633	.528
Bilateral coordination:	Constant	-10.650	5.008		-2.126	.036
	Age	.261	.048	.489	5.388	.000
	Gender	.572	.831	.061	.688	.493
	BMI	.352	.224	.143	1.571	.119
Balance:	Constant	-12.761	7.190		-1.775	.079
	Age	.553	.069	.631	7.979	.000
	Gender	.977	1.200	.064	.815	.417
	BMI	.159	.326	.039	.488	.627
Running speed & agility:	Constant	-9.368	6.958		-1.346	.181
	Age	.466	.067	.576	6.945	.000
	Gender	.781	1.161	.055	.673	.503
	BMI	-.061	.315	-.016	-.192	.848
Upper-limb coordination:	Constant	-11.494	7.117		-1.615	.110
	Age	.464	.069	.560	6.757	.000
	Gender	-2.117	1.193	-.145	-1.775	.079
	BMI	-.324	.322	-.083	-1.007	.317
Strength:	Constant	-.995	4.080		-.244	.808
	Age	.177	.039	.416	4.502	.000
	Gender	-.074	.681	-.010	-.109	.913
	BMI	-.082	.185	-.041	-.444	.658
BOT-2 total:	Constant	-95.327	31.954		-2.983	.004
	Age	3.377	.308	.737	10.969	.000
	Gender	11.340	5.331	.141	2.127	.036
	BMI	.512	1.449	.024	.354	.724

Note: The boy gender was coded as 0, and the girl gender was coded as 1.

Discussion

The present study examined the role of age, gender, and BMI on the motor competence level of preschool children. Results indicate that age has a significant effect on all subtests and total BOT-2 scores. Consistent with previous research (Livesey et al., 2006; Smits-Engelsman, & Hill 2012; Westendorp et al. 2012), age plays an important role in the development of motor proficiency. Age has been found to correlate positively with motor proficiency. This association is demonstrated in a study by Luze et al. (2010), where older children tended to demonstrate better gross and fine motor skills than their younger counterparts. This is largely attributed to the physical and neurological maturation that comes with age. Iivonen, and Sääkslahti (2014) compiled the findings of eight studies examining children's motor competencies and found that

developments in motor skills follow an age trend: older children demonstrate greater proficiency in motor skills compared to younger children. The findings of the current study are also consistent with evidence cited in well-known literature suggesting that preschool-age increases in children's FMS proficiency occur to a point during maturational processes with age (Gallahue et al., 2012; Malina et al., 2004). However, no studies reported that the highest level of FMS competence was achieved solely with age; all noted the importance of environmental opportunities provided by education and/or home and community life (Iivonen, & Sääkslahti, 2014).

The current study found that girls performed better than boys in terms of fine-motor precision, fine-motor integration, manual dexterity, and BOT-2 total scores. Similarly, Piek et al. (2008) reported that girls have better hand-eye coordination and fine motor dexterity than boys, this ability often manifests itself in tasks that require precision and detail, such as drawing, writing, or manipulating small objects. Additionally, Morley et al. (2015) specified that boys were generally more skilled in gross motor skills such as running and jumping. However, Hardy et al. (2010) found that preschool girls generally had higher mastery of locomotor skills, while boys had higher mastery of object control skills. In addition, some review studies also indicated that boys tend to have more developed manipulative skills than girls, and that girls achieve better results than boys in balancing and locomotor skills (Iivonen, & Sääkslahti, 2014; Thomas, & French, 1985; Toole, & Kretzschmar, 1993;). Furthermore, a study that examined the relationship between balance performance and gender in preschool children reported that although there were differences, the low values for gender showed that these differences were not very important (Venetsanou & Kambas, 2011). On the other hand, in a study that found a difference in favor of boy preschool children in all motor skills, no gender difference was found in children's gross motor skills when the analyses were adjusted for the age effect (Chow & Lily, 2011).

It has been suggested that gender differences in motor skills in early childhood are affected by more by environmental factors rather than biological factors. For example, McKenzie et al. (2002) stated that boys are better at skills requiring object control because they play more ball games, while girls are better at balancing and locomotor skills because of the games they prefer. Studies also highlight the importance of opportunity and practice in motor proficiency. It remains crucial not to limit children's activities based on gender, but rather encourage a comprehensive development of both fine and gross motor skills. Although these physiological and developmental differences exist, sociocultural factors can also contribute to these disparities in motor proficiency. Social and environmental factors may also influence these gender differences. Pitchford et al. (2016) described how social norms and expectations may influence differences in FMS performance. For example, boys may be more encouraged to participate in sports and outdoor games, which can facilitate the development of gross motor skills. However, Okely and Booth (2004) suggested that if girls are provided with equal opportunities to these skills, differences in FMS proficiency between girls and boys could be decreased.

Unlike age and gender, BMI had no significant effect on any BOT-2 subtests or the BOT-2 total score. This is consistent with other studies that found no relationship between preschool children's BMI and motor proficiency level (Chow and Lily, 2011; Logan et al., 2011). On the contrary, studies indicate that increasing BMI may cause a decrease in physical performance as well as a decrease in hopping, jumping, flexibility, balance, and coordination skills (D'Hondt et al., 2013; Nervik et al., 2011). Interestingly, Cattuzzo, et al. (2016) found that it is not only obesity that is a concern: Underweight or malnourished children demonstrated inferior motor skills compared to their adequately nourished peers. Therefore, maintaining a healthy BMI might be crucial for optimized motor proficiency in children. Moreover, Nervik, et al. (2011) showed that increased BMI could lead to decreased physical performance, including functional tasks such as hopping, jumping, and balance. However, it is important to remember that while a correlation exists, BMI is not the sole determinant of motor proficiency and physical fitness. Factors such as physical activity level, opportunities for skill development, and genetics also play significant roles. In addition to that, Ferreira et al. (2019) concluded that sports participation plays an important role in the development of motor competence in school-age children, but this association is not generally mediated by weight status.

There were some limitations of the study. The sample for this study was taken from a preschool in western Turkey, so caution should be taken when generalizing the results. Another limiting factor is that BOT-2 can be applied to a limited number of children because it takes too much time to apply to a child. On the other hand, the contribution of the findings in the literature, especially considering the scarcity of studies conducted to determine the motor proficiency level of Turkish preschool children & to examine the role of age, gender, & BMI is the strength of the study.

Conclusions

This study found that all BOT-2 sub-test scores and the BOT-2 total score increase significantly with age. These findings are consistent with the motor development literature. In addition, the results indicated that girls have significantly higher scores than boys on fine-motor precision (4.172 points higher), fine-motor integration (4.452 points higher), manual dexterity (2.579 points higher), and the BOT-total scores (11.340 points higher). The subtests in which girls performed better were all related to fine motor skills. Future studies are needed to determine whether these explanations are to generalize.

In conclusion, the findings suggest age and gender as significant predictors of motor proficiency in preschool children. However, more comprehensive studies considering other potential contributing factors including socio-economic status, physical activity levels, and parental influence are needed to have a clearer understanding of the development of motor skills in preschool children. It is therefore imperative to investigate these factors as predictors for motor proficiency in preschool children for targeted interventions. Such research could not only provide insights into individual differences in motor development but also devise strategies to promote motor skills among preschoolers effectively. Special attention must be paid to high-risk groups, like overweight or obese children, those with delayed motor skills, and children with less opportunity for physical activities. Tangible efforts are therefore important to instill motor activities from a young age, fostering an active lifestyle from the early developmental stages. This could lead to better overall health, cognitive function, and academic achievements, thereby significantly enhancing the quality of life in the long term.

Ultimately, while age and gender play predictive roles in children's motor proficiency, they are not rigid determinants, and each child's unique developmental trajectory must be considered. The results from the study showed a significant positive correlation between age and motor proficiency, indicating that as children grow older, their motor proficiency tends to improve. The findings of the study suggest that gender plays an integral part in preschool children's motor proficiency. The role of BMI was not significant in predicting motor proficiency, suggesting that it changes as children grow and develop and thus might not be the best predictor of motor proficiency. In conclusion, the study highlighted that age and gender are strong predictors of motor proficiency in preschool children. These findings could have implications in early childhood education and intervention programs, helping teachers and caregivers to promote physical activities that are appropriate for their age and gender. It also underscores the need to monitor children's motor skills from a young age to detect and address any potential developmental delays.

Ethics Committee Statement

The study was conducted in accordance with the Declaration of Helsinki. However, since there was no ethics committee approval required at the time the study was conducted, the study was conducted only by obtaining parental approval.

Conflict of Interest Statement

Since there is no institution providing funding for the study, no institution or organization has any influence on the design of the study, the analysis of the data or the interpretation of the results.

Funding

No funding source was used in the study. The researcher carried out the study with his own means.

Data Availability Statement

The data supporting the findings of this study are available in the personal database of the corresponding author (omballi@pau.edu.tr).

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Note

This study was presented as an oral presentatrion at the following international congress: Mülazmoglu-Balli, Ö. (2018). The Predicting Role of Age, Gender and, BMI on Motor Proficiency of Prescholar Children. Health Across Lifespan (HAL) International Conference on Healthiness and Fitness Across the Lifespan, 12-15 September. Magdeburg, Germany.

ESTADÍSTICAS Y REVISORES

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, ERIHPLUS, 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: C1 (DEPORTE Y EDUCACIÓN)
MIAR (2020): 9.7
ARCE 2014 (FECYT): Sello de calidad - Actualizado 2020
ERIH PLUS (European Reference Index for Humanities and Social Sciences): Indexada

Redes sociales
Twitter: https://twitter.com/UCAM_CCD

Impacto
ISI Web of Science 2023: 1.1 (JCR) Journal Impact Factor // 0.16 (JCI): Q3 en Hospitality, Leisure, Sport & Tourism - ESCI (98 de 139)

SCOPUS: 2023: 0.291 (SJR). Índice H: 18. Q1 en Cultural Studies, Q3 en Health (Social Science), Q3 en Physical Therapy, Sports Therapy and Rehabilitation y Q4 en Sports Science.

Emerging Sources Citation Index (ESCI): 2023 1.1 (JCR). Tercer cuartil en HOSPITALITY, LEISURE, SPORT & TOURISM.

FECYT 2023: Ranking de Calidad de las Revistas Científicas Españolas Q3 en Ciencias de la Educación (puntuación: 27.52) y Psicología (puntuación: 28.49).

Ranking Iberoamericano de Revistas (REDIB) 2020: primer cuartil en el área temática de Ciencias Sociales y Humanidades, materia Hostelería, Ocio, Deporte y Turismo.

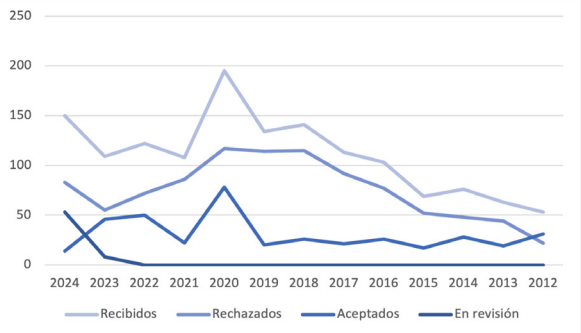
IN-RECS Education (2011): 0.103. Second quartile. Position: 47/162

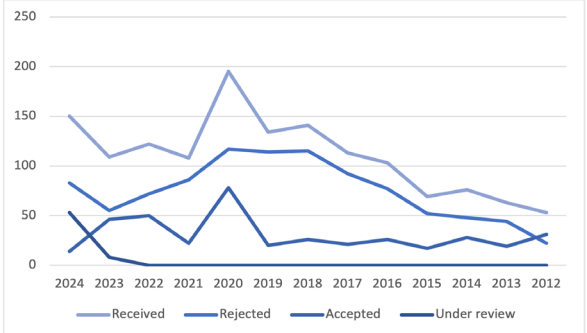
Índice H (2013-17): 11. Mediana H: 18. Posición 36/96

Scientific Journal Impact Factor (SJIF) 2018: 6.91

Nivel CONICET (Res. 2249/14): Grupo 1

Estadísticas





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9. Política de conflicto de intereses

Todos los autores deben revelar cualquier relación financiera y personal con otras personas u organizaciones que puedan influir de manera inapropiada (sesgo) en su trabajo.

Entre los ejemplos de posibles intereses contrapuestos se incluyen el empleo, las consultorías, la propiedad de acciones, los honorarios, los testimonios pagados de expertos, las solicitudes/registros de patentes y las subvenciones u otros fondos. Los autores deben revelar cualquier interés en una declaración resumida de intereses en el archivo que incluye los datos de los autores. Si no hay intereses que declarar, indíquelo: 'Declaraciones de interés: ninguna'.

10. 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.

CULTURA, CIENCIA Y DEPORTE MANUSCRIPTS SUBMISSION GUIDELINESS

The *Cultura, Ciencia y Deporte* journal shall be open to research papers related to the different thematic areas and work fields in Physical Education and Sport, provided they are scientifically founded. Due to the specialised nature of this journal, neither purely dissemination articles nor articles that merely state opinions instead of conclusions derived from contrasted research will be considered for publication. Papers shall be submitted electronically using our website, on which the author must sign up as an author and proceed as instructed.

1. Paper submission

All submissions must include TWO DOCUMENTS. The first one will correspond to the 'Template' and the second one to the 'Title Page'.

The template must be completely anonymous: THE TEMPLATE MUST BE COMPLETELY ANONYMOUS, WITHOUT ANY REFERENCE THAT WOULD ALLOW THE REVIEWERS TO IDENTIFY THE AUTHORS OF THE MANUSCRIPT. THE 'ANONYMOUS ARTICLE'.

Every author who submits a manuscript in Spanish, and whose article is finally accepted, must send the **final version in both Spanish and English**, for publication in the two languages. This is not necessary if the article is initially submitted in English.

When submitting a paper to be part of a **monograph**, select the tab with the name of the monograph in which you intend to publish it during the submission process.

If you use a citation and reference manager, you must submit the manuscript in plain text.

2. Types of articles considered for peer review in the Cultura, Ciencia y Deporte Journal

2.1. Original research

These are articles that report on an original empirical study structured in sections that reflect the steps followed in the research. The full text must follow the IMRDC structure (Introduction, Method, Results, Discussion and Conclusions).

2.2. Review article

Review articles shall follow the format and structure of original research.

Reviews on the current state or level of scientific development of a particular topic must be systematic, critical or narrative.

2.3. Editorial.

This section of the Culture, Science and Sport section shall accept essays on sport-related topics that are properly structured and sufficiently justified, well-founded, argued and logically coherent. This section is expected to be dynamic and up to date, setting the editorial line on sport that underlies the journal.

Here you do not need to follow the structure of original research, just the same format.

3. Length

Abstract, unstructured: cannot exceed 200 words in English.

Manuscript (original articles, systematic reviews): an article for this journal should be no more than 8000 words, inclusive of:

- Text of the article.
- Figures.
- Tables.

4. Relevant information about the journal

4.1. The Cultura, Ciencia y Deporte journal adheres to the Code of Conduct and Best Practices Guidelines for Journal Editors of the Committee on Publication Ethics (COPE) and to the Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals of the International Committee of Medical Journal Editors (ICJME). The journal is committed to the detection of plagiarism and other types of fraud in the writing and submission of articles to Cultura, Ciencia y Deporte.

4.2. The editorial policy of the journal promotes the use of inclusive language in scientific articles. Please consider this guideline and review your paper before submitting it to the journal.

5. Processing of personal data

Pursuant to the provisions of Article 17 of Spanish Royal Decree 994/1999, approving the Regulations on Security Measures for Automated Files containing Personal Data, as well as Spanish Organic Law 15/1999 on the Protection of Personal Data, and Spanish Organic Law 3/2018, of 5 December, on the Protection of Personal Data and the guarantee of digital rights, the Cultura, Ciencia y Deporte executive board guarantees the proper processing of personal data.

6. Information regarding proofreading / galley proofing following acceptance of the article

Once the article has been accepted for publication, it will be typeset. To this end, the editorial team of Cultura, Ciencia y Deporte will contact the authors, sending them the manuscript with the necessary stylistic modifications. Authors must respond to the requests made within a maximum period of 7 to 10 days (this will be indicated in the email depending on the changes to be made).

Once the modified documents have been received, they will be sent to the layout team to generate the final PDF of the article. This PDF (galley proofs) will be sent to the authors for review within a maximum of 48 hours. This review may indicate aspects relating to errors made

during the layout process, but under no circumstances may content be added or substantial changes made to the article.

7. Statements

The title page must include the following information:

- Ethics Committee Statement
- Conflict of Interest Statement
- Funding
- Contribution of the Author
- Data Availability Statement
- Acknowledgements

8. Payment as partial funding of the publication

According to the Open Access philosophy of this journal and in order to cover part of the publication costs and thus improve the quality, visibility and impact of the publication, Cultura, Ciencia y Deporte sets a publication fee of €120 (VAT included). From 1/09/2024 onwards, submissions will be subject to a publication fee of €250 (VAT included). This fee must be paid upon notification of acceptance of the article.

Once the article has been accepted, please complete a bank transfer to the account number ES0200815089383800010944 20, whose holder is the 'FUNDACIÓN UNIVERSITARIA SAN ANTONIO', specifying '**Revista CCD + nº of the article**' (CCD journal + article number) in the concept. Then send the proof of payment to ccd@ucam.edu.

In Cultura, Ciencia y Deporte, article reviewers are awarded one publication free of charge for every five articles they have reviewed in the time and manner requested by the editors. To that effect, they must specify the revised articles in order to benefit from the exemption from payment upon request. Editors are exempt from payment.

9. Conflict of interest policy

All authors must disclose any financial and personal relationships with other individuals or organisations that could inappropriately influence (bias) their work.

Examples of potential competing interests include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Authors must disclose any interests in a summarised statement of interests in the file that includes the details of the authors. If there are no interests to declare then please state this: 'Declarations of interest: none'.

10. Proposal for the publication of monographs in Cultura, Ciencia y Deporte

Anyone interested in submitting a proposal for the publication of a monograph in the journal Cultura, Ciencia y Deporte must send a description of 500-600 words (including references) to the email address of the journal (ccd@ucam.edu). The email must include a description of the subject matter and content of the proposed monograph, as well as the CVs of the coordinator(s) (maximum 3 people).

Upon acceptance of the monograph proposal, there will be a call for papers and a deadline for submissions, to be determined by the coordinator of the monograph. The editorial team of the Cultura, Ciencia y Deporte Journal will set a date for the publication of the monograph, depending on its availability. The duties of the coordinator of the monograph will be to write the editorial of the monograph, and to provide a list of potential 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 monograph coordinator may invite authors to contribute manuscripts. However, 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.

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 res- pondido 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.

Equipo editorial de Cultura, Ciencia y Deporte.
(ccd@ucam.edu)

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 di-sappear from your reviewer profile, where you will find none "Active Submissions".

Equipo editorial de Cultura, Ciencia y Deporte.
(ccd@ucam.edu)

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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