





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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Short title:

External Physical Load on Soccer Referees During First Division Matches

How to cite this article:

Díaz-Escobar, C., Araya-Astudillo, J., Cabezas-Caballero, F., & Díaz-Narváez, V. (2024). External physical load control in professional soccer referees during first division matches. *Cultura, Ciencia y Deporte*, 19(62), 2174. <https://doi.org/10.12800/ccd.v19i62.2174>

Received: 10 February 2024 / Accepted: 05 July 2024

Abstract

Soccer, as a high-intensity and intermitten 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 $11,202 \pm 706$ m; of which $1,139 \pm 722$ 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: $80,07 \pm 4.32$ kg); registrándose la carga física en 67 partidos de primera división nacional. Exponiéndose como resultados, que en promedio los árbitros recorrieron $11,202 \pm 706$ m; de los cuales $1,139 \pm 722$ 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.



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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: $1.79 \pm .04$ 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 Spearman'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

	<i>n</i>	<i>Mín</i>	<i>Máx</i>	<i>Med</i>	<i>SEM</i>	<i>DE</i>	<i>Asi</i>	<i>Kur</i>
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, Fernández-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 $1,139 \pm 722$ 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-Gracia 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.

Funding

This research did not receive any type of funding because it was part of the activities in the annual planning of the physical training of professional soccer referees in Chile during the 2023 season.

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.

Acknowledgements

We would like to thank the Referees Commission and the Science Department of the National Professional Soccer Association of Chile for their willingness and collaboration in the development of this research on professional first division referees.

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