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Technical and Physical Load Variables at Different Positions in U18 Semi-Professional Soccer Players: Differences between the First and Second Half

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Abstract: Among the many factors that can affect men's soccer performance, technical and tactical actions can obscure relevant game data, even affecting specialists in both the programming and design of training tasks. We aimed to evaluate the technical and physical load variables of different positions in U18 semi-professional soccer players and observe the differences between the first and second halves during 10 matches of the 2021/2022 Spanish Football U18 National League Championship. A total of 246 match records (10 matches) were collected from the 2021/2022 Spanish Football U18 National League Championship. Two teams participated, with a total of 49 athletes. Our study's results indicate that, concerning technical performance, no significant differences between halves were found for goalkeepers, wingers, and forwards. However, significant declines were observed in the number of ball contacts, different actions per time, and possessions per time among central defenders, lateral defenders, and central midfielders. Regarding the observed physical load demands, it was noted that in outfield players, there was a significant decline in total distances covered at different speed thresholds, as well as a decrease in the number and distance of acceleration measures, most of which were lower in the second halves compared to the first, irrespective of playing positions. This study contributes to enhancing our understanding of the multifaceted dynamics of soccer performance and provides valuable insights for coaches, players, and researchers aiming to optimize player performance.

Keywords: team sports; soccer; technical load; physical load; professional players

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1. Introduction

In professional soccer, assessing the player work load (WL) imposed during training sessions and competitive matches is recognized as a fundamental aspect of the daily tasks of coaching staff, assuming that the process of monitoring and quantifying the load should assist coaches and physical trainers in decision making to enhance both individual and collective team performance while minimising the risk of injuries [1]. Load is typically represented by indicators and variables of external load (EL) and internal load (IL), which are, respectively, defined as the work performed by the athlete and the physiological response associated with it [2]. In this sense, the assessment of load in soccer encompasses various aspects, such as duration, intensity, frequency, and type of activities performed during training sessions and matches [3]. Moreover, advancements in technology, particularly the utilisation of GPS tracking devices and wearable sensors, have provided unprecedented opportunities for the real-time monitoring and analysis of player work load, enabling more precise and individualised training programs tailored to meet the specific needs of each player and optimise performance outcomes [4]. Furthermore, the integration of load monitoring data with other performance metrics such as physiological, biomechanical, and psychological parameters offer a comprehensive understanding of the demands placed on players during soccer activities, facilitating informed decision making by coaching staff to maximise team performance while minimising the risk of injuries [5].

A review of the literature reveals that traditionally, the design of soccer training sessions and drills predominantly focuses on technical load (TL) values, aiming to replicate real game scenarios, alongside physical conditioning [6,7]. It is widely known that professional soccer teams use methods such as GPS technology for monitoring and quantifying physical load (PL) throughout the season [8–10]. For this reason, the individual and specific use of the chronic workload ratio has been criticised as a means to control the load and reduce injury risk [11].

However, to the best of our knowledge, there are not many studies exclusively investigating technical load (TL) in soccer [12]. Given these circumstances, the development of new technological devices, such as inertial measurement units (IMUs), could help assess TL more effectively [13]. IMUs, by providing detailed movement analysis, offer a promising tool for capturing the intricacies of technical skills in soccer, which are not adequately captured by traditional PL monitoring methods.

In fact, recent studies have revealed a high capability for assessing, monitoring, and controlling both TL and PL in different professional teams in England [14,15] and Spain [13]. The precise measurement of TL through these advanced devices not only aids in improving performance but also holds clinical relevance. Accurate TL assessment can help in understanding the impact of technical demands on players' musculoskeletal health, thus aiding in the development of targeted interventions to prevent injuries and optimise recovery strategies. Overall, the integration of IMUs in soccer training and performance analysis represents a significant advancement, bridging the gap between physical and technical load management and enhancing our ability to safeguard player health and performance.

Considering the previous statement, it can be inferred that PL, which has been extensively studied, could be enhanced from a holistic perspective by incorporating TL. In fact, scientific literature reflects that identifying differences in TL and PL between the first and second halves reveals patterns of fatigue and tactical adjustments as the game progresses [14,15]. Additionally, understanding how different positions experience and manage loads informs position-specific training and recovery strategies. Therefore, further research is necessary to understand TL and PL by individual profiles.

The main aims of the present study are as follows: (i) to record, quantify and analyse the TL and PL of U18 semi-professional soccer players during ten official matches, and (ii) to compare TL and PL records between the first and second halves and among players in different specific positions. By achieving these aims, this study will contribute to a more nuanced understanding of the demands placed on soccer players, potentially leading to enhanced performance, better injury prevention strategies, and more effective player management overall.

2. Materials and Methods

2.1. Experimental Approach to the Problem

A quasi-experimental and descriptive design was used to evaluate the TL and PL variables of different positions in U18 semi-professional soccer players and observe the differences between the first and second halves. This study was conducted during 10 matches of the 2021/2022 Spanish Football U18 National League Championship (September to December). All matches were played against teams of the same level. The U18 semi-professional soccer players were recorded from two academies of first-division teams. In addition, these players trained 5 times a week (90 min per session) and played 1 match per week.

2.2. Participants

A total of 246 official match records (10 matches) and 49 U18 semi-professional soccer players from two professional Spanish clubs [first team (age: 17.70 ± 0.60 years; height: 177.80 ± 6.50 cm; body-mass: 72.50 ± 6.80 kg) and second team (age: 18.10 ± 0.70 years; height: 177.40 ± 6.10 cm; body-mass: 71.50 ± 7.60 kg] were utilized to evaluate the technical and physical load. The number of players records comprised the following: goalkeeper (n = 18); defenders: centre-back (n = 50) and left and right back (n = 44); midfielder: defensive midfielder: (n = 26) and centre midfielder (n = 36); and forwards: winger: (n = 41), left and right forward (n = 31).

G*Power™ software 3.1. [www.gpower.hhu.de (accessed on 1 January 2020)], with a power level (α) to 0.05, desired power (1–β error probability) to 0.80, revealed that a sample size of 16 professional soccer players would be sufficient for the analysis. In this sense, the inclusion criteria for this study were as follows: (a) normal vision and no history of any neuropsychological impairments that could affect the results of the experiment, (b) being an active player of the federated team, (c) not presenting any injuries during the last 2 months, and (d) participation in each half-time match for at least 30 min.

All soccer players in this study were treated according to the American Psychological Association guidelines, which ensure the safety and anonymity of participants' responses. The study was conducted in accordance with the ethical principles of the Helsinki Declaration for human research and was approved by the Research Ethics Committee of the University of Granada, No. 3882/CEIH/2023.

2.3. Instruments, Procedure, and Variables Analysed

2.3.1. Instruments

The technical and physical loads of the U18 semi-professional soccer players during match play were registered using IMUs ("Inertial Measurement Units") with Playermaker devices (Tel Aviv, Israel). All values were recorded and stored in the IMU sensor, to be later downloaded via Bluetooth to an iPad (Apple Inc., Bakersfield, CA, USA, 9th generation). The data were then transmitted to the servers, where they could be processed and analysed on the website. For more information about the instruments used, see the protocol of Losada-Benitez, Nuñez-Sánchez, and Barbero-Álvarez (2023) [13] (Figure 1).

2.3.2. Procedure

In the first instance, throughout the months encompassing September, October, November, and December, constituting half of the regular season, the coaches of the participating teams received notification regarding the procedural protocol to be implemented over the ensuing weeks. This underscored the coaches' dedication to the process of data collection.

Prior to each match, the team's physical trainer distributed a pair of IMU sensors to each player in the locker room. These sensors were securely fastened to each foot using silicone straps, positioning the device below the external lateral malleolus and above the boot. Activation of the sensors occurred via Bluetooth through the Playermaker® app on an iPad, which facilitated the initiation and termination of training or match recordings. Throughout both warm-up and the match, itself, players wore the sensors. Upon conclusion of each competitive match, players removed the sensors from their boots and entrusted them to the physical trainer for insertion into a charging/discharging docking station contained within a briefcase.

At the conclusion of each session (match), data from each sensor (both right and left) were transmitted via Bluetooth through the Playermaker® app on the iPad. Once an internet connection was established, the app transmitted the data to the cloud-based software 3.6. (Dashboard) provided by the respective commercial brand. Subsequently, raw data were downloaded into Microsoft Excel spreadsheets for further processing and analysis.

Figure 1. Playermaker© devices and iPad linked. Posiositioning device below the lateral malleolus and above the boot and connected via Bluetooth through the Playermaker® app on an iPad.

2.3.3. Variables

The players' demands during matches were monitored using an IMU technology-based data collection instrument. Smart motion devices were directly mounted on the soccer players' boots to quantify technical and player load variables (Table 1).

Table 1. Technical and physical load variables.

Technical Variables		
Abbreviature	**Explanation**	**Value**
PPT	Number of minutes in which the player participated in the session	min
TT	Number of contacts with left and right foot	n
TPM	Number of times the ball hits the player's foot in a period of 1 min	n/min
R	Releases or number of times in which the player executes (hits—passes or throws)	n
RPM	Releases per minute or Number of times in which the player pass, hits or throws with his foot in a period of 1 min	n/min
RVA	Release Velocity Max (m/s)—Maximum intensity hit performed	m/s
RVM	Release Velocity Avg (m/s)—Average intensity of all hits performed	m/s
RIB	Release Index (Striking Index)	a.u.
RHI	Number releases of high intensity (>15 m/s)	n
TP	Number of possessions that the player has control of the ball (1 touch, short possession, and long possession)	n
TTOB	Total time in seconds that the player kept the ball in his possession during the match or session	s
Physical load variables		
TS	Maximum speed reached or Highest peak reached by a player (m/s).	m/s
DC	Total distance covered during the session.	m
WR	Average distance covered or work rate.	m/min
HIDC	Distance covered at high intensity (>5.83 m/s—21 km/h)	m
HID	Distance covered at high intensity per minute of play	m/min
SDC	Distance covered sprinting (>6.66 m/s—24 km/h)	m
SD	Distance covered sprinting per minute of play (m/min). Range of speed >5.5 m/s between the record time of a (1) min	m/min

Table 1. *Cont.*

Technical Variables		
SC	Number of sprints or times in which the player reaches a speed greater than 6.66 m/s—24 km/h.	n
SZDC1	Distance covered in meters in Zone 1 [0–3.33 (m/s)]	m
SZDC2	Distance covered in meters in Zone 2 [3.33–4.17 (m/s)]	m
SZDC3	Distance covered in meters in Zone 3 [4.17–5.00 (m/s)]	m
SZDC4	Distance covered in meters in Zone 4 [5.0–5.83 (m/s)]	m
SZDC5	Distance covered in meters in Zone 5 [5.83–6.67 (m/s)]	m
SZDC6	Distance covered in meters in Zone 6 [>6.67 (m/s)]	m
ISCAD	Intense speed changes or accelerations and decelerations per minutes of play (<3 m/s^2)	n
HACC1	Number of accelerations in Zone 1. [1.0–2.0 (m/s^2)]	n
HACC2	Number of accelerations in Zone 2 [2.0–3.0 (m/s^2)]	n
HACC3	Number of accelerations in Zone 3 [3.0–4.0 (m/s^2)]	n
HACC4	Number of accelerations in Zone 4 [4.0–5.0 (m/s^2)]	n
HACC5	Number of accelerations in Zone 5 [5.0–6.0 (m/s^2)]	n
HACC6	Number of accelerations in Zone 6 [>6.0 (m/s^2)]	n
ACCHI	Number of accelerations of high intensity (<3 m/s^2)	n
HDCC1	Number of decelerations in Zone 1. [1.0–2.0 (m/s^2)]	n
HDCC2	Number of decelerations in Zone 2 [2.0–3.0 (m/s^2)]	n
HDCC3	Number of decelerations in Zone 3 [3.0–4.0 (m/s^2)]	n
HDCC4	Number of decelerations in Zone 4 [4.0–5.0 (m/s^2)]	n
HDCC5	Number of decelerations in Zone 5 [5.0–6.0 (m/s^2)]	n
HDCC6	Number of decelerations in Zone 6 [>6.0 (m/s^2)]	n
DCCHI	Number of decelerations of high intensity (<3 m/s^2)	n
HACCDC1	Distance covered in meters by acceleration in Zone 1 [1.0–2.0 (m/s^2)]	m
HACCDC2	Distance covered in meters by acceleration in Zone 2 (2.0–3.0 m/s^2)	m
HACCDC3	Distance covered in meters by acceleration in Zone 3 (3.0–4.0 m/s^2)	m
HACCDC4	Distance covered in meters by acceleration in Zone 4 (4.0–5.0 m/s^2)	m
HACCDC5	Distance covered in meters by acceleration in Zone 5 (5.0–6.0 m/s^2)	m
HACCDC6	Distance covered in meters by acceleration in Zone 6 (>6 m/s^2)	m
DACC HI	Distance covered in meters of high intensity by accelerations (<3 m/s^2)	m
HDCCDC1	Distance covered in meters by deceleration in Zone 1 (1.0–2.0 m/s^2)	m
HDCCDC2	Distance covered in meters by deceleration in Zone 2 (2.0–3.0 m/s^2)	m
HDCCDC3	Distance covered in meters by deceleration in Zone 3 (3.0–4.0 m/s^2)	m
HDCCDC4	Distance covered in meters by deceleration in Zone 4 (4.0–5.0 m/s^2)	m
HDCCDC5	Distance covered in meters by deceleration in Zone 5 (5.0–6.0 m/s^2)	m
HDCCDC6	Distance covered in meters by deceleration in Zone 6 (>6 m/s^2)	m
DDCC HI	Distance covered in meters of high intensity by decelerations (<3 m/s^2)	m

Note: a.u. = arbitrary units; n = number; m = meter; min: minutes; s: seconds.

2.4. Statistical Analysis

For data processing, adequate statistical methods were used to calculate means and standard deviation parameters. Normal distribution and homogeneity tests (Kolmogorov–Smirnov and Levene's, respectively) were conducted on all metrics. Statistically significant differences between halves (first–second) were analysed using paired-sample *t* test, which was used for determining differences between halves (first–second). Cohen's d was the effect size indicator. To interpret the magnitude of the effect size, we adopted the following criteria: $d = 0.20$, small; $d = 0.50$, medium; and $d = 0.80$, large. Data were analysed using Statistica software (version 13.1; Statsoft, Inc., Tulsa, OK, USA), and the significance level was set at $p < 0.05$.

3. Results

A *t*-test with the goalkeeper data from the technical and load variables did not reveal significant differences between halves in any case [Supplementary Materials (Table S2)].

A *t*-test with the centre-back defender data from the technical variables revealed significant differences between halves in TT, $p < 0.001$, $d = 1.20$; TPM, $p < 0.01$, $d = 1.01$; R, $p < 0.001$, $d = 0.99$; RPM, $p < 0.001$, $d = 0.93$; RHI, $p < 0.001$, $d = 0.89$; TP, $p < 0.001$, $d = 1.18$, and TTOB, $p < 0.001$, $d = 1.08$. Then, another t-test with the centre-back defender data from the physical load variables revealed significant differences between halves in DC, $p < 0.001$, $d = 0.75$; WR, $p < 0.01$, $d = 0.88$; SZDC2, $p < 0.001$, $d = 0.41$; SZDC3, $p < 0.001$, $d = 0.71$; SZDC4, $p < 0.001$, $d = 0.34$; SZDC5, $p < 0.04$, $d = 0.23$; HACC2, $p < 0.04$, $d = 0.75$; HACC3, $p < 0.001$, $d = 0.69$; HDCC2, $p < 0.001$, $d = 0.69$; HDCC3, $p < 0.001$, $d = 0.83$; HDCC4, $p < 0.01$, $d = 0.76$; HACCDC2, $p < 0.001$, $d = 0.78$; HACCDC3, $p < 0.01$, $d = 0.52$; HDCCDC2, $p < 0.001$, $d = 0.88$, and HDCCDC3, $p < 0.001$, $d = 0.72$ [Supplementary Materials (Table S3)].

Similarly, new t-tests with the left- and right-back defenders' data from the technical variables revealed significant differences between halves in TT, $p < 0.04$, $d = 0.56$; R, $p < 0.02$, $d = 0.61$; RPM, $p < 0.05$, $d = 0.52$, and TP, $p < 0.03$, $d = 0.55$. Regarding physical load variables, another t-test revealed significant differences between halves in DC, $p < 0.02$, $d = 0.76$; WR, $p < 0.04$, $d = 0.70$; SZDC2, $p < 0.03$, $d = 0.35$, SZDC3, $p < 0.001$, $d = 0.71$; HACC1, $p < 0.01$, $d = 0.88$; HACC2, $p < 0.04$, $d = 0.55$; HACCDC1, $p < 0.001$, $d = 0.81$, and HDCCDC, $p < 0.001$, $d = 0.89$ [Supplementary Materials (Table S4)].

Afterwards, the data analysis relative to defensive midfielders and the technical variables revealed significant differences between halves in PPT, $p < 0.01$, $d = 1.35$, TT, $p < 0.02$, $d = 1.10$, R, $p < 0.01$, $d = 1.13$, RVM, $p < 0.01$, $d = 1.06$, RIB, $p < 0.01$, $d = 1.18$, RHI, $p < 0.01$, $d = 1.32$, TP, $p < 0.01$, $d = 1.32$, and TTOB, $p < 0.01$, $d = 0.91$. Subsequently, the analysis for physical load variables showed significant differences between halves in DC, $p < 0.01$, $d = 1.54$; SZDC1, $p < 0.01$, $d = 1.53$; SZDC2, $p < 0.03$, $d = 1.41$; SZDC3, $p < 0.05$, $d = 1.02$; SZDC4, $p < 0.05$, $d = 0.89$; SZDC5, $p < 0.02$, $d = 1.31$; ISCAD, $p < 0.02$, $d = 1.50$; HACC1, $p < 0.001$, $d = 1.96$; HACC2, $p < 0.04$, $d = 1.96$; HACC3; $p < 0.04$, $d = 1.18$, HACC4, $p < 0.01$, $d = 1.48$; ACCHI, $p < 0.01$, $d = 0.84$; HDCC1, $p < 0.001$, $d = 1.56$; HDCC2; $p < 0.001$, $d = 2.47$, HACCDC1, $p < 0.01$, $d = 1.82$; HACCDC2, $p < 0.03$, $d = 1.30$; HACCDC3, $p < 0.001$, $d = 1.50$; HACCDC4, $p < 0.02$, $d = 0.63$; DACCHI, $p < 0.001$, $d = 1.47$; HDCCDC1, $p < 0.01$, $d = 1.16$, and HDCCDC2, $p < 0.001$, $d = 2.30$ [Supplementary Materials (Table S5)].

Along the same line, a new t-test with the centre midfielder position concerning technical variables revealed significant differences between halves in PPT, $p < 0.04$, $d = 0.84$, and RHI, $p < 0.05$, $d = 0.70$. A subsequent t-test with data from physical load variables showed significant differences between halves in DC, $p < 0.01$, $d = 1.28$; SZDC1, $p < 0.02$, $d = 1.04$; SZDC2, $p < 0.01$, $d = 1.14$; SZDC3, $p < 0.03$, $d = 0.87$; HACC1, $p < 0.001$, $d = 1.26$; HACC2, $p < 0.001$, $d = 1.17$; HACC3, $p < 0.02$, $d = 0.89$; ACCHI, $p < 0.04$, $d = 0.81$; HDCC1, $p < 0.001$, $d = 1.31$; HDCC2, $p < 0.001$, $d = 1.20$; HACCDC1, $p < 0.001$, $d = 1.09$; HACCDC2, $p < 0.01$, $d = 1.29$; HDCCDC1, $p < 0.01$, $d = 1.13$, and HDCCDC2, $p < 0.001$, $d = 1.09$ [Supplementary Materials (Table S6)].

Similar t-tests were performed with the forward data from the technical variables and did not reveal significant differences between halves. However, the same analysis of physical load variables showed significant differences between halves in DC, $p < 0.001$, $d = 1.63$; WR, $p < 0.04$, $d = 0.74$; HIDC, $p < 0.04$, $d = 0.45$; SZDC1, $p < 0.01$, $d = 1.02$; SZDC3, $p < 0.001$, $d = 1.53$; SZDC4, $p < 0.001$; $d = 1.31$; SZDC5, $p < 0.02$; $d = 0.67$; HACC1, $p < 0.001$, $d = 1.76$; HACC2, $p < 0.01$, $d = 1.08$; HACC3, $p < 0.26$, $d = 0.67$; HDCC1, $p < 0.001$, $d = 1.52$; HDCC2, $p < 0.001$, $d = 1.50$; HDCC3, $p < 0.01$, $d = 0.95$; HACCDC1, $p < 0.001$, $d = 1.71$; HACCDC2, $p < 0.001$, $d = 1.18$; HDCCDC1, $p < 0.001$, $d = 1.85$; HDCCDC2, $p < 0.001$, $d = 1.43$, and HDCCDC3, $p < 0.02$, $d = 0.80$ [Supplementary Materials (Table S7)].

Lastly, different t-tests with the winger data from the technical variables did not reveal significant differences between halves in any value. On the contrary, the same analysis of physical load variables revealed significant differences between halves in DC, $p < 0.001$, $d = 1.30$; WR, $p < 0.04$, $d = 1.08$; SZDC2, $p < 0.001$, $d = 0.59$; SZDC3, $p < 0.001$, $d = 1.18$; SZDC4, $p < 0.01$, $d = 0.70$; SZDC5, $p < 0.02$, $d = 0.73$; HACC1, $p < 0.001$, $d = 1.41$; HACC2, $p < 0.001$, $d = 1.14$; HACC3, $p < 0.04$, $d = 0.63$; ACCHI, $p < 0.04$, $d = 0.69$; HDCC1, $p < 0.001$, $d = 1.45$; HDCC2, $p < 0.001$, $d = 1.69$; HACCDC1, $p < 0.001$, $d = 1.30$; HACCDC2, $p < 0.001$, $d = 0.97$; HACCDC3, $p < 0.04$, $d = 0.58$; DACCHI, $p < 0.04$, $d = 0.66$; HDCCDC1, $p < 0.001$, $d = 1.51$; HDCCDC2, $p < 0.01$, $d = 1.05$, and HDCCDC3 $p < 0.03$, $d = 0.71$, respectively [Supplementary Materials (Table S8)].

4. Discussion

The current research focused on analysing the effect of halves on technical performance and physical demands. Our study's results indicate that, concerning technical performance, no significant differences between halves were found for goalkeepers, wingers, and forwards. However, significant declines were observed in the number of ball contacts, releases per minute, and possessions per time among central defenders, lateral defenders, and central midfielders. Regarding the observed physical demands, it was noted that in outfield players, there was a significant decline in total distances covered at different speed thresholds, as well as a decrease in the number and distance of acceleration measures, most of which were lower in the second halves compared to the first, irrespective of playing positions (see Figure 2A,B for better comprehension).

We note that central and lateral defenders, along with central midfielders, showed a decline in the number of technical actions and overall involvements during the second halves compared to the first. However, goalkeepers, wingers, and forwards maintained similar levels of technical performance throughout both halves. These findings are consistent with a study conducted during the English Championship season, which reported that match-specific factors led to a reduction in total possessions and the number of passes during the second half of matches [16]. Additionally, these results align with another study conducted in the Italian Serie A league, which found a decline in certain technical scores, such as involvements with the ball, short passes, and successful short passes, from the first to the second half [17].

(A) Technical variables

Figure 2. *Cont.*

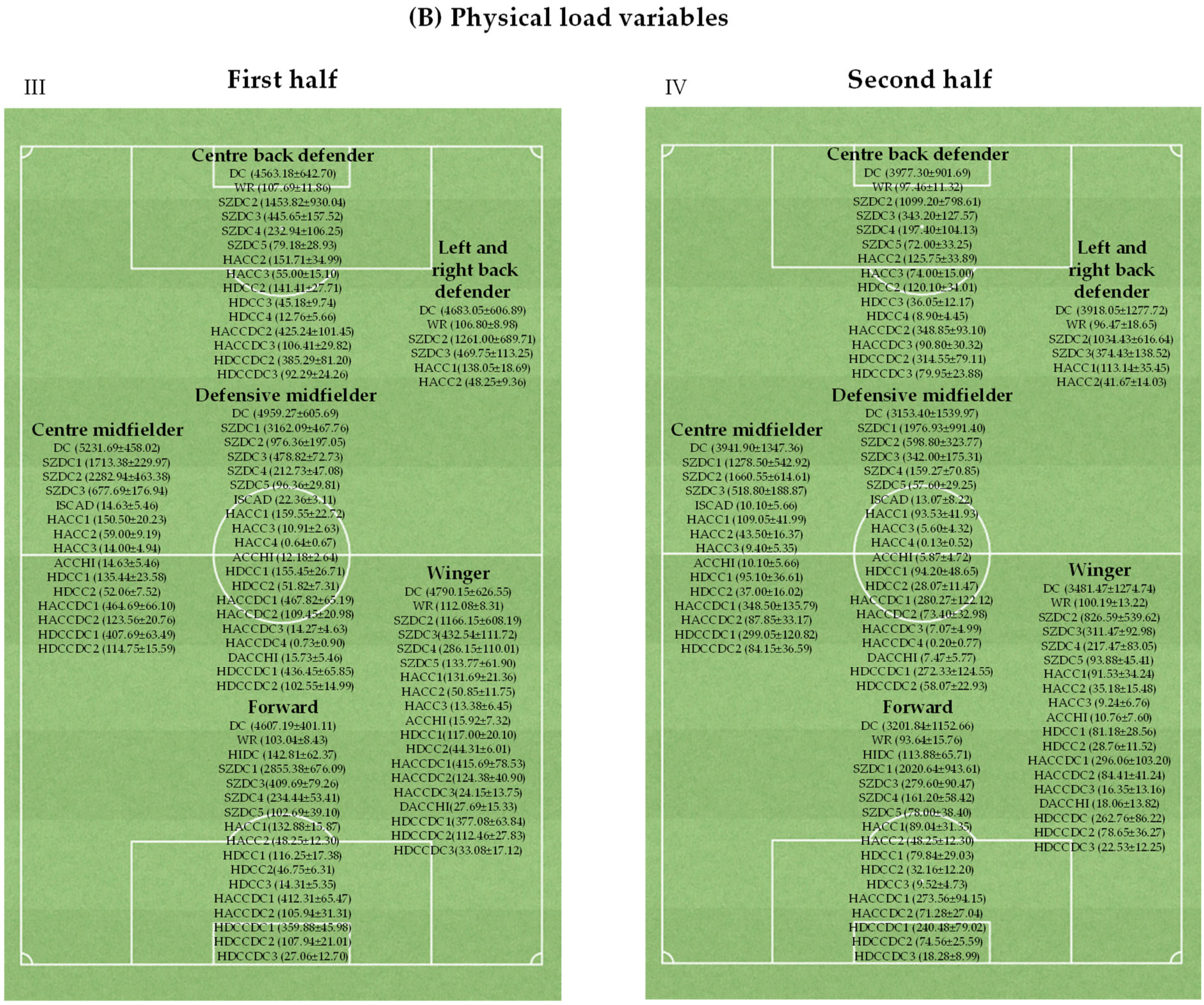

Figure 2. (**A**) Summary figure. Variables with significant differences between halves can be observed for technical variables. (**B**) Summary figure. Variables with significant differences between halves can be observed for physical load variables.

In soccer, the decline in technical actions among central defenders, lateral defenders, and central midfielders from the first to the second halves of matches can be attributed to a combination of physical, physiological and tactical factors. Scientific studies have shown that as matches progress, players experience fatigue due to the continuous physical demands of the game [18]. This fatigue can lead to a decrease in cognitive function and decision-making ability, which are crucial for executing technical actions, such as accurate passing, intercepting passes, and maintaining positional discipline [19]. Additionally, central defenders, lateral defenders, and central midfielders often bear the brunt of defensive responsibilities, requiring them to cover large areas of the field and engage in frequent physical duels with opponents. As fatigue sets in, these players may become less effective in their defensive duties and less inclined to contribute to attacking plays [20], resulting in a decline in technical actions in the second half.

Conversely, goalkeepers, wingers, and forwards are less affected by the fatigue-induced decline in technical actions due to differences in their movement pattern, physiological demands and tactical roles. Goalkeepers typically engage in intermittent bouts of intense activity, such as diving saves and commanding their defensive line, but they experience fewer continuous running demands compared to outfield players [21]. Wingers and forwards, on the other hand, often rely on short bursts of speed and explosive movements to create scoring opportunities, which may be less affected by fatigue than the sustained running and defensive efforts of central defenders and midfielders [22]. Moreover, the tactical roles of these players often prioritise attacking contributions over defensive responsibilities, allowing them to conserve energy and maintain their technical proficiency throughout the duration of the match [23]. Thus, while central defenders, lateral defenders, and central midfielders may experience declines in technical actions in the second half due to fatigue, goalkeepers, wingers, and forwards are able to maintain similar levels of performance across both halves of a soccer match. Another factor could be that wingers and forwards are often prioritised for substitution by coaches, leading to their being fresher compared to defenders, who are less frequently substituted.

Our findings also showed a trend towards a decrease in the distance covered, as well as the number and distance of accelerations and decelerations, from the first to the second halves. These results are consistent with previous studies, indicating that locomotor demands tend to diminish in the second halves, especially following particularly demanding initial halves [24].

For instance, midfielders typically exhibit a higher total distance covered during a match compared to other positions. This heightened distance is attributed to their role as orchestrators of play, necessitating frequent transitions between offensive and defensive manoeuvres [25]. Moreover, midfielders usually perform numerous short sprints and quick changes of direction to maintain possession or thwart opposition advances. These movements demand significant energy expenditure, thereby contributing to the observed decline in the intensity of their accelerations and decelerations as the match progresses [26]. As fatigue sets in, the ability to sustain high-intensity efforts diminishes, leading to a reduction in the frequency and distance covered during such bursts of activity [27].

Conversely, the role of a central defender offers insights into a contrasting pattern of movement. Central defenders are characterized by their focus on defensive solidity, requiring fewer explosive bursts of speed and quick changes of direction) compared to midfielders or forwards. Instead, their movements often entail maintaining positional awareness, engaging in physical duels, and executing precise interceptions [28]. Consequently, while central defenders may cover significant distances over the course of a match, their movements are typically characterized by fewer high-intensity accelerations and decelerations. This trend is further accentuated as the match progresses, as the physical demands placed on defenders tend to be more consistent throughout the game, with a lower reliance on sudden bursts of speed or quick changes of direction [29].

The present study contributes to understanding the impact of halves on technical performance and physical demands in soccer, shedding light on both limitations and avenues for future research. One limitation of our study lies in its focus primarily on male soccer players, potentially limiting the generalisability of our findings to other populations, such as female players. Addressing these limitations and challenges allows for the optimisation of Playermaker™ devices and wearable sensors to provide valuable insights into player performance, as well as to inform training and recovery strategies effectively. However, what might appear to be limitations in this environment are actually strengths. For example, the accuracy and precision of Playermaker™ devices have been demonstrated in various studies [30–32]. The data management system is intuitive and easy to use, facilitating efficient handling and analysis of large datasets. Furthermore, the wearable sensors are designed to be comfortable and do not affect player performance or willingness to wear the devices. By leveraging these strengths, Playermaker™ devices and wearable sensors can enhance our understanding of player dynamics and contribute to more effective athletic training and performance optimisation strategies.

Another crucial aspect to highlight is the interaction between TL and PL and how they jointly influence performance. Understanding this relationship allows for the identification of optimal load levels for different positions, leading to tailored training and better management of energy expenditure. This holistic approach helps in developing reliable fatigue metrics and identifying injury patterns, enhancing the use of wearable technology and data analytics post event and real-time load monitoring. Additionally, exploring the mental load and stress recovery dynamics can significantly optimise decision making and overall player well-being. Future research could explore whether similar patterns emerge across diverse player demographics and competition levels. Additionally, while our study highlighted declines in technical actions and physical demands in the second halves, the specific mechanisms driving these changes remain incompletely understood. Further investigation could delve into the interplay between tactical dynamics, physiological fatigue, and psychological factors to elucidate the underlying causes more comprehensively. Moreover, our study predominantly relied on match statistics and physical performance measures, overlooking potential qualitative insights from player interviews or observational data. Incorporating qualitative methodologies could provide richer insights into players' experiences and perceptions of fatigue-related changes during matches. Furthermore, while our findings underscored differences in performance between playing positions, future research could delve deeper into positional variations within broader player categories (e.g., defensive midfielders vs. attacking midfielders) to uncover more significant patterns.

5. Conclusions

In conclusion, this research sheds light on the impact of halves on technical performance and physical demands in soccer, revealing distinct patterns across playing positions. While goalkeepers, wingers, and forwards maintain consistent performance levels throughout both halves, central and lateral defenders, along with central midfielders, exhibit declines in technical actions and overall involvement in the second halves. These declines may be attributed to a combination related to the movement pattern, the physiological demands and tactical responsibilities, particularly for defenders who bear the brunt of defensive duties. This study also highlights variations in locomotor demands, with most players experiencing decreased intensity in accelerations and decelerations as the match progresses, as well as distances covered at different speed thresholds. Overall, this study contributes to enhancing our understanding of the holistic and multifaceted dynamics of soccer performance and provides valuable insights for coaches, players, and researchers aiming to optimise player performance.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app14135811/s1, Table S2: Differences between halves in Technical and physical load variables in goalkeeper; Table S3: Differences between halves in Technical and physical load variables in centre-back defender; Table S4: Differences between halves in Technical and physical load variables left and right back; Table S5: Differences between halves in Technical and physical load variables in defensive midfielder; Table S6: Differences between halves in Technical and physical load variables in centre midfielder; Table S7: Differences between halves in Technical and physical load variables in forward; Table S8: Differences between halves in Technical and physical load variables in winger.

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Institutional Review Board Statement: The study was conducted in accordance with the ethical principles of the 1964 Helsinki declaration for human research and was approved by the Research Ethics Committee of the University of Granada (nº: 3882/CEIH/2023.).

Informed Consent Statement: Participants were briefed on the research objectives and provided consent indicating their understanding of potential benefits and risks. They were also made aware of their right to withdraw from participation at any point. Prior to the intervention, participants were verbally briefed and asked for their consent.

Data Availability Statement: The data that support the findings of this study are available from the main author (José Carlos Barbero-Álvarez) upon reasonable request.

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