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First vs. Second Half Match Running Performance in Professional Football: Insights from GPS Tracking

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Abstract

This study aimed to determine whether there are differences in the running performance of football players between the first and second halves. For this study, 10 professional outfield football players from FK Budućnost (Podgorica, Montenegro), who competed in the Montenegrin First League during the 2022/23 season, were analyzed. They had participated in the full duration of both halves in a single match. Using Global Positioning System (GPS) technology (K-Sport Universal, Montelabbate, Italy), players' MRP was analyzed based on 13 variables related to distances at various intensities, total distance, number of sprints, high acceleration/deceleration metrics, distance per minute, maximum speed, and heart rate parameters. The results showed that there were differences between the first and second halves in eight out of thirteen MRP parameters, including distance at very high-intensity speed (p=0.018), distance at sprinting speed (p=0.022), number of sprints (p=0.027), distance at very high deceleration (p=0.023), distance per minute (p=0.014), maximum speed (p=0.007), number of decelerations (p=0.008), and average heart rate (p=0.034). The main findings indicate that players demonstrated significantly higher levels of physical and physiological performance in the first half compared to the second. Our results show that due to the high demands of football matches, players' performance tends to decline and is difficult to maintain at the desired level. Although our findings are noteworthy, they should be interpreted with caution, as the study involved a relatively small sample size.

Keywords: *match running performance, soccer, halves differences, physical fitness, high-speed running, GPS data*

Introduction

The importance of physical preparation in football has changed over time and today represents an indispensable factor. Modern football is played stronger, faster, and more explosively, with an assumed flawless technical–tactical readiness (Katanić, Ugrinić, & Ilić, 2019). Some authors emphasize that physical fitness is of crucial importance for the manifestation of football players' performance (Castagna, Chamari, Stølen, & Wisløff, 2005), and that technical–tactical skills can only come to the fore if a player possesses a high level of physical preparedness (Bangsbo, 1994; Hoff, Wisløff, & Engen, 2002).

We are witnessing that football today imposes ever-increasing demands on players. During a single football match, players cover on average around 10–12 km, performing between 1,000 and 1,200 changes of movement. In other words, activity changes occur every 5–6 seconds (Bangsbo, 1994; Helgerud, Engen, Wisløff, & Hoff, 2001). In addition, throughout the match, players perform various movements, including walking (25%), low-intensity running (37%), submaximal running (20%), sprinting (11%), and backward running (7%) (Di Salvo et al., 2007; Marković & Bradić, 2008).

In recent years, one of the most monitored parameters of physical fitness in football has been match running performance, which has become the subject of numerous scientific studies (Katanić, Radaković, et al., 2025; Modrić, Versić, & Sekulić, 2021; Modrić, Versić, Morgans, & Sekulić, 2023; Ponce-Bordón, López-Gajardo, Lobo-Triviño, Pulido, & García-Calvo, 2024; Radaković et al., 2025; Radaković,

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Katanić, Stanković, Jelaska, & Jelaska, 2026).

For monitoring movement performance, the Global Positioning System (GPS) has established itself as the standard tool in team sports (Bourdon et al., 2017), with confirmed validity and reliability of GPS devices (Hoppe, Baumgart, Polglaze, & Freiwald, 2018; Varley, Fairweather, & Aughey, 2012). Consequently, there has been a growing number of studies using GPS tracking in soccer (de Albuquerque Freire et al., 2022; Katanić, Bjelica, et al., 2025; Oliva-Lozano, Granero-Gil, & Panascì, 2024).

Match running performance (MRP) can influence outcomes, as higher-ranked teams cover greater total distance and achieve more high-speed running compared to lower-ranked teams (Chmura et al., 2022). This is particularly important because high-speed running allows differentiation between various phases of play (Nobari, Oliveira, Brito, Pérez-Gómez, & Ardigò, 2021). It is also essential to recognize that cumulative fatigue during a match (i.e., differences between the first and second half) leads to declines in performance regarding total distance covered, high-speed running, and sprinting (Vigne, Gaudino, Rogowski, Alloatti, & Hautier, 2010).

When comparing the two halves, some studies report greater total distance and more high-speed running in the first half (Baron, Cardinale, & Di Salvo, 2007; Di Salvo et al., 2007; Nobari et al., 2021). In contrast, other authors found no significant differences (Bradley, Sheldon, Wooster,Olsen, & Krustrup, 2009; Di Salvo et al., 2007), while certain findings suggest higher total and sprint distance in the second half (Andrzejewski, Chmura, Pluta, & Konarski, 2015).

It is evident that, although several studies have examined this aspect of physical fitness through players' movement performance during matches, the precise dynamics of match halves, fatigue, and high-speed running are still not well defined. Due to these inconsistent findings, further research is needed to more accurately determine differences in players' physical fitness throughout a match. The GPS system, as the standard monitoring tool, can undoubtedly contribute to this understanding. In this regard, our study aims to use an advanced GPS system to identify differences in players' running performance between the first and second halves. The findings of this research will add to the existing body of knowledge on MRP and may help improve understanding of how players' physical condition evolves during a match.

Methods

Sample and study design

For this study, 10 professional outfield football players from FK Budućnost (Podgorica, Montenegro), who competed in the Montenegrin First League during the 2022/23 season, were analyzed. All players had participated for the full duration of both halves in a single match. Goalkeeper was excluded from the study due to their specific role (Konefał et al., 2019; Modrić et al., 2021). The players were informed about the study's aims and provided written consent to participate. The identities of the players and teams were kept anonymous to ensure confidentiality, in accordance with principles of the Declaration of Helsinki. Additionally, this research was approved by the Institutional Board of the Montenegrin Sports Academy.

Procedures

During a non-competitive football match, FK Budućnost players were equipped with portable Global Positioning System (GPS) technology. The GPS has established itself as the standard tool in team sports (Bourdon et al., 2017), with confirmed validity and reliability of GPS devices (Hoppe, Baumgart, Polglaze, & Freiwald, 2018; Varley, Fairweather, & Aughey, 2012). The GPS devices (K-Sport Universal, Montelabbate, Italy) were securely placed in special vests worn underneath their jerseys and were designed not to interfere with player comfort. This system enables precise tracking of all player activities during the match and has been used similarly in previous research (de Albuquerque Freire et al., 2022; Katanić, Bjelica, et al., 2025; Oliva-Lozano, Granero-Gil, & Panascì, 2024; Rampinini et al., 2015). After each match, all data were extracted using specialized data analysis software (K-Fitness, K-Sport International, Italy).

Variables

Using the described GPS system, numerous movement parameters were analyzed, including high-intensity running distance (14–19 km/h), very high-intensity running distance (19–25 km/h), sprinting distance (>25 km/h), total distance

Table 1. Match running performance variables

No.	Variable	Abbreviation
1.	Distance at High Intensity Speed > 14-19 Km/h (meters)	14-19 km/h
2.	Distance at Very High Intensity Speed 19-25 Km/h (meters)	19-25 Km/h
3.	Distance at Sprint >25 Km/h (meters)	>25 Km/h
4.	Total Distance Covered (meters)	Total Distance
5.	Number of Sprints (number)	Num Of Sprints
6.	Distance at Very High Acceleration > 3 m/s (meters)	Dist Accelerations
7.	Distance at Very High Deceleration < 3 m/s (meters)	Dist Decelerations
8.	Distance per minutes (meters/minutes)	Dist/min
9.	Maximum Speed (kmh)	Speed Max
10.	Number of Accelerations >3 (number)	Num Accelerations >3
11.	Number of Decelerations <-3 (number)	Num Decelerations <-3
12.	Average heart rate (bpm)	HrAverage
13.	Maximum heart rate (bpm)	Hrmax

covered, number of long-distance sprints >3 m^2, very high deceleration (<-3 m/s^2), distance per minute, maximum speed, number of accelerations (>3 m/s^2), number of decelerations (<-3 m/s^2), average heart rate (HR average), and maximum heart rate (HR max). Specific running speed thresholds for soccer players correspond to previous research (Katanic et al., 2025; Modrić et al., 2021; Radaković, Katanić, Stanković, Masanovic, & Fišer, 2024).

Statistics

All gathered data underwent descriptive statistical procedures, with means and standard deviations calculated. To examine potential differences between the first and second halves, an independent samples t-test was conducted. Statistical processing was carried out using IBM SPSS Statistics software (version 26; SPSS Inc., Chicago, IL, USA), with the threshold for significance established at $p<0.05$.

Results

A comparison between the first and second halves of the football match revealed statistically significant differences in several running and physiological parameters. Players covered greater distances in high-speed zones during the first half. Specifically, in the 19–25 km/h zone, the average distance was 450.20±111.28 meters compared to 369.30±122.97 meters in the second half (p=0.018). Similarly, in the >25 km/h zone, players ran 129.70±64.92 meters in the first half and only 64.90±57.72 meters in the second half (p=0.022).

The number of sprints also decreased from 7.90±2.85 in the first half to 4.90±3.48 in the second half (p=0.027). A notable reduction was also observed in the distance covered during deceleration, with players covering 92.00±24.12 meters in the first half compared to 76.20±27.63 meters in the second (p=0.023).

Analysis of overall activity per minute showed a significantly higher average distance per minute in the first half (111.00±10.01 m/min) than in the second (95.90±19.27 m/min; p=0.014). Maximum speed was also higher in the first half (30.53±1.62 km/h) than in the second (28.80±2.05 km/h; p=0.007).

The average heart rate (HRavg) was significantly higher in the first half (134.00±12.74 bpm) compared to the second half (125.70±13.65 bpm; p=0.034). On the other hand, no significant differences were found between halves for parameters such as total distance covered, distance during accelerations, number of accelerations >3 m/s^2, maximum heart rate, and similar measures (p>0.05).

Table 2. Comparison of physical and physiological parameters between the first and second halves of a football match

Variables	First half	Second half	t	p
14-19 km/h (m)	871.60±203.99	770.30±267.28	1.775	0.110
19-25 km/h (m)	450.20±111.28	369.30±122.97	2.878	0.018*
25 km/h (m)	129.70±64.92	64.90±57.72	2.749	0.022*
Total distance (m)	5356.60±489.64	4921.00±1046.95	1.641	0.135
Num. Of Sprints (n)	7.90±2.85	4.90±3.48	2.642	0.027*
Dist Accelerations (m)	80.90±12.56	74.50±25.70	1.200	0.261
Dist Decelerations (m)	92.00±24.12	76.20±27.63	2.746	0.023*
Dist/min (m/min)	111.00±10.01	95.90±19.27	3.063	0.014*
Speed Max (kmh)	30.53±1.62	28.80±2.05	3.455	0.007*
Num Accelerations >3 (n)	17.90±4.33	17.80±8.09	0.034	0.974
Num Decelerations <-3 (n)	28.50±8.20	21.30±10.73	3.400	0.008*
HrAverage (bpm)	134.00±12.74	125.70±13.65	2.497	0.034*
Hrmax (bpm)	214.50±10.91	207.00±13.86	1.800	0.105

Notes. The values are presented as arithmetic mean and standard deviation (mean ± SD); t – t-value; p – p-value; * - p<0.05; n – number; m – meters.

Discussion

This study aimed to determine whether there are differences in the running performance of football players between the first and second halves. The main findings of the study indicate that players exhibited significantly higher physical and physiological performance in the first half of the match compared to the second, including greater distances covered at high speeds, more sprints, higher maximum speed, and a higher average heart rate. In contrast, no significant differences were observed between halves in total distance covered, acceleration metrics, or maximum heart rate.

Our findings show that a significant difference was established in players' high-intensity running between halves. Specifically, players achieved greater distances at higher intensities in the first half compared to the second, both at speeds of 19–25 km/h (450.20±111.28 m vs. 369.30±122.97 m; p=0.018) and above 25 km/h (129.70±64.92 m vs. 64.90±57.72 m; p=0.022). These results correspond to the findings of Vigne, Gaudino, Rogowski, Alloatti, and Ottier (2010), who demonstrated a significant decline in running performance during the second half. Similarly, Nobari et al. (2021) observed a 10% decrease in sprints towards the later stages of matches. This decline in performance is expected and is a direct consequence of accumulated fatigue in players during the course of the game.

When it comes to other running speeds, it should be highlighted that at 14–19 km/h, players covered approximately similar distances in both halves, which is consistent with the study of Nobari et al. (2021). Furthermore, our findings indicate that the total distance covered was slightly greater in the first compared to the second half, but without statistical significance (5356.60±489.64 m vs. 4921.00±1046.95

m). These values correspond to those reported by Dijkhuis, Kempe, and Lemmink (2021) (5275±223 m), which are also in line with elite Premier League players (5100 and 5340 m per half; Bradley et al., 2009), as well as Europa League players (Andrzejewski et al., 2015). It should be noted that Di Salvo et al. (2007) reported slightly higher TD values in the first half (5709±485 m). Distances covered in the second half were similar to ours, ranging from 4906 ± 225 m (Dijkhuis et al., 2021), whereas Di Salvo et al. (2007) also recorded higher values even in the second half (5684±663 m). Although a difference between halves was also noted in this parameter, it was not statistically significant, most likely due to the small sample size.

Other findings reveal that players performed significantly more sprints, covered greater distances in decelerations, achieved higher average distance per minute, reached higher maximum speeds, performed a greater number of intense decelerations, and recorded a higher average heart rate compared to the second half. These results correspond to the findings of Bangsbo (1994), who noted that distances covered at high to maximal intensities were shorter and the number of sprints lower in the second half compared to the first. It is well known that distance covered at high intensities is one of the key indicators of physical performance in football (Krustrup, Zebis, Jensen, & Mohr, 2010; Mohr, Krustrup, Andersson, Kirkendal, & Bangsbo, 2008; Mohr, Krustrup, & Bangsbo, 2003), given that success in key match activities often depends on players' ability to perform high-speed running (Andrzejewski, Chmura, Konefał, Kowalczuk, & Chmura, 2017; Chmura et al., 2018). This parameter is also considered discriminatory between players competing at higher versus lower levels (Andersson, Randers, Heiner-Møller, Krustrup, & Mohr, 2010; Nielsen, 2004).

Since periods of high-intensity effort during matches place substantial demands on the players' bodies, they result in increased activation of energy systems, accumulation of lactic acid, and a reduction in pH values in active muscles (Krustrup, Mohr, Steensberg, Bencke, Kjær, & Bangsbo, 2006; Šentija, 2009). Consequently, the decline in running performance during the second half can be attributed to fatigue and situational influences (Bradley & Noakes, 2013). This conclusion is further reinforced by the fact that cardiorespiratory fitness shows a strong association with total distance covered and high-intensity running (Radakovic et al., 2024). Therefore, it is essential for football players to maintain a high level of cardiorespiratory fitness and simultaneously develop both aerobic and anaerobic systems. Good aerobic conditioning facilitates better plasma circulation and faster removal of harmful metabolic by-products (Gharbi, Dardouri, Haj-Sassi, Chamari, & Souissi), which enhances recovery between intermittent efforts, while well-developed anaerobic capacity enables players to cope with the high-intensity demands of the game (Forsyth & Farrally, 2000).

These findings may be useful to strength and conditioning coaches, as they highlight the decline in running performance in the second half, which directly reflects an insufficient level of conditioning in players. Accordingly, coaches should place greater emphasis on the development of cardiorespiratory fitness throughout the year. It is also advisable to follow the recommendation of monitoring players' physical fitness across the entire season (Parpa, Katanic, & Michaelides, 2024) and adjust conditioning training plans accordingly, in order to prepare players to meet the high demands of football matches during the competitive period.

Limitations and future directions

Probably the main limitation of this study concerns the small sample size; therefore, for future research on differences in running performance between the first and second halves, a larger sample of participants should be ensured. A suggestion for future studies is to classify players according to their team positions, which would allow us to observe movement differences related to specific playing roles. It would also be valuable to consider analyzing running performance across multiple time intervals within the match, rather than only by comparing the two halves.

Conclusion

This study examined differences in the running performance of football players between the first and second halves. The main findings indicate that players demonstrated significantly higher levels of physical and physiological performance in the first half compared to the second, including greater distances covered at high speeds, more sprints, higher maximum speed, and a higher average heart rate.

Our results show that due to the high demands of football matches, players' performance tends to decline and is difficult to maintain at the desired level. Therefore, football and conditioning coaches should focus on developing cardiorespiratory endurance so that players are able to sustain movement performance in the second half.

Although our findings are noteworthy, they should be interpreted with caution, as the study involved a relatively small sample size. For more detailed conclusions, future research should certainly include a larger number of participants, as well as a greater number of matches.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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