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External Load Seasonal Variations and Positional Differences in Elite Soccer Players

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Abstract

The present study explored the external load in professional soccer players throughout the extent of a full competitive season using GPS tracking technology. Twenty-seven male players were categorized based on their playing position: (1) central defenders (n=5), (2) full-backs (n=4), (3) midfielders (n=9), (4) wingers (n=3), and (5) forwards (n=6). Their physical performance was analyzed and interpreted as the overall external load over the extent of 36 competition recordings and 169 recordings of training sessions from up to 5 days prior to match day (i.e., MD-5, MD-4, MD-3, MD-2 and MD-1). The data were collected only from outfield players (excluding goalkeepers) who participated in >90min of total duration in official games and were analyzed with the use of a 10-Hz GPS tracking device (WIMUPRO, RealTrack Systems Almeria, Spain). The results indicated match days minus three and four as the sessions with the highest intensities and physical demands, with no significant differences between the two days. Significant differences in high-speed running and sprint distance were observed between central defenders and full-backs during matches and training sessions. These results would benefit practitioners in designing the annual plan of professional soccer teams and allow for proper monitoring of the external load based on the players' playing position.

Keywords: *Soccer, GPS, positional differences, high-speed running, sprint distance, high metabolic load distance*

Introduction

Soccer requires great levels of physical conditioning, and practitioners have a complex objective of quantifying the activities to meet these demands (Bradley et al., 2010). In addition, the nature of the sport has evolved tremendously throughout the last decade in terms of physicality, tactical perspectives, and variations in training load (Bradley et al., 2013). Soccer players are required to frequently transition between brief bouts of high-intensity actions and periods of extended low or very low activity. Thus, each weekly microcycle consists of different training designs, triggering endurance, strength/power, speed, the ability to change direction, and reactive agility.

Recently, the global positioning system (GPS) has been implemented in elite-level soccer, and practitioners can quantify the exercise dosage accurately (Randers et al., 2010). The various systems used by professional clubs worldwide have been presented as valid and reliable in quantifying the speed and total distance (TD) covered (Portas et al., 2010). Although disparity may exist, researchers have established categories for important external load variables. For instance, high-speed running (HSR) is heralded as an essential variable and is delineated as the distance covered from 19.8km/h to 25.2km/h. Furthermore, recorded distances above the 25.2km/h threshold are presented as 'sprint distance' (Gregson et al., 2010). The GPS technology can further assess accelerations and decelerations, change of direction, and vertical power (Vickery et al., 2014). Accelerations at maximum intensity have been established and categorized with three different thresholds, 2.78m/s-2,9 3m/s-2,10 and 4m/s-2, respectively (Buchheit et al., 2014). The high volume of accelerations and decelerations during competitive matches was associated with an increased mechanical load which, if altered, could decrease muscular performance and intensify risks of muscular damage (Gastin et al., 2014). The authors discuss that the high-intensity intermittent activity that characterizes both the training sessions and official matches can potentially increase the mechanical, locomotor, and metabolic external

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and internal load of players. Mallo & Dellal (2012) suggest that practitioners must have an annual plan (periodization) to adjust the external load appropriately. Emphasis is given to the microcycle, which is the weekly training plan designed to prepare the players for the official game. Microcycle variability is challenging to encapsulate and is a subject of debate among practitioners (Carling et al., 2016). The authors argue that a major reason for the difficulties in microcycle planning is the significant variability in physicality among player positions. Typically, defenders cover less distance with low metabolic power, whereas midfielders perform more accelerations and decelerations. Wingers and strikers cover more distance with high speed-running and perform more high-velocity actions (Delaney et al., 2018). Thus, an ideal microcycle should include the appropriate training load variations considering the positional playing needs of the athletes. Despite the successful physical performance being influenced by a myriad of factors, the design of the preceding to the official game microcycle is one of them. Although the literature is limited, recent reports demonstrated that the microcycle running performance might affect the official game running performance (Harriss, Macsween & Atkinson, 2019). Therefore, this study aims to quantitatively analyze the physical performance of elite soccer players throughout a complete competitive season, assess the weekly microcycles and how they relate to game day's physical performance, and evaluate the variations in physical performance between playing positions.

Methods and materials

Participants

Twenty-seven male division-1 elite soccer players (age: 28.12±5.5 years, height: 179.3±6.25 cm, body mass: 75.8±6.6 kg) participated in this study. The players were categorized based on their playing position. The study examined their physical performance during the weekly microcycles and official matches throughout an entire season. Furthermore, data were collected only from outfield players (excluding goalkeepers) who participated in >90min of the total duration of official games. The study was approved by the University of Central Lancashire Science, Technology, Engineering, Medicine and Health (reference number STEMH 541) ethics committee board and the Cyprus National Committee on Bioethics (CNCB, 7 July 2021). Furthermore, this study was conducted ethically based on the international standards (Harriss, Macsween & Atkinson, 2019).

Sample

The sample consisted of 36 competition recordings and 169 recordings of training sessions from up to 5 days before matchday 5 (MD-5) (i.e., MD-5, MD-4, MD-3, MD-2, and MD-1). Similarly to previous studies by Di Salvo et al. (2013), players were categorized into five different playing positions: central defenders (n=5), full-backs (n=4), midfielders (n=5), wingers (n=3), and forwards (n=6) (Table 1).

Table 1. Descriptive characteristics (Mean ± SD) of the professional soccer players per playing position.

Positions	n	Age (years)	Height (cm)	Weight (kg)	Body fat (%)	VO2max (ml/kg/m)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Defenders	3	33 ± 2	181.67 ± 4	82.60 ± 2.5	9.71 ± 1.3	52.69 ± 3.8
Full backs	6	26.7 ± 4.6	176.83 ± 6.2	71.13 ± 3.5	9.73 ± 1	54.79 ± 2.7
Midfielders	6	28.2 ± 5.7	178.33 ± 2.3	76.85 ± 5.6	10.43 ± 1.5	56.83 ± 3.6
Wingers	3	30 ± 7	175 ± 7	71.67 ± 2.9	9.25 ± 1	54.44 ± 3.9
Forwards	4	29 ± 6.3	178 ± 2	77.63 ± 3.8	8.01 ± 0.7	55.01 ± 2.2
All positions	22	29.4 ± 2	178.0 ± 1.8	76.0 ± 1.2	9.4 ± 0.3	54.8 ± 0.8

Equipment and data collection

Recordings of external load parameters were analyzed with the use of a 10-Hz GPS tracking technology (WIMUPRO, RealTrack Systems Almeria, Spain). The efficiency and reliability of these devices have been successfully evaluated in recent studies (Gomez et al., 2019; Pino et al., 2019). Detailed intercession of separating drills and acquiring recordings of active time was executed in real-time (SVIVO software, version 2021.211.2.0, RealTrack Systems Almeria, Spain). Following the conclusion of each session, all data and activity markings were transferred to a computer and examined by SPROTM (RealTrack Systems Almeria, Spain).

Analyzed parameters

The external load parameters were recorded as the following: The total distance (TD) covered in meters. The high metabolic load distance (HMLD) is the distance covered in meters when the metabolic power is over 25.5 W/kg. Furthermore, this value corresponds to the moments when running is intense >5.5 m/s2, including high acceleration activities (Tierney et al., 2016). Absolute high-speed running (HSR) represents the distance covered at >21km/h. The sprint distance was recorded when the running speeds were greater than 24km/h (Di Salvo et al., 2013). Finally, the number of accelerations and decelerations and the respective distances covered during these actions.

Statistical analyses

Statistical analyses were performed using the statistical package of social science SPSS (Version 26.0 for Windows; SPSS inc., Chicago, IL, USA). Descriptive statistics are presented as means and standard deviations for the anthropometric measurements and the physical parameters during training sessions and match days. Data were analyzed using the (ANOVA) repeated measures within-between interactions to assess possible differences between player positions and their physical performance between training sessions and match days. Furthermore, the weekly external load and its effect on match performance were analyzed using (ANOVA) repeated measures over time. Finally, a G*power analysis for the (ANOVA) repeated measures within-between interactions with a medium effect size (d=.50) was conducted to determine the appropriate sample size (Faul et al., 2017). The required sample size of minimum eight participants per group was needed to obtain 95% statistical power.

Results

The results were normally distributed, and equal variances were assumed based on the results of Levene's test ($F(4,17)=1.02$, $p=.421$). No significant differences were observed in the remaining parameters between player positions. The mean scores for all parameters and sessions depending on playing position are presented in Table 2.

Significant differences were observed between all sessions concerning the player's performance (Table 3).

Table 2. Players' performance parameters (mean and standard deviation) on each session independent of their playing position.

Match Days		Distance (m)	Duration (min)	HMLD (m)	Explosive Distance (m)	Accelerations (count)	Decelerations (count)	Distance Acceleration (m)	Distance Deceleration (m)
-1 MD	Mean	3546.94	58.75	460.04	426.36	2215.96	2215.64	163.82	77.69
	Std. Deviation	320.75	9.80	61.09	50.12	404.75	404.73	34.36	17.36
-2 MD	Mean	3687.98	61.36	478.67	436.51	2244.32	2243.38	160.78	75.26
	Std. Deviation	269.51	9.19	94.42	70.83	363.80	363.08	36.56	20.26
-3 MD	Mean	4917.47	65.74	814.39	657.55	2340.94	2340.62	265.66	136.62
	Std. Deviation	447.19	7.10	106.72	90.54	308.22	308.37	54.96	28.58
-4 MD	Mean	4574.86	65.33	744.53	622.80	2366.03	2365.83	262.95	123.34
	Std. Deviation	522.40	8.87	103.73	97.95	371.36	371.59	44.05	27.15
-5 MD	Mean	4525.48	61.70	656.13	616.40	2217.64	2217.14	209.17	110.02
	Std. Deviation	445.00	8.48	153.98	118.26	395.10	395.53	55.85	34.29
MD	Mean	10023.30	93.04	1962.92	1343.54	2929.61	2929.43	417.89	307.62
	Std. Deviation	796.71	2.01	354.06	222.81	313.94	314.45	91.34	64.86
Total	Mean	5212.67	67.65	852.78	683.86	2385.75	2385.34	246.71	138.42
	Std. Deviation	2266.58	14.06	542.59	332.01	435.32	435.46	103.46	86.59

Note. HMLD: high metabolic load distance

Table 3. Significant differences between sessions in all parameters.

Parameters	Wilks' (Λ)	F
Total Distance	0.007	364.850*
High Metabolic Load Distance	0.026	96.479*
High-Speed Running	0.42	59.545*
Sprint Distance	0.064	38.188*
Acceleration Count	0.027	93.855*
Deceleration Count	0.025	101.593*
Acceleration Distance	0.087	27.141*
Deceleration Distance	0.063	38.770*

Note. *$p<0.05$

The TD and HMLD covered by the players independent of their playing position had no significant difference among training sessions during MD-5, MD-4, and MD-3 and between MD-2 and MD-1. However, training sessions during MD-5, MD-4, and MD-3 demonstrated a significant difference com-

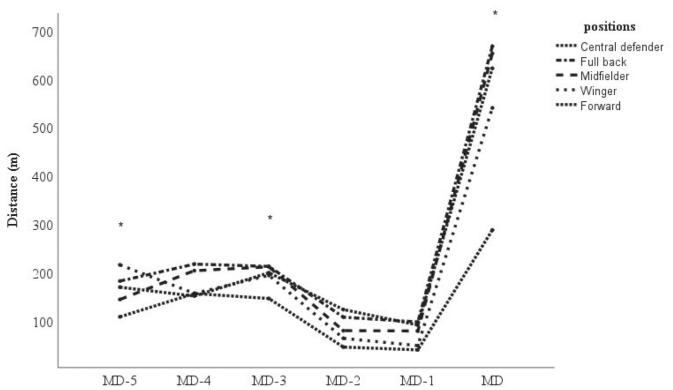

FIGURE 1. Estimated sessions based on player position. Estimations were performed for HSR (distance covered >21km/h). Significant differences were observed between central defenders and full-backs when indicated by * ($p<0.05$).

pared to MD-2 and MD-1. Similar results were observed for HSR and sprint distance between the sessions with a single exception, as MD-1 and MD-2 differed significantly. The accelerations and decelerations count significantly differed between MD-1, MD-5, and MD-1, MD-4. Further assessment of the distance covered in acceleration and deceleration indicated significant differences between MD-2 and MD-1 and MD-5, MD-4, and MD-3. A significant difference in the distance covered in acceleration and deceleration was also observed between MD-5 and MD-4. Furthermore, the MD-3 was significantly different from both MD-5 and MD-4. The MD was significantly different from all sessions in all parameters, and the MD-2 and MD-1 were significantly different from MD-5, MD-4, and MD-3. The player position had significant effects on HSR and sprint distance. Specifically, the significant differences were between central defenders and full-backs (Figures 1 & 2).

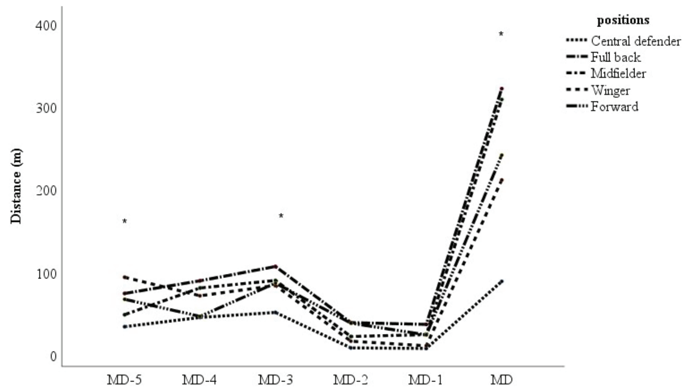

FIGURE 2. Estimated sessions based on player position. Estimations were performed for Sprint distance (distance covered >24km/h). Significant differences were observed between central defenders and full-backs when indicated by * ($p<0.05$).

Discussion

The present study aimed to demonstrate the professional soccer players' seasonal variations in measures of external load during training sessions and official matches using GPS technology. The study further quantified the work-rate outcome of each player depending on their playing position and the effects of the weekly microcycles on their physical performance during the official games. The results demonstrated that the mean TD of an elite Cypriot division-1 soccer player independent of playing position throughout a 90-min match amounted to 10148m. Our findings rank fairly below the average recordings for TD covered by elite international soccer players. Based on the literature, players participating in the UEFA Champions League cover an average of 10723m, top-level Europa league players cover an average of 11320m, while TD covered by elite Premier league players is reported to be around 10500m (Andrzejewski et al., 2015; Bradley et al., 2016). Although TD can deviate between leagues, the results of our study could have been significantly affected by external elements such as player formation, team strategy, different climates, and match outcomes (Pons et al., 2021).

The external load parameters analysis indicated a significant difference in training load between the MD-5, MD-4, and MD-3 as well as between the MD-2 and MD-1. The highest values of external load were recorded during the MD-4 and MD-3 days, representing the loading phase of the weekly microcycles (Delaney et al., 2018). In contrast, the lowest values were documented during the MD-2 and MD-1. Additionally, locomotor values of external load, such as HSR and sprint distance, decreased gradually throughout each microcycle, therefore characterizing the tapering and pre-game phases (Vanrenterghem et al., 2017). There was a significant difference demonstrating greater values of locomotor performance in MD-2 than in MD-1. Premier League teams have reported similar training periodization (Malone et al., 2015). Nonetheless, few studies diverge from applying HSR within the last three days before competition due to the limited recovery time, typically on the hamstring muscles. The total load deriving from HSR on the hamstring muscles should be followed by a seventy-two-hour rest period for the full recovery of the muscle group (Ekstrand, Hagglund, & Walden, 2011). Therefore, operating with HSR-related exercises on MD-3, MD -2, and MD-1 could prevent a complete hamstring muscle recovery. The current study recorded a mean score of 199m of HSR in MD-3, which is 33% of the HSR usually recorded during MD, and it is considered a low-risk value (Rampinini et al., 2007). Nevertheless, high-velocity sessions are necessary to maintain and improve performance and aid injury prevention (Sweeting et al., 2017). Locomotor parameters are significantly different from soccer players' total metabolic demands (Buchheit et al., 2015). The highest accelerations count, decelerations count, and distance covered, indicating the metabolic power and external mechanical load, were recorded during MD-4 and MD-3. The results show the additional locomotor external load recorded from HSR and sprint distance, thus, categorizing the two sessions as the peak performance from within the microcycle. Research indicated that distances covered with high metabolic power are relatively different from high-velocity distances (Guadino et al., 2014). The high metabolic load distance covered in training sessions and matches is approximately twice as high as the distance covered at high velocities (Osgnach et al., 2010). The load applied from these explosive parameters is often underestimated and neglected in basic analytics, even though 85% of maximum accelerations fail to extend into high-speed movements (Varley & Aughey, 2013). Inadequate monitoring of high metabolic load during training sessions can be crucial as increases in accelerations and decelerations during competitive matches are associated with decreased neuromuscular performance and risks of skeletal muscle damage (Gastin et al., 2019). Therefore, obtaining precise data from each training is essential to appropriately analyze the total external load (Cummins et al., 2013). The current study presented no significant difference in mechanical and locomotor external load between MD-4 and MD-3. Although greater emphasis is typically applied to monitoring HSR, it is indicated that the quantity of medium and high accelerations and decelerations are very similar between training sessions and matches (Tom et al., 2017). Therefore, differentiating the appropriate required stimulus from accelerations and decelerations in conjunction with HSR/sprint distance between training sessions can aid in developing superior training models.

The current study assessed the positional differences in player performance during competitive matches and demonstrated significant differences between central defenders and full-backs on HSR and sprint distance. Similar results were observed during training sessions as full-backs recorded the highest values in HSR and sprint distance. Our findings agree with the theory that central defenders typically cover significantly less distance at high velocities, and midfielders and full-backs are accountable for the superior metrics in those parameters (Delaney et al., 2018). Obtaining knowledge of the physical requirements depending on the player's position can be highly beneficial in designing a training regime that could support each position's physical necessities with the appropriate training load. Accordingly, training sessions should include regiments based on the player's physical profile considering the high-velocity activities and external locomotor load significantly different from the total metabolic demands (Guadino et al., 2014).

To our knowledge, this is one of the few studies that analyzed the GPS data of professional adult male players of the first division in the region. Despite the significant findings, this study comes with limitations. The main limitation is the small sample per playing position. Future studies with a greater number of players in each position are encouraged using video analysis with GPS.

Conclusion

In sum, the current observational study presented data from a complete season of a professional soccer team that competes at the highest level of the Cyprus Soccer League. The outcome of the current study demonstrated the applied external load during training sessions and official matches amongst different playing positions in elite soccer players. The results on external load from weekly microcycles categorized MD-4 and MD-3 as the sessions with the highest intensities and physical demands, with no significant differences between the two days. Whereas the sessions with the lowest physical values were those of MD-1. Significant differences in HSR and sprint distance were observed between central defenders and full-backs during matches and training sessions. The study demonstrated how the training load varies during the microcycles and official match days, as well as playing position differences. Finally, this study presented the annual data on accelerations and decelerations. The results revealed significant differences between training sessions in both the distance covered in accelerations and decelerations and the extent of their quantity. These results would benefit practitioners in designing the annual plan of professional soccer teams and allow for proper monitoring of the external load based on the players' playing position.

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Conflict of Interest
The author declares that there is no conflict of interest.

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