Original Article

Seasonal physical performance of a professional team's football players in a national league and European matches

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ABSTRACT

To quantify the seasonal motor skills profile by a professional team's football players in official matches covered all pre-season matches in national and European championships of the 2016/2017 season. Twenty-seven players were sampled using Global-Positioning-System Technology (GPS). Total distance in meters-(TD), Maximal-Sprinting-Speed running (MS), Very-High-Intensity speed running (VHS), relative Distance/time (D/T) were estimated at two high speed categories: VHS; from 19.8 to 25.2Km/h and MS;>25.2Km/h). Analysis of variance was performed. Midfielders players seem to cover significantly greater mean TD than defenders and forwards (10363 vs. 9887 and 9717 meters, respectively, $p<0.001$). Furthermore, Midfield players covered greater mean D/T than forward group (99.3 vs. 92.0 meters/mins, respectively, $p=0.001$). With regard to the match outcome, lower average of TD was covered in matches were the end result was the defeat than those with match outcome win or draw (9488 vs. 10188 and 10148 meters, respectively, $p<0.001$). Similarly, the same was noted when the TD levels were controlled for the match outcome, with adjustment of the characteristics of the players, playing position and the three periods of the competitive season. This study showed the changes in all types of tested motor skills by the top national team across an annual season. The use of this monitoring approach may contribute to the development of individual training programs for the football players according to their position and specific demands through the season which serve to further enhance soccer performance and reduce the incidence of fatigue or injury.
Keywords: Football; GPS; Match analysis; Motor skills; Total distance running.

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INTRODUCTION

Modern football is characterized by highly dynamic and acyclical game movements, interspersed with frequent bouts of high-speed movements and a number of high variability of actions, players' motor and mental preparation as well as technical-tactical skills (Bangsbo, 1994; Bangsbo, 2009). Motion analysis of the match performance of elite football players is important in order to determine the necessary motor potential for players and define standards in modern football (Konefal et al.,2015).

Professional football clubs utilize Global Positioning Satellite (GPS) system to monitor the players speed and distance covered during training and official competitive matches. Collectively, the data provides the total external workload placed on a player. Distance covered by players and teams in a game is one of the objective methods in assessing performance. Elite football players can cover from 10 to 13,5 km during a game, which depends on playing position (Bangsbo, 1994; Barros et al.,2007; Di Salvo et al.,2007). The longest mean distance in a match is shown to be covered my midfielders (9.83-12.29Km), followed by defenders (9.57-11.41Km) and forwards (9.61-11.38Km) (Bangsbo et al.,2009; Di Salvo et al., 2007). During a football match each player performs 1,000 to 1,400 actions. Sprints, which can last from 2 to 4 seconds, are repeated by football players every 1.5 minutes on the average (Stolen et al.,2005). Football players from the UEFA European league teams can cover sprinting distance from 167 to 345m while in the English and Spanish top football leagues the highest number of sprints per game is performed by forwards (from 12 to 16) and the lowest by defenders (from 8 to 9) (Bradley et al., 2009; Di Salvo et al.,2009; Andrzejewski et al., 2013). Furthermore, it has been observed that football players reach peak running speeds close to 32km/h during match play (Rampinini et al., 2007a; Rampinini et al., 2007b).

It is very difficult for football players to maintain their motor skills at a relatively high level across an annual season including both the pre-season and in-season phases using GPS monitoring methods. Although GPS devices are now being used officially during matches by numerous football clubs, very little information is still available about their application to the study of physical profiles in elite football players during official competition matches. To current knowledge, no published studies have described the physical and physiological profile of players using GPS technology in seasonal official matches. Accordingly, the aim of the current study was to analyse for the first time the physical and physiological profile of elite professional football team in official matches of a national League and in European matches during an annual season (including pre-season matches) using GPS, quantifying the dose-response of the match stimulus (external load incurred by football players).

MATERIALS AND METHODS

Participants

The study covered all domestic national league games, national Cup and European league (qualification of Champions League or UEFA Europa league groups) of 45 matches in 2016/2017 season. Data were collected for one entire annual season spanning 49 weeks, from June 27th, 2016 to April 30th, 2017 (6 weeks pre-season, 43 weeks in-season). The team used for data collection competed in 3 official competitions across the season, included European competition, which often means that the team played 2 or 3 matches per week (included national Cup matches).

Twenty-seven elite outfield professional football players belonging to a team in a European Championship League (mean age: 26.6 years, body weight 74.1 Kg, body height 180.9 cm), participated in the present study with 302 total measurements. The participating players consisted of 11 defenders (159 measurements), 13

midfielders (115 measurements) and 3 forwards (28 measurements). Only those players were selected who played the entire duration of a match during the season. The study was approved by the institutional ethics board and written informed consent was obtained for each participant (Smpokos et al., 2017).

Measures - Match analysis data

Each match was monitored using a computerized semi-automatic video match analysis image recognition system (data were supplied by Viper pod 2, STATSport, Belfast, UK). The data systematically analysed using proprietary software to provide an interactive coaching and analysis tool that provided a comprehensive data on each individual (Impellizzeri et al., 2006). Match data collection for this study was carried out at the football club's official stadium and both home and away stadiums, respectively.

Each player's physical activity, during each match, was monitored using portable global positioning system (GPS) units (Viper pod 2, STATSports, Belfast, UK). This device provides position velocity and distance data at 10Hz. Each player wore a special adjustable neoprene harness which enables this device to be fitted to the upper part of his back (i.e. between the left and right scapula). All devices were activated 30 minutes before data collection to allow acquisition of satellite signals, and synchronize the GPS clock with the satellite's atomic clock (Maddison and Mhurchu, 2009). GPS data were downloaded after every match and analysed using the respective software package (Viper PSA software, STATSport, Belfast, UK). In order to avoid inter-unit error, players wore the same GPS device for each game (Buchheit et al., 2014; Jennings et al., 2010).

Physical performance external measurements

The players' external load that were selected for analysis included total distance covered (TD), relative total distance: distance/time (meters/minutes) (D/T), and two high speed categories were used: Very High Speed running (VHS; from 19.8 to 25.2 Km/h) and Maximal Speed-Sprint (MS;>25.2Km/h) (Di Salvo et al., 2009; Jennings et al., 2010). A sprint was defined as a running exercise lasting at least 1 sec at the speed of at least 25.2 Km/h (>7 m/s).

Seasonal variation in match activity profiles

The seasonal variations were investigated comparing the mean TD, VHS, D/T, VHS and MS of the players during three periods of the competitive season: Start (From pre-season period: 16th of June to November, 14 matches,), mid (From December to first half of February, 14 matches) and End (last half of February to end of April, 17 matches).

Statistical analysis

Data were analysed using the SPSS software (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp). Distributions of descriptive characteristics of the 27 professional football players were estimated. Various descriptive characteristics were assessed according to players' position with non-parametric Kruskal-Wallis test. Using analysis of variance, motor activity measurements were also assessed according to players' position or matches' outcome. Furthermore, multiple analysis of covariance was performed to assess motor activity measurements by the three periods of the season 2016/17. As covariates were used age, weight, height, the position of the players and the matches' outcome. Effect size (η^2) and heterogeneity of comparisons were also estimated.

RESULTS

A comprehensive overview of the studied population and its characteristics is given in table 1. Participants were 27 elite professional football players [mean age 26.6 years (±4.6), body weight 74.1 kg (±6.7) and height 180.9 cm (±7.0)]. The participating players consisted of 11 defenders that covered all 45 matches of the 2016/2017 season and involved 159 measurements, 13 midfielders involved with 115 measurements and 3 forwards with 28 measurements.

It is worth noticing to mention that age, weight and height that they were obtained at the beginning of the season 2016/2017, were not found any difference by the players' position (p>0.10). Moreover, in 45 matches the outcomes were 27 wins (60.0%), 9 draws (20.0%) and 9 defeats (20.0%).

Table 1. Descriptive characteristics of 27 selected professional football players, participating in the current study.

		mean	*stand. deviation*	*min*	*max*
Age, *years*		26.6	4.6	17.9	35.9
Body weight, *kg*		74.1	6.7	63.0	90.0
Body height, *cm*		180.9	7.0	169.0	193.0
Position	*defenders*	n=11(159 measurements†)			
	midfielders	n=13(115 measurements)			
	forwards	n=3(28 measurements)			

Age, weight and height were obtained at the beginning of the season 2016/2017 and were not different by the players' position (Kruskal-Wallis tests, p>0.10).
† The total measurements were 302 and retrieved from 45 matches during the 10th month season of 2016/2017 (27th June 2016 to 30th April 2017). In 45 matches the outcome was: 27 wins, 9 draws and 9 defeats.

Table 2 outlines the mean motor activities measurements (TD and D/T covered in match play by players, in each speed category) across the different playing position. Overall Midfielders players covered greater TD than the defenders or forwards (10363 vs. 9887 and 9717 meters, respectively, p<0.001).

Furthermore, Midfield players covered significantly greater mean D/T than forward group (99.3 vs. 92.0 meters/mins, respectively, p=0.001). The analysis of covered distance in various intensity ranges [MS> 25.2 Km/h and VHS >19.8 Km/h] revealed that there were no statistical differences in each speed category. With regard to the match outcome (table 3), a significantly lower mean TD was covered in matches were the matches' outcome was the defeat than those of win or draw (9488 vs. 10188 and 10148 meters, respectively, p<0.001).

Table 2. Motor activities measurements of football players in the current study, according to their position in matches in the season of 2016/17.

	Measurements			
	Total Distance *meters*	**Maximal Sprinting Speed running distance**, *meters (sprinting or speed>25.2 Km/h)*	**Very high-intensity speed running distance**, *meters (sprinting or speed>19.8-25.2 Km/h)*	**Distance/Time**, *meters/minutes*
Position	mean(stand. error)			
defenders	9887(87)	126.5(6.4)	466.1(13.6)	96.5(0.8)
midfielders	10363(102)	140.1(7.5)	475.8(16.0)	99.3(0.9)
forwards	9717(206)	133.8(15.3)	477.7(32.4)	92.0(1.8)
p-value	<0.001	0.385	0.877	0.001
η^2	0.050	0.006	0.001	0.046

Analysis of variance. Effect size was estimated by the partial eta-square (η^2). Post-hoc comparisons (based on Bonferroni test) were shown midfielders having significant higher levels of defenders and forwards in Total Distance ($p<0.05$) and forwards in Distance/Time ($p<0.05$).

Table 3. Motor activities measurements of football players in the current study, according to matches' outcome in the session of 2016/17.

	Measurements			
	Total Distance *meters*	**Maximal Sprinting Speed running distance**, *meters (sprinting or speed>25.2 Km/h)*	**Very high-intensity speed running distance**, *meters (sprinting or speed>19.8-25.2 Km/h)*	**Distance/Time**, *meters/minutes*
Matches' outcome	mean(stand. error)			
win	10188(80)	137.9(5.9)	482.4(12.6)	96.9(0.7)
draw	10148(136)	113.7(10.1)	451.0(21.4)	96.8(1.2)
defeat	9488(146)	135.6(10.9)	455.4(23.1)	98.5(1.3)
p-value	<0.001	0.114	0.342	0.535
η^2	0.057	0.014	0.007	0.004

Analysis of variance. Effect size was estimated by the partial eta-square (η^2). Post-hoc comparisons (based on Bonferroni test) were shown in wins and draws significant higher levels versus to defeats in Total Distance ($p<0.05$) as well as in wins versus to draws in very high-intensity running distance ($p<0.05$).

Similarly, the same was noted when the TD levels were controlled for the match outcome, with adjustment of the characteristics of the players, playing position and the three periods of the competitive season (figure 1). Time-motion analyses of the observed football matches demonstrates that in matches were the outcome was defeat significantly lower mean TD was observed compare to the outcome that was wining or drawing (9542 vs. 10187 and 10104 meters, respectively, p=0.001). The effect size of the match outcome on TD measurement was also estimated at η^2=0.05 and based on interaction of the two previous factors (position & outcome), significant effects were revealed in TD and in D/T (two-way analysis of variance: p<0.001, η^2=0.111 and p=0.035, η^2=0.054, respectively) (results not shown in table/figure).

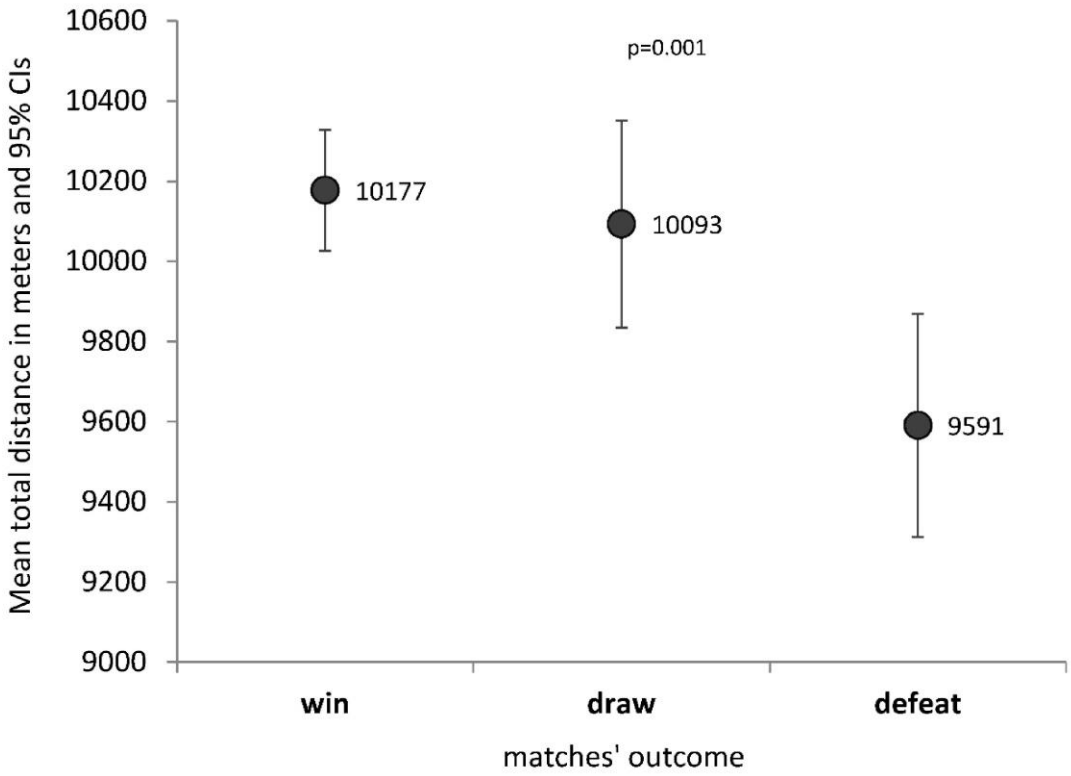

Figure 1. Total distance covered by the football players in the current study and according to matches' outcome during in the season of 2016/17.

Analysis of covariance. As covariates were used age, weight, height, the position of the players and the periods of the season. Effect size was estimated as η^2=0.05. Heterogeneity was tested by Levene's test

Finally, significant differences were observed in motor activities measurements according to the three periods of the competitive season 2016/17 (table 4). The mean TD was greater in the second period (mid-season) of the annual league season compared to first and third (10318 vs. 9806 and 10021 meters, respectively, p=0.004).

However, during the beginning of the official league matches and through the transition from the 1st to 2nd and 3rd period, significant increases in MS running distance were observed (120.3, 130.9 and 144.2 meters, respectively, p-trend=0.027), in VHS distance (416.6, 487.4 and 502.8 meters, respectively, p-trend<0.001) and in D/T (93.9, 97.0 and 100.1 meters/minutes, respectively, p-trend<0.001).

Table 4. Motor activities measurements of football players in the current study, according to three periods of the season 2016/17.

	Three periods of the season 2016/17				
	1st †	2nd	3rd		
Measurements	mean (stand. error) [n]			*p*-value	p-trend
Total Distance, *meters*	9806(106) [94]	10318(107) [100]	10021(103) [108]	0.004	0.145
Maximal Sprinting Speed running distance, *meters (sprinting or speed>25.2 Km/h)*	120.3(7.7)	130.9(7.8)	144.2(7.5)	0.086	0.027
Very high speed-intensity running distance, *meters (sprinting or speed>19.8-25.2 Km/h)*	416.6(16.3)	487.4(16.5)	502.8(15.9)	<0.001	<0.001
Distance/Time, *meters/minutes*	93.9(0.9)	97.0(1.0)	100.1(0.9)	<0.001	<0.001

† The periods of the season were the 1st: pre-season to the 1/3 of the Greek Super League Championship (14 matches), the 2nd: the 2/3 of the Championship (14 matches) and the 3rd: the last part 3/3 of the Championship (17 matches). Multiple analysis of covariance. As covariates were used age, weight, height, the position of the players and the matches' outcome. Effect sizes were estimated with partial η^2 in above four measurements: 0.038, 0.017, 0.053 and 0.069, respectively. Heterogeneity was tested by Levene's test.

DISCUSSION

The aim of the present study was to identify for the first time the seasonal motor skills profile of elite football players competing in a national League and in European official matches (including pre-season matches) using GPS monitors. The main findings of the present study reflected that: 1) playing position impacted significantly on relative mean TD covered thus Midfielders players covered greater TD 2) With regard to the match outcome, lower average of TD was covered in matches were the outcome result was the defeat than those in win or draw, and 3) The motor activity measurement of the TD according to three periods of the competitive season 2016/17, was revealed that TD in the second period of the annual League season was greater compared to first and third.

The results of the present study show that the average total match distance for the midfield players, throughout the 90-min play, amounted to 10,363m. Although large discrepancies exist in published data for the distance covered by players in football matches, our results are not in accordance with recent investigations which show that the mean distance covered by male elite outfield players is about 11,000m (Bangsbo, 2002). It could be demonstrated that midfield team role or formation probably because of their linking role in the team, covered a significantly greater distance than both defenders and forward group ($p<0.001$). In line with match-play observations the TD was generally highest in midfield players with the lowest values in forwards. However our results are comparable to the studies performed by Di Salvo et al. (2007) and Rampinini et al. (2007) showing that midfield players covered significantly greater distance per

game than defenders and forwards. The distances reported for midfield players in these earlier studies by Di Salvo et al. (2007): 12027m for central midfield players, 11990m for external midfielders; Rampinini et al. (2007): 11,720m, respectively are markedly longer, compared to data of this current study (10,363m) indicating that in league matches during 2016/2017 domestic season are played probably at lower relative running demands compared to other elite European league matches.

In relative terms midfielders in the present study covered less distance per minute (99.3m· min^{-1}) than those reported in semi-professional football players (113m· min^{-1}) Casamichana et al. (2012) and Australian football players (104m· min^{-1}) Varley et al. (2013), indicating that in other European league official matches are played at higher relative running demands or this difference in relative distance could be a result of a different methodology in how "game time" is defined, or a reflection of the style of play in the team they monitored.

Interestingly, the distance covered at MS did not show any differences between the playing positions. This may partly reflect the fact that players may not frequently reach maximal speed during match play or could reflect the slow pace of the League matches.

The results of the present study appear to confirm the notion that the mean TD covered during an official game is depended on match outcome. The team covered significantly longer distance in won matches than in draw and lost matches ($p<0.001$). This could be explained by the observation that the team may regulate the physical efforts according to the specific demands of individual matches and periods of the game. Match outcome should be taken into account during the assessment of physical aspects of football performance (Andrzejewski et al., 2016). Along with this, as the absolute distance covered could be flawed by the playing time (duration of the game or the player being substituted during the game or just entering to substitute another player), we chose to express the distance relatively to time that is, distance covered per minute (Vigne et al., 2013). Interestingly, the relative TD covered by the team did not show any significant differences depended on match outcome.

One of the most interesting findings of the present study is the observation that TD in the second period (December to first half of February) of the domestic annual league season was significantly greater compared to first and third. Such differences in TD during the 2nd period of in-season competitive period is likely due to the fact that the team was challenging for domestic league matches without any competition to European match. It is generally accepted that fatigue causes a reduction in exercise intensity during sports that require prolonged, high-intensity intermittent exercise. Similar to the present study TD was increased in the second third of the period, suggesting less levels of fatigue. The highest TD covered at the 2nd period of the season may be due to the coaches' decision to give some emphasis on physical conditioning as a continuation of the Christmas break. Notably the VHS and D/T response in the players was higher during the last period of the season than in the first and second. In agreement with our findings, others observed that players covered a greater distance in high intensity at the end than in the middle of the competitive season (Mohr et al.,2003; Rampinini et al., 2007a). Although not controlled in the present study, an improved physical capacity in the last part of the season could explain, at least in part, our results (VHS and D/T). Several studies observe an increase in different physical parameters towards the end of the season (Caldwell and Peters, 2009; Impellizzeri et al., 2008; Nunez et al., 2008).

When interpreting the current findings, a number of limitations should be considered. It is prudent to note that these data were focusing on seasonal variations in physical performance only considered three time points of the season (beginning, middle, and end of the season) (Rampinini et al., 2007a; Mohr et al., 2003). Therefore studies dealing with a higher number of time points for data collection throughout the season are

needed to better comprehend the seasonal variations in game related physical parameters. This study is also reflective of one team only (albeit reflective of the top League team) and hence may not be representative of the customary official game demands of other domestic teams that may be influenced by different coaching philosophies. For example, as players of a lower standard of the league standing generally undergo higher load during match play, there is likely to be a greater total fatigue which determine the effectiveness of match performance. Finally, a future study that seeks to maintain the capacity for a player to perform acceleration and decelerations through the full duration of a match also warrant further investigation.

CONCLUSIONS

In conclusion, this study showed the changes in all types of tested motor skills by the top League team across an annual season. The data from the study revealed that Midfielders players cover a significantly greater TD than the groups of defenders and forwards did. The results of the present study are not in accordance with recent investigations which show that the mean distance covered by male elite outfield players is about 11000m indicating that matches in the national league are played probably at lower relative running demands compared to other elite European league matches. The motor activity measurement of the TD according to three periods of the competitive season 2016/17 was revealed that TD in the second period of the annual League season was significantly greater compared to first and third probably due to the coaches' still having some emphasis on physical conditioning as a result of the Christmas break. Consequently, the use of this monitoring approach may contribute to the development of individual training programs for the football players according to their position and specific demands through the season which serve to further enhance performance and reduce the incidence of fatigue or injury.

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