Journal of Physical Education and Sport ® (JPES), 18 Supplement issue 1, Art 70, pp. 490 - 496, 2018
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Differences in motor activities of Greek professional football players who play most of the season (2016/17)

EMMANOUIL SMPOKOS[1,]; CHRISTOS MOURIKIS[2]; MANOLIS LINARDAKIS[3]
[1,3] Department of Social Medicine, Faculty of Medicine, University of Crete, GREECE.
[1,2] Specialist in Football Science, Football Fitness Coach, Football Performance Analyst

Published online: April 30, 2018
(Accepted for publication April 19, 2018)
DOI:10.7752/jpes.2018.s170

Abstract
Problem statement: In football the quantification of match load can aid to decrease injuries and optimize performance in players. This study examined the seasonal variations in physical/motor activities during an annual season, in professional Greek football players who play most of a season (2016-2017).
Approach: Twenty-seven players were classified as Regular Participants (RPP) (n=5, participating in at least one match in every period of the separated season) and Irregular Participants (IPP) (n=22, did not participate or play in every match over the eight-month-period). Using Global-Positioning-System Technology-(GPS), Total-distance-(TD), high-speed-running-(HSR), very-high-intensity-speed-running-(VHS), maximal-sprinting-(MS), relative-distance/time-(D/T), high-metabolic-load-distance-(HMLD), dynamic-stress-load-(DSL) or number of accelerations-decelerations were measured. Multivariate analysis was performed.
Results: Although there were no significant differences in HSR (p=0.376), HMLD (p=0.071) and VHS (p=0.083) between player categories, RPP completed significantly more MS (151.8 vs. 118.5meters, respectively or difference +33.3, p=0.001), sprints (10.6 vs. 8.5, p=0.001), accelerations (62.4 vs. 57.1n, p=0.016) or decelerations (n) (78.1 vs. 71.9, p=0.027) than IPP. Additionally, in the DSL was recorded for the RPP a significant positive difference up to +53.5% (343.3 vs. 289.9units, p<0.001).
Conclusions: We observed that RPP displayed significant differences in most of the motor activities with MS recording the highest difference. The greater positive values in DSL that was observed in RPP during the season in association to continuous match loads and their fatigue levels could increase the risk of fatigue or injury.
Key Words: GPS; motor skills; football; match analysis; seasonal variations; total distance.

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 & Krustrup, 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, Chumura, Kowalczuk, Andrzejewski, & Chumura, 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 13.5km during a game, which depends on playing position (Bangsbo, 1994; Barros et al., 2007; Di Salvo et al., 2007).

Players' speed skills are crucial for top football performance. Football players from top-level national leagues can cover sprinting distances from 152 to 446m, depending on their position on the field, while players from the UEFA European League teams, from 167 to 345m (Andrzejewski, Chmura, Pluta, Strzelczyk, & Kasprzak, 2013; Bradley et al., 2009; Di Salvo, et al., 2007).

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 (preparation phase) and in-season phases using GPS monitoring methods (Andrzejewski, et al., 2013). Although the typical training daily program of professional players may be sufficient in order to promote readiness for the next match, it could also be suggested that it is the participation in match play itself that is the most important and appropriate stimulus for preparing players for the physical demands of match play (Silva et al., 2011). In this way, discrepancies in physical loads between players could lead to differences in important components of fitness which could subsequently presented itself on match day when irregular participants players not accustomed to match loads are now required to complete the habitual physical loads performed by regular staring players (Anderson et al., 2016).

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

Corresponding Author EMMANOUIL SMPOKOS, E-mail: msbokos@edu.med.uoc.gr

during official competition matches. To the best of this study author's knowledge, no study addressed the physical and physiological profile of players with different starting status [Regular Participants-(RPR) and Irregular Participants (IPP)] using GPS technology in seasonal official matches in Greek League.

With this in mind, the aim of the present study was to investigate the seasonal variations in physical (motor) activities of elite professional Greek football players in official matches of a national League and in UEFA European matches across an annual season by separated the season in eight month period in those players considered as RPP and IPP.

Materials & methods

Design and 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 of the preparation phase and 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 Greek team took part in the present study. The total measurements were 302 and retrieved from 45 matches. When quantifying data from the entire season there were 5 regular participation players (RPP) (mean age: 24.1years, body weight 70.6Kg, height 178.8 cm, body mass index 22kg·m^{-2}, player position percentage: defenders 60%, midfielders 40%) and 22 irregular participation players (IPP) (mean age: 27.2, body weight 75Kg, height 181.4cm, body mass index 22.8kg·m^{-2}, players position percentage: defenders 36.4%, midfielders 50%, forwards 13.6%). Their weight was measured on calibrated digital scales (Seca 861; Seca, Hamburg, Germany) to the nearest 0.1 kg and height was measured to the nearest 0.5 cm with a wall mounted stadiometer (Seca 225; Seca), without shoes. Body mass index (BMI) was calculated as weight divided by height, squared (kg·m^{-2}). The seasonal variations were investigated comparing the levels of physical (motor) activities of the players during eight periods (months) of the competitive season: start from preparation phase period of June-August (14 matches for RPP vs. 7 for IRP, respectively) and October (12 matches for RPP vs. 17 for IRP respectively), November (10 matches for RPP vs. 13 for IRP, respectively), December (15 matches for RPP vs. 27 for IRP, respectively), January (19 matches for RPP vs. 32 for IRP, respectively), February (20 matches for RPP vs. 34 for IRP, respectively), March (16 matches for RPP vs. 23 for IRP, respectively) and April (20 matches for RPP vs. 23 for IRP respectively,). It is noted that in September there were no measurements as official matches of the national league games were started in October. The study was approved by the institutional ethics board and written informed consent was obtained for each participant (Smpokos, Mourikis, & Linardakis, 2017).

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 analyzed using proprietary software to provide an interactive coaching and analysis tool that provided a comprehensive data on each individual (Impellizzeri, Sassi, & Rampinin, 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, Viper 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 & Ni Mhurchu, 2009). GPS data were downloaded after every match and analyzed 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, Cormack, Coutts, Boyd, & Aughey, 2010).

Physical (motor) activity measurements

The players' external load that were selected for analysis included total distance covered (TD; km), relative total distance: distance/time (meters/minutes) (D/T), maximum sprint velocity reached (Vmax) (m/s) and high speed categories were used: Very High Speed running (VHS; from 19.8 to 25.2Km/h) and Maximal Speed-Sprint (MS;>25.2Km/h) or High Speed Running (zone 5 + zone 6) (HSR;>19.8Km/h, in meters) (Di Salvo, et al., 2007; Jennings, et al., 2010). A sprint was defined as a running exercise lasting at least 1 sec at the speed of at least 25.2Km/h (>7 m/s). Acceleration activity was measured on the basis of the change in GPS speed data and was defined as a change in speed for a minimum period of 0.5 s with a maximum acceleration in the period at least 0.5 m·s^{-2}. The acceleration was considered finished when the player stopped accelerating. The classification of accelerations by zone is based on the maximum acceleration reached in the acceleration period. The same approach was used with regard to deceleration. The load and intensity measures were identified as total number of accelerations or decelerations (>2 m·s^{-2}) and accelerations/min or decelerations/min, respectively. In addition, the "dynamic stress load" was calculated as the total of the weighted impacts. Impacts were weighted using convex-shaped function (approximately a cubic function), an approach similar to the one used in the speed

intensity calculation, with the key concept being that an impact of 4g is more than twice as hard on the body as an impact of 2g. The weighted impacts were totaled and finally scaled to give more workable values expressed in arbitrary units (AU). The load and intensity measures were identified as Dynamic Stress Load (DSL) (Bangsbo & Krustrup, 2009). Both speed intensity and dynamic stress load were calculated automatically using a custom algorithm included in the proprietary software provided by the manufacturers (Viper Version 1.2, STATSports, Belfast, UK). High Metabolic Load Distance (HML; distance covered >25.5 W $\cdot Kg^{-1}$) was used as measure of movement intensity (Gaudino et al., 2015). The HML distance measure combines the energy cost of all constant velocity running above 5.5m$\cdot s^{-1}$ and acceleration and deceleration activity over 2 m$\cdot s^{-2}$ during intermittent running (Coutts et al., 2015; Osgnach, Poser, Bernardini, Rinaldo, & di Prampero, 2010). Players who didn't get into HSR zones because of covering short, sharp distances were given credit in their HML score because the intensity of the work could be just great.

Statistical analysis

Data were analyzed using the SPSS software (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp). Distributions of descriptive characteristics of the 27 professional football players were estimated according to their participation in matches (RPP and IRP groups). Age and body mass index were compared between the two groups with non-parametric Mann-Whitney test or with chi-square test according to players' position distribution. Multivariate analysis of covariance (mancova) was also performed to assess the differences of motor activity measurements between the two groups (Levene's test was used for testing the equality of error variances). In seasonal differences of Dynamic Stress Load and Maximal sprinting speed, linear models were fitted in order to assess the change of their mean levels into the season of 2016/17.

Results

A comprehensive overview of the studied samples and their characteristics is given in **table 1**. Participants were 27 elite Greek professional football players. The players were classified as RPP (n=5, mean age: 24.1years, body weight 70.6Kg, height 178.8 cm, body mass index 22kg$\cdot m^{-2}$, player position percentage: defenders 60%, midfielders 40%) and Irregular Participants (IPP) (n=22, mean age: 27.2, body weight 75Kg, height 181.4cm, body mass index 22.8kg$\cdot m^{-2}$, players position percentage: defenders 36.4%, midfielders 50%, forwards 13.6%). Furthermore, the total measurements over the eight month period were 126 for the RPP and 176 from the IPP and retrieved from 45 matches.

Table 1. Characteristics of 27 Greek football players according to their participation in matches at different periods during the season of 2016/17.

		Players with	
		Regular participation - RPP†	Irregular participation - IPP†
		n=5	*n=22*
		mean (stand. dev.)	
Age, *years*		24.1 (3.7)	27.2 (4.5)
Body weight, *kg*		70.6 (7.2)	75.0 (6.5)
Body height, *cm*		178.8 (8.7)	181.4 (6.7)
Body Mass Index, *kg·m^{-2}*		22.0 (0.3)	22.8 (1.3)
Player position, *%*	*defenders*	60.0	36.4
	midfielders	40.0	50.0
	forwards	-	13.6
Seasonal Period, *measurements*	*June-August*	14	7
	October	12	17
	November	10	13
	December	15	27
	January	19	32
	February	20	34
	March	16	23
	April	20	23
Total measurements††		126	176

[†]Separation of the players as regular participation – RPP (n=5), was involved their participation in at least one match in every period of the separated season (June-August, October, November, December, January, February, March, and April).
Age, body weight, height and mass index were obtained at the beginning of the season 2016/2017 and were not different by the two groups (Mann-Whitney tests, p>0.10). Non significant difference were also found between the two groups in distribution of their position or in measurements on seasonal period (chi-square test, p>0.10).
[††] The total measurements were 302 and retrieved from 45 matches during the season of 2016/2017 (27th June 2016 to 30th April 2017).

A comparison between player categories (RPP-IPP) in motor activities measurements across the seasonal period 2016/17 is presented in **table 2**. Although there was no significant difference in TD (p=0.062), HSR (p=0.376), HMLD (p=0.071) and VHS (p=0.083) between player categories (RPP/IPP), RPP completed significantly more MS than IPP (151.8 vs. 118.5meters, respectively or difference +33.3, p=0.001), sprints (10.6 vs. 8.5, respectively or difference +2.1, p=0.001), accelerations (62.4 vs. 57.1n, respectively or difference +5.3, p=0.016, decelerations (n) (78.1 vs. 71.9, respectively or difference +6.2, p=0.027), Vmax (8.67 vs. 8.50m/s, respectively or difference +0.17, p=0.016). Additionally, in the DSL was recorded for the RPP a significant positive difference up to +53.5% (343.3 vs. 289.9 units, respectively or difference +53.5, p<0.001).

Table 2. Differences in motor activities of Greek professional football players in the season of 2016/17.

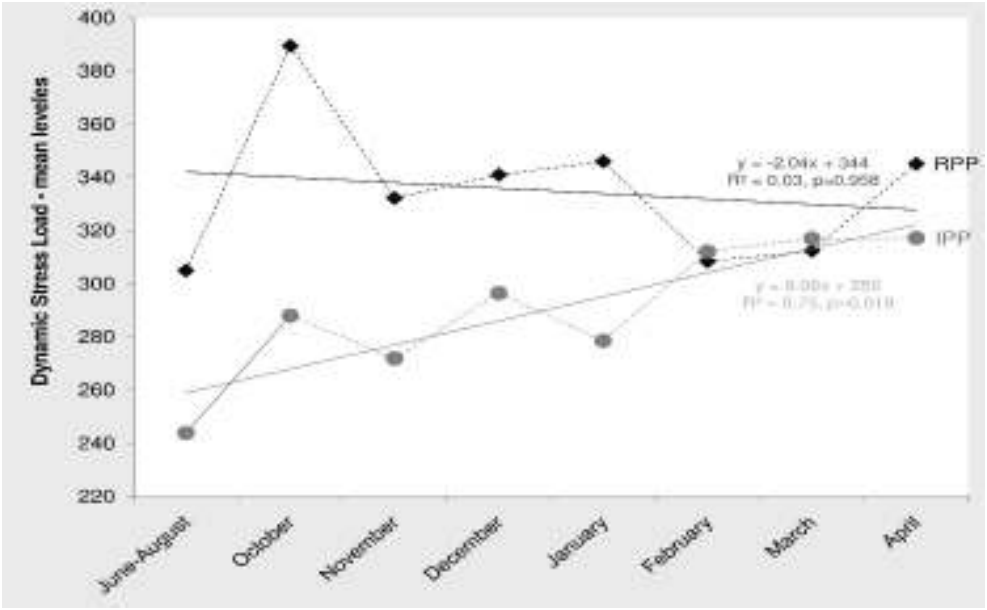
	Players with				
	Regular participation - RPP, n=5	Irregular participation - IPP, n=22			
measurements	i_{RPP}=126	i_{IPP}=176			
	mean (stand. error)		*Difference*	*p*-value	η^2
Total Distance, TD *(meters)*	9903 (100)	10160 (83)	-257	0.062	0.012
High Speed Running, HSR *(running speed >19.8 Km/h, in meters)*	620.9 (21.7)	594.6 (18.1)	+26.3	0.376	0.003
Very high-intensity speed running distance, VHS *(sprinting or speed 19.8-25.2 Km/h, in meters)*	468.3 (16.2)	472.7 (13.5)	-4.4	0.843	0.001
Maximal sprinting speed running distance, MS *(sprinting or speed>25.2 Km/h, in meters)*	151.8 (7.6)	118.5 (6.3)	+33.3	**0.001**	0.033
Distance/Time, D/T *(meters/minutes)*	95.9 (0.9)	98.1 (0.7)	-2.2	0.080	0.010
Dynamic Stress Load, DSL *(Arbitrary Units)*	343.3 (9.5)	289.8 (7.9)	+53.5	**<0.001**	0.054
Sprints *(number)*	10.6 (0.5)	8.5 (0.4)	+2.1	**0.001**	0.035
High Metabolic Load Distance, HMLD *(meters)*	1709 (38)	1803 (32)	-94.0	0.071	0.011
Accelerations *>2m/s2 (n)*	62.4 (1.6)	57.1 (1.3)	+5.3	**0.016**	0.019
Decelerations *>2m/s2 (n)*	78.1 (2.0)	71.9 (1.7)	+6.2	**0.027**	0.016
Maximum velocity (Vmax) (m/s)	8.67 (0.05)	8.50 (0.04)	+0.17	**0.016**	0.019

Multivariate analysis of variance (Levene's test was used for testing the equality of error variances). Age, body mass index ($kg \cdot m^{-2}$) and players' position were used as covariates.

Fig. 1 presents graphically the seasonal differences in DSL in relation to eight month period between the two player categories. In the RPP group, the DSL increased significantly during the eight month period (p=0.019) whereas in IPP group there was not observed any significant difference (p=0.958).

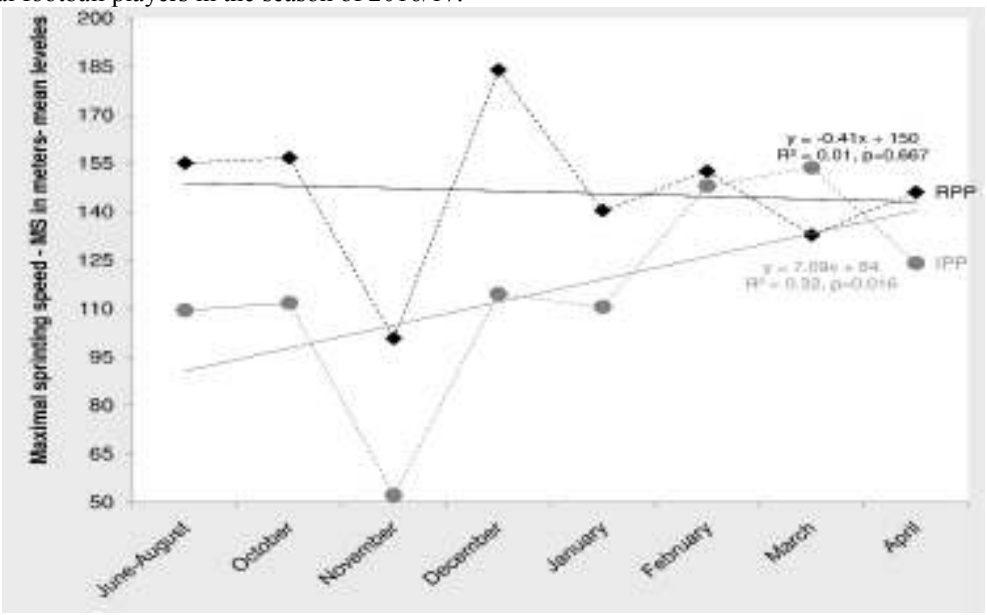
Furthermore **fig. 2** shows RPP group only to significantly increase MS over the eight month period (p=0.001).

Fig. 1. Seasonal differences in Dynamic Stress Load of two groups of Greek professional football players in the season of 2016/17.



RPP, Regular Participation Players; IPP, Irregular Participation Players.

Fig. 2. Seasonal differences in Maximal sprinting speed - MS of two groups of Greek professional football players in the season of 2016/17.



RPP, Regular Participation Players; IPP, Irregular Participation Players.

Discussion

The aim of the present study was to quantify the seasonal variations in physical/motor activities during an annual season in football players in official-matches in those players considered as RPP and IPP. We observed that RPP did not display significant difference in TD, D/T, HMLD and in VHS than IRP. Perhaps more important, was the observation of significant differences during the matches within specific high-intensity speed zones. Moreover in this study RPP had higher DSL values up to +53.5% difference compared to IPP during the annual season.

In this regard, we report that RPP generally performed better values in most of tested motor skills during the season. It appears that during in-season, when RPP have to peak frequently in competition (1-2 times a week), matches actually form the most important physiological stimulus (Issurin, 2010). In our seasonal analysis, we observed no evidence of starting status affecting TD and HMLD covered across the entire period. TD response in IRP was higher compared with RPP but with no significant difference. The average TD ran during the matches in our study (RPP: 9903m vs. 10160m for the IRP) almost reflected that of top-level leagues in Europe and Australia (range 10.063-11.230m) (Bradley et al., 2013; Bradley, Di Mascio, Peart, Olsen, & Sheldon, 2010; Dalen, Jørgen, Gertjan, Geir Havard, & Ulrik, 2016; Manzi, Impellizzeri, & Castagna, 2014; Osgnach, et al., 2010; Wehbe, Hartwig, & Duncan, 2014).

In addition, the significant differences in high intensity patterns for the RPP compared to IPP (MS, Max-speed, accelerations, decelerations, sprints) is also especially relevant when considering that such differences were probably due to RPP engaging in the high-intensity activity associated with match play (Anderson, et al., 2016). These data clearly highlight that it is the participation in frequent match play per se which represents the most appropriate opportunity to achieve high-intensity loading patterns (Anderson, et al., 2016). In addition to the seasonal long physical loads, during official matches, we also quantified the match load separated the season in 8 month periods. In this analysis, we observed that variations in MS between the two groups were especially evident in all of the periods, an effect that was especially apparent between RPP and IPP. Moreover, in November we observed a unexpected drop in MS for both groups and maybe were reflective of a period where the team was challenging for domestic (Greek League/Cup and European honors. In that period the management and coaching staff displayed little squad rotation policies and hence, differences in loading inevitably ensued. Additionally, when players are classified as RPP or IPP are then required to manipulate them in a specific way when designing the daily training program to maintain overall squad physical fitness and game readiness and a potential for injury also exist for both categories due to the necessity to complete uncustomary loading patterns (Gabbett, 2004). The large to very large differences found in DSL accumulation between RPP and IPP were solely related to the playing time probably in the continuous official matches. That is, probably often competition time was the main source of between-players categories differences in accumulated DSL variables (Los Arcos, Mendez-Villanueva, & Martinez-Santos, 2017). To the authors' knowledge this is the first study to report seasonal variations in physical/motor activities completed by elite Greek football players.

There are certain difficulties in making comparisons between studies on match analysis because in football, different analysis systems have been used (position of cameras or technology applied), different intensities have been measured (threshold velocities and criteria time 0.5-1.0 s, for activity classification), different magnitudes have been used to analyze the activity (time or distance), and the criteria to classify the positions of the players have differed across studies (Bangsbo, Norregaard, & Thorso, 1991; Rienzi, Drust, Reilly, Carter, & Martin, 2000). Limited data are available on the between official matches motor activities variability's by separating or splitting the whole season and classify players into two categories as RPP and IPP.

When interpreting the current findings, a number of limitations should be considered. This study is 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 or training 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. Furthermore it is prudent to note that these data do distinguish between specific playing positions. Further research is needed to report data from weekly training for both categories in order to quantify differences as opposed to training time. Future work may focus to address the possible variations of a single squat over multiple seasons. Finally it should be noted that the possibility of some injuries during the season could influence negatively some of the motor activities of the players.

Conclusions

In summary, this study quantified the seasonal variations in physical/motor activities during an annual season in football players in official-matches in those players considered as RPP and IPP. We observed that RPP displayed significant differences in most of the motor activities except in TD, D/T, HMLD and in VHS than IRP. Perhaps more important, was the observation of significant differences during the matches within specific high-intensity speed zones between the two groups and specially in MS with a great difference +33.3%. Moreover in this study RPP had higher DSL values up to +53.5% difference compared to IPP during the annual season, which was solely related to the playing time probably in the continuous official matches and displayed little squad rotation policies. The greater positive values in DSL that was observed in RPP during the season in association to continuous match loads and their fatigue levels could increase the risk of fatigue or injury.

Conflict of interest

No potential conflict of interest was reported by the authors.

References

Anderson, L., Orme, P., Di Michele, R., Close, G. L., Milsom, J., Morgans, R., . . . Morton, J. P. (2016). Quantification of Seasonal-Long Physical Load in Soccer Players With Different Starting Status From the English Premier League: Implications for Maintaining Squad Physical Fitness. *Int J Sports Physiol Perform, 11*(8), 1038-1046. doi: 10.1123/ijspp.2015-0672

Andrzejewski, M., Chmura, J., Pluta, B., Strzelczyk, R., & Kasprzak, A. (2013). Analysis of sprinting activities of professional soccer players. *J Strength Cond Res, 27*(8), 2134-2140. doi: Doi: 10.1519/JSC.0b013e318279423e

Bangsbo, J. (1994). The physiology of soccer--with special reference to intense intermittent exercise. *Acta Physiol Scand Suppl, 619*, 1-155.

Bangsbo, J., & Krustrup, P. (2009). Physical demands and training of top-class soccer players. In T. Reilly & F. Korkusuz (Eds.), *Science and football VI* (pp. 318-330). New York: Routledge.

Bangsbo, J., Norregaard, L., & Thorso, F. (1991). Activity profile of competition soccer. *Can J Sport Sci, 16*(2), 110-116.

Barros, R. M., Misuta, M. S., Menezes, R. P., Figueroa, P. J., Moura, F. A., Cunha, S. A., . . . Leite, N. J. (2007). Analysis of the distances covered by first division brazilian soccer players obtained with an automatic tracking method. *J Sports Sci Med, 6*(2), 233-242.

Bradley, P. S., Carling, C., Gomez Diaz, A., Hood, P., Barnes, C., Ade, J., . . . Mohr, M. (2013). Match performance and physical capacity of players in the top three competitive standards of English professional soccer. *Hum Mov Sci, 32*(4), 808-821. doi: 10.1016/j.humov.2013.06.002

Bradley, P. S., Di Mascio, M., Peart, D., Olsen, P., & Sheldon, B. (2010). High-Intensity Activity Profiles of Elite Soccer Players at Different Performance Levels. *The Journal of Strength & Conditioning Research, 24*(9), 2343-2351. doi: 10.1519/JSC.0b013e3181aeb1b3

Bradley, P. S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P., & Krustrup, P. (2009). High-intensity running in English FA Premier League soccer matches. *J Sports Sci, 27*(2), 159-168. doi: Doi: 10.1080/02640410802512775

Buchheit, M., Al Haddad, H., Simpson, B. M., Palazzi, D., Bourdon, P. C., Di Salvo, V., & Mendez-Villanueva, A. (2014). Monitoring accelerations with GPS in football: time to slow down? *Int J Sports Physiol Perform, 9*(3), 442-445. doi: Doi: 10.1123/ijspp.2013-0187

Coutts, A. J., Kempton, T., Sullivan, C., Bilsborough, J., Cordy, J., & Rampinini, E. (2015). Metabolic power and energetic costs of professional Australian Football match-play. *J Sci Med Sport, 18*(2), 219-224. doi: Doi: 10.1016/j.jsams.2014.02.003

Dalen, T., Jørgen, I., Gertjan, E., Geir Havard, H., & Ulrik, W. (2016). Player Load, Acceleration, and Deceleration During Forty-Five Competitive Matches of Elite Soccer. *The Journal of Strength & Conditioning Research, 30*(2), 351-359. doi: 10.1519/jsc.0000000000001063

Di Salvo, V., Baron, R., Tschan, H., Calderon Montero, F. J., Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. *Int J Sports Med, 28*(3), 222-227. doi: Doi: 10.1055/s-2006-924294

Gabbett, T. J. (2004). Influence of training and match intensity on injuries in rugby league. *Journal of Sports Sciences, 22*(5), 409-417. doi: 10.1080/02640410310001641638

Gaudino, P., Iaia, F. M., Strudwick, A. J., Hawkins, R. D., Alberti, G., Atkinson, G., & Gregson, W. (2015). Factors influencing perception of effort (session rating of perceived exertion) during elite soccer training. *Int J Sports Physiol Perform, 10*(7), 860-864. doi: Doi: 10.1123/ijspp.2014-0518

Impellizzeri, F., Sassi, A., & Rampinin, E. (2006). Accuracy and reliability of a commercial video-computerized, semi-automatic, soccer match analysis system: preliminary results. In H. Hoppeler, T. Reilly, E. Tsolakidis, L. Gfeller & K. Cologne (Eds.), *11th Annual Conference of the European College of Sport Science* (pp. 319-320). Lausanne, Switcher land: Sportverlag Strauss.

Issurin, V. B. (2010). New horizons for the methodology and physiology of training periodization. *Sports Med, 40*(3), 189-206. doi: 10.2165/11319770-000000000-00000

Jennings, D., Cormack, S., Coutts, A. J., Boyd, L. J., & Aughey, R. J. (2010). Variability of GPS units for measuring distance in team sport movements. *Int J Sports Physiol Perform, 5*(4), 565-569.

Konefal, M., Chumura, P., Kowalczuk, E., Andrzejewski, M., & Chumura, J. (2015). The impact of players' motor skills on performance in top German Bundesliga teams. *Trends in Sport Sciences, 4*(22), 185-190.

Los Arcos, A., Mendez-Villanueva, A., & Martinez-Santos, R. (2017). In-season training periodization of professional soccer players. *Biol Sport, 34*(2), 149-155. doi: 10.5114/biolsport.2017.64588

Maddison, R., & Ni Mhurchu, C. (2009). Global positioning system: a new opportunity in physical activity measurement. *Int J Behav Nutr Phys Act, 6*, 73. doi: Doi: 10.1186/1479-5868-6-73

Manzi, V., Impellizzeri, F., & Castagna, C. (2014). Aerobic fitness ecological validity in elite soccer players: a metabolic power approach. *J Strength Cond Res, 28*(4), 914-919. doi: 10.1519/JSC.0000000000000239

Osgnach, C., Poser, S., Bernardini, R., Rinaldo, R., & di Prampero, P. E. (2010). Energy cost and metabolic power in elite soccer: a new match analysis approach. *Med Sci Sports Exerc, 42*(1), 170-178. doi: Doi: 10.1249/MSS.0b013e3181ae5cfd

Rienzi, E., Drust, B., Reilly, T., Carter, J. E., & Martin, A. (2000). Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *J Sports Med Phys Fitness, 40*(2), 162-169.

Silva, J. R., Magalhaes, J. F., Ascensao, A. A., Oliveira, E. M., Seabra, A. F., & Rebelo, A. N. (2011). Individual match playing time during the season affects fitness-related parameters of male professional soccer players. *J Strength Cond Res, 25*(10), 2729-2739. doi: 10.1519/JSC.0b013e31820da078

Smpokos, E., Mourikis, C., Theodorou, A., & Linardakis, M. (2017). Lower extremity strength ratios in professional Greek soccer players. A follow-up study during in-season. *Archives of Hellenic Medicine, 34*(5), 682-689.

Wehbe, G. M., Hartwig, T. B., & Duncan, C. S. (2014). Movement analysis of Australian national league soccer players using global positioning system technology. *J Strength Cond Res, 28*(3), 834-842. doi: 10.1519/JSC.0b013e3182a35dd1