

Physical Activity during a Prolonged Congested Period in a Top-Class European Football Team

Léo Djaoui^{*1ACDG}, MSc; Del P. Wong^{2EG}, PhD; Vincent Pialoux^{1EG}, PhD; Christophe Hautier^{1EG}, PhD; Cristiano D. Da Silva^{3EG}, MSc; Karim Chamari^{4EG}, PhD; Alexandre Dellal^{1,5,6BDEG}, PhD

Authors' Affiliation:

1. Centre de Recherche et d'Innovation sur le Sport (CRIS), Université de Lyon 1, France
2. Technological and Higher Education Institute of Hong Kong, Hong Kong
3. Department of Physical Education, Faculty of Viçosa, Viçosa, Brazil
4. Research and Education Centre, Aspetar, Qatar Orthopaedic and Sports Medicine Hospital, Doha, Qatar
5. Laboratory of "Sport Performance Optimization", National Centre of Medicine and Science in Sports, University of Tunis, Tunis, Tunisia
6. FIFA Medical Excellence Centre, Santy Orthopaedicae clinical, sport science and research department, Lyon, France

Authors' Contribution

- A** Concept / Design
- B** Acquisition of Data
- C** Data Analysis / Interpretation
- D** Manuscript Preparation
- E** Critical Revision of the Manuscript
- F** Funds Collection
- G** Approval of the Article

* Corresponding Author;

Address: CRIS, Bâtiment Raphaël DUBOIS, Campus Universitaire de la Doua 69622 Villeurbanne Cedex, France

E-mail: leo.djaoui@gmail.com

Received: Mar 03, 2013

Accepted: Sep 08, 2013

Available Online: Nov 26, 2013

Abstract

Purpose: The aim of the present study was to examine the variation in physical activity of elite soccer players within successive prolonged periods of fixture congestion over 5 months of competition during the competitive season 2011-2012.

Methods: Sixteen international players, classified into 6 positions (central defenders: CD; full-backs: FB; central defensive midfielders: CDM; wide midfielders: WM; central attacking midfielders: CAM; forwards: FW), were examined during the French First League, French Cup, and UEFA Champion's League matches. The total distance covered at light (<12 km.h⁻¹), sustained-cruising (>18-21 km.h⁻¹), high (>21-23 km.h⁻¹), very high (>23-25 km.h⁻¹), sub-maximal (>25-27 km.h⁻¹), and maximal (>27 km.h⁻¹) intensity running (IR) were measured and analysed using a semi-automatic match analysis system (Amisco Pro™).

Results: No differences were observed between congested and non-congested periods (two vs. one match a week, respectively) for the total distance covered at all the speed thresholds over 18 km.h⁻¹, with no variation in physical fitness over the 5 studied months. Specifically to the playing positions, regardless of the congestion periods, FB and WM covered more distance than CDM over 21km.h⁻¹; FB, WM and FW covered similar distances for all running intensities; and CD and CDM covered shorter distance during non-congested compared to congested periods ($P<0.05$) at light-IR.

Conclusion: The present study reveals that prolonged congested match fixture did not affect the high-intensity physical activity of top-class soccer players during official games during a 5 months fixture period.

Key Words: Fitness Training; Soccer; High-Intensity Running; Motion Analysis; Work Rate; Match Congestion

Asian Journal of Sports Medicine, Volume 5 (Number 1), March 2014, Pages: 47-53

INTRODUCTION

Performance in soccer has been described as the interaction of several factors such as the technical, tactical, physical, and mental aspects [1]. The analysis of the changes of these parameters following a sequence of games or all across a season has already been reported, with data about the eventual differences

in-between players of different positions on the field [2-8]. However, a better understanding of these changes may help to improve the physical preparation of the players according to their playing position.

Since several years, visual estimating methods in soccer have been substituted by the semi-automatic video analysis [6,8,9,10]. This tracking system allows provision of much information in less time than visual

evaluation because it simultaneously collects physical and technical data. More precisely, this system allows the follow-up of all players on the pitch during the match and monitors the total distance covered by the players at different intensities while reporting their technical actions at the same time ^[11].

In general, central defenders (CD) cover the lowest overall distance whereas full-backs (FB) and forwards (FW) complete the greatest number of sprints ^[12]. It has also been shown that the overall distance covered, the distance covered at high intensities and sprinting ($>25.2 \text{ km}\cdot\text{h}^{-1}$) decreased during the second half, more importantly for wide midfielders (WM) and FW than other positions ^[6,7].

However, a congested calendar may also influence physical activity and could modify the time motion characteristics according to the playing positions. In this context, Dellal et al ^[13] and Dupont et al ^[14] did not find significant differences in physical activity when playing two versus one match per week, but reported an increase of injury rates in top-level French and in professional Scottish soccer players.

However, Carling et al ^[15] analyzing French elite soccer data, have reported decreased distances covered at low intensities ($<14 \text{ km}\cdot\text{h}^{-1}$) in a short period of fixture congestion (i.e. 1 month), with a relatively small number of matches analysed. This lack of significant effect of congested periods on high intensity running distances may be explained by the relative short duration of observation, and therefore number of games played, which may decrease the statistical power of the analyses. Moreover, in these studies, running intensity has not been analysed at speeds higher than $25.1 \text{ km}\cdot\text{h}^{-1}$ ^[6], although the maximal running speed in elite soccer match has been found to be between 29 and $35 \text{ km}\cdot\text{h}^{-1}$ ^[1]. Finally, this lack of effect observed during congested fixture, could also be explained by a poor definition/division of the playing positions. It may thus be hypothesized that a more precise classification of the playing positions may reveal an eventual effect of congested fixture as it has been shown for the distance covered ^[2].

In this context, the aim of the present study was to determine the variation of physical activity of international soccer players according to their precise playing positions and the number of matches per week

in a successive prolonged period of fixture congestion (2 matches per week). These findings may help to better individualize physical training according to playing position in professional soccer and to plan training schedule, in particular during prolonged congested fixture.

METHODS AND SUBJECTS

Subjects:

Sixteen international players (age: 24.3 ± 3.2 years; height: 178.1 ± 4.2 cm; body mass: 76.9 ± 4.3 kg) from the same French first League team, took part in this study and were classified into six detailed positional roles: central defenders (CD, $n=3$), full backs (FB, $n=2$), central defensive midfielders (CDM, $n=3$), wide midfielders (WM, $n=3$), central attacking midfielders (CAM, $n=2$) and forwards (FW, $n=3$). Only players who participated in complete match durations were used for analysis, and altogether 132 players' activity was analysed. The study was conducted according to the principles of the declaration of Helsinki and the local university ethics committee approved the study's protocol before the commencement of the assessments.

Protocol:

Elite European matches have been analysed during 4 successive congested periods (2 matches per week) separated by periods of international truce and normal one-game per week microcycles ($n=5$) during the 2011-2012 season. The first congested period was located in August with six matches played over 21 days (P1), the second period in September-October with seven matches in 21 days (P2), the third period occurred in October-November with seven matches in 22 days (P3) and the fourth period was in November-December with six matches in 24 days (P4). Among these 26 matches, only 15 could have been analysed because of match analysis tool unavailability in some stadiums. Physical performances of players were examined in 11 French League matches, one French cup match and three European Champions league matches, using a semi-automatic video tracking system (Amisco ©). The non-

congested and congested periods (1 match vs. 2 matches per week, respectively) were identified during the four periods. Only players who played two matches in a row were included in the congested period's analysis. All players performed about seven training sessions when they played one match a week, and five sessions when they played two matches a week, including recovery strategy sessions such as massages, recovery-drinks and diet supplementation, and alternating cold and hot water immersion of the legs. Recovery strategies were performed on the days after the games and were consistent during the whole season.

Physical performance:

Measurements were recorded using Amisco Pro® system (Nice, France), which has been used and validated by several authors [11,16]. This tracking system records the movements of the 20 outfield players during the whole match by means of 8 stable synchronized and calibrated cameras positioned at the top of the stadium with a sampling frequency of 25 Hz. Signals and angles obtained by the encoders were sequentially converted into digital data and recorded on computers for post match analyses.

Physical performance of each player was recorded and classified as: total distance covered, total distance covered at light (<12 km.h⁻¹), sustained cruising (>18 to 21 km.h⁻¹), high (>21 to 23 km.h⁻¹), very high (>23 to 25 km.h⁻¹), sub-maximal (>25 to 27 km.h⁻¹), and maximal (>27 km.h⁻¹) intensities.

Statistical analysis:

All values were expressed as means ± standard deviations (mean±SD). Kruskal-Wallis tests were used to analyse differences between matches and between periods according to the different speed categories. Then, Mann-Whitney tests were used to analyse the differences between all playing positions according to speed categories first, and to differentiate playing positions according to the congested periods (number of matches per week: 1 or 2) in the same speed running categories. Bonferroni correction was applied for the 15 two by two in-between playing positions' comparisons ($P \leq 0.003$). The level of significance was set at $P < 0.05$.

RESULTS

No significant differences between congested and non-congested periods were found for all distances covered in the zones over 18 km.h⁻¹. However, CD and CDM covered shorter distances than other positions at intensities <12 km.h⁻¹ during non-congested as compared to congested periods (Table 1).

Over the four congested periods analysed, for maximal intensities (>27 km.h⁻¹), FB covered significantly ($p < 0.003$) more distance than CD, CDM, and CAM whereas WM and FW covered more distance than CDM. At sub-maximal intensity running (>25-27 km.h⁻¹) FB covered significantly ($P < 0.003$) more distance than CD and CDM, and WM and CAM more distance than CDM. At very high intensity running (>23-25 km.h⁻¹), FB, WM and FW covered significantly ($P < 0.003$) more distance than CD and CDM. At high intensity running (>21-23 km.h⁻¹), FB, WM, CAM and FW covered significantly ($p < 0.003$) more distance than CD and CDM. At sustained cruising intensity running (>18-21 km.h⁻¹), CAM covered significantly ($P < 0.003$) more distance, and CD less distance ($P < 0.001$), than the other playing positions. At light intensity running (<12 km.h⁻¹), CD and CDM covered significantly ($P < 0.003$) more distance than FW, WM and FW (Table 2).

DISCUSSION

The purpose of this study was to determine if the match physical activity varied during successive congested periods in elite European players according to the playing positions while comparing it to non-congested periods. The main finding was that no significant differences between congested and non-congested periods were observed in distances covered at the running intensities over 18 km.h⁻¹ for all playing positions (Table 1).

These results are in-line with those of Dellal et al [13] and Dupont et al [14] who did not find any effect of a congested fixture period for running speed categories over 19 km.h⁻¹, although the study of Dupont et al

Table 1: Mean distances covered by professional soccer players according to the number of match per week, their playing positions and speed running categories

Variables	N	Total	Distances Covered (meters)						
			>27 km.h ⁻¹	27-25 km.h ⁻¹	25-23 km.h ⁻¹	23-21 km.h ⁻¹	21-18 km.h ⁻¹	<12 km.h ⁻¹	
Central Defenders (CD)	Non-congested	70	10212.1 (451.7)	82.4 (49.9)	83.1 (28.3)	80.4 (40.1)	152.5 (53.5)	371.6 (151.1)	7282.1* (314.3)
	Congested	134	10384.8 (614.1)	71.4 (66.4)	64.9 (41.6)	98.0 (35.0)	138.2 (40.9)	397.2 (122)	7842.3 (290.9)
Full Backs (FB)	Non-congested	70	10581.2 (718.8)	170.5 (69.3)	118 (59.7)	190.3 (81.1)	294.9 (105.1)	604.5 (153.6)	6970.7 (234.7)
	Congested	112	10813.5 (677)	187.6 (77.8)	121.8 (51.6)	189.6 (62.0)	241.9 (73.4)	640.5 (140)	7239.4 (371.3)
Central Defensive Midfielders (CDM)	Non-congested	54	11373.9 (753.3)	36.3 (12.8)	64 (35.5)	87.3 (57.1)	166.7 (78.6)	463.3 (136.7)	7414.3* (456.3)
	Congested	120	11820 (651.7)	38.1 (18.3)	54.6 (30.7)	90.1 (58.3)	140.7 (66.4)	561.7 (155.4)	7854.7 (367.7)
Wide Midfielders (WM)	Non-congested	47	10838.3 (778.2)	100.4 (86.2)	86.2 (44.2)	169.6 (68.3)	269.1 (82.4)	679.9 (131.4)	6676.1 (811.6)
	Congested	99	10733.5 (772.9)	170.9 (101.2)	124.8 (65.6)	177.6 (50.3)	210.9 (33.2)	621.7 (107.8)	6973.0 (449.9)
Central Offensive Midfielders (CAM)	Non-congested	6	12784.0	0.0	89.0	147.0	376.0	952.0	7265.0
	Congested	36	12193.7 (822.9)	41.6 (18.2)	126.2 (40.1)	136.6 (27.8)	309.5 (62.7)	804.0 (74.9)	7323.0 (418.9)
Forwards (FW)	Non-congested	47	10476.7 (646.2)	82.3 (52.4)	89.4 (19.6)	158.7 (46.4)	243.7 (60.1)	646.7 (92.9)	6856.3 (658)
	Congested	88	10513.4 (759.3)	120.5 (72.9)	86.2 (49)	171.8 (69.4)	231.3 (66.3)	590.6 (131.4)	7051.9 (656)
All players	Non-congested	294	10736.3 (824.2)	100.7 (72.8)	90.9 (43.3)	135 (73.8)	225.9 (97.4)	548.8 (185.4)	7135.7 (583.9)
	Congested	589	10974.7 (915.4)	111.3 (90.1)	91.0 (55.0)	141.4 (67.2)	194.6 (78.1)	569.1 (167.3)	7436.8 (559.3)

* $P < 0.05$: significantly lower than same playing position for congested period

Note: non-congested=1 match per week; congested=2 matches per week

presented limited number of matches analysed^[14]. In that regard, high intensity running is one of the most important indicators of physical activity in elite soccer

because it corresponds to decisive short and intense actions which characterize soccer players' effort^[15].

In addition, since total distance covered and high

Table 2: Mean distances covered by professional soccer players according to their playing positions and speed running categories

Playing positions	N	Total	Distance Covered (meters)					
			>27 km.h ⁻¹	27-25 km.h ⁻¹	25-23 km.h ⁻¹	23-21 km.h ⁻¹	21-18 km.h ⁻¹	<12 km.h ⁻¹
Central Defenders (CD)	204	10327.2 (563.3)	75.2 (60.5)	71.2 (38)	91.9 (37.1)	143.1 [‡] (45.2)	388.3 [‡] (130.6)	7752.6 (319.4)
Full Backs (FB)	182	10724.2 (688.7)	181.0 (73.7)	120.3 (53.7)	84.6 (56.7)	262.3 [‡] (88.9)	626.7 (143.5)	7136.1 (346.9)
Central Defensive Midfielders (CDM)	175	11711.6 [*] (687.2)	37.6 (16.7)	57.1 (31.5)	189.8 (68.4)	139.9 [‡] (70.2)	519.3 (154.2)	7779.2 (439.6)
Wide Midfielders (WM)	146	10796.2 (754.6)	148.5 (100.4)	114.6 (62)	175.0 (55.3)	229.4 [*] (58.7)	640.0 (116)	6874.0 (591.4)
Central Offensive Midfielders (CAM)	42	12278 [*] (783.6)	41.6 (18.2)	120.0 (38.9)	138.3 (25.2)	319.0 [*] (62.5)	840.3 [*] (84.5)	7313.3 (375.4)
Forwards (FW)	137	10499.9 (701.3)	105.5 (67.3)	87.1 (42.3)	167.3 (61.4)	238.1 [‡] (61.3)	610.3 (119.9)	6983.5 (646.3)
All players	887	10894.6 (889.8)	107.8 (84.7)	90.7 (51.2)	139.2 (69.3)	205.9 (85.8)	562.2 (173.2)	7335.7 (583.2)

* $P < 0.003$: significantly higher than others playing positions

‡ $P < 0.003$: significantly lower than others playing positions

intensity running distances did not vary during the prolonged period of fixture congestion, it may be suggested that the studied team and players maintained their level of physical performance despite short recovery time between matches. This can indeed be achieved by implementing training sessions with light training load in-between games. In this context, it has to be mentioned that the studied team implemented light technical sessions along with fitness training sessions mainly developing: prevention (proprioceptive and stretching training), agility and short sprinting training. Additionally, the team turn-over (players' rotation) strategy and the in-between matches training (essentially tactical and small-sided games) could also be an explanation of the observed results. Moreover, all these players systematically received post-match recovery strategies (alternating hot and cold water immersion of legs, massage, diet and drink supplementation), which have probably contributed the maintenance of their physical activity in the concerned periods [16,17,18].

The lack of significant differences in high intensity running categories across the different periods of congestion strengthens the literature in this topic [13,14,19,20,21,22], suggesting that intense activity profiles are likely not affected by congested match fixtures. In this context, it has to be noted that the other previous studies analysed high intensity running on short congested period (2 to 8 matches in a row); however, the present study is the first one to analyse variations of physical performance on a prolonged congested period with 26 played matches (15 analysed) in 4 separate periods, over 5 months. Furthermore, running intensity has never been analysed in the thresholds higher than 25.1 km.h⁻¹ [6] whereas the sprinting running speed in elite soccer matches has been found to be around 29 and even reach 35 km.h⁻¹ [1]. The lack of match activity close to these high speeds running could represent a limit for deeper analyses of previous studies.

Unlike high-intensity running, significant differences were found for distances covered at light intensities (<12 km.h⁻¹) for CD: ~7200m vs. ~7800m and for CDM: ~7400m vs. ~7800m (for congested vs. non-congested, respectively) (Table 1).

These results are in contrast with those found by Lago et al (2011) [23] who reported no differences in playing positions and running speed intensities;

however the present study results are in agreement with those found by Carling et al. (2011) who analysed the effects of an 8 matches sequence over 26 days on low intensity running (<11 km.h⁻¹) and total distance coverage. Overall, the results of the present study show that the studied elite French soccer players are able to keep the important efforts for soccer (i.e. high intensity runs and sprints) even in congested periods of repetitive official matches while decreasing the light intensity runs for some playing positions. Indeed, and accordingly Stolen et al (2005) have reported that elite soccer players deal with the fatigue appearing in the second half of a game, by reducing the walking and slow speed running distances, but, keeping high intensity distances at the same level of the first half. This strategy allows the player to cover less absolute distance, while keeping the important efforts, i.e. high intensity runs, in an attempt to keep a minimum standard of performance. Whether this is a natural adaptation of the elite soccer players or in opposition, a voluntary choice is not known.

The present study results did not show any significant variations when comparing the covered distances period by period or match by match in opposition to the results of Carling et al (2011). Such differences might be explained by the number of matches analysed and the statistical logic which would show less difference, in a two by two analysis, with a larger sample. Many explanations could be advanced to justify these results such as player rotation strategy in different matches being used for tactical reasons and/or injury or suspension cases, and would have permitted maintainance some physical shape for the whole team. Indeed, it has been suggested that coaches, scientists and medical staff should consider player rotation to help maintaining performance and to reduce injury risks during congested periods [14]. Sixteen different players participated in the fifteen matches analysed, and none of them have played all 15 matches; the 3 most used players played 13 matches, for instance. Therefore, players' rotation has certainly contributed to maintaining physical performance through matches and periods. Furthermore, most of the analysed players included in the present study have participated in international matches in-between the 4 periods, which should also certainly contribute to increase in their fatigue. Despite that, the results show that they

managed to maintain their high intensity efforts during the games.

The adjustment of the training load could also have contributed to these results. Indeed, during congested weeks, team coaches set the training load according to the fatigue level and placed recovery in priority whereas in non-congested weeks, some training sequences could have been more tiring. Thus, training load was reduced during congested calendar.

The present study is the first one reporting results of sprint intensities over 27 km.h⁻¹. Speed thresholds calibration is also innovative since it has been proposed to analyse physical performance variations every 2 or 3 km.h⁻¹. Sprinting activity variations analysis showed that FB covered significantly more distance than CD and CDM on every high intensities thresholds (from 21 to 27 km.h⁻¹ and higher). This adds new information to results already reported by Dellal et al^[3] and Lago et al^[23], for instance, who found that only CD covered lower distances than other positions' players for these high intensities. No differences were found between FB, WM, and FW at all running intensities (Table 2). Differences between playing positions are, in most cases, in accordance with their specific tactical roles in the playing formation^[24]. These results are in contrast with those of Dellal et al^[2] and Carling et al^[11] who respectively showed that FW and FB covered the higher distances at high intensities (in English FA First League and Spanish La Liga for Dellal et al and French Ligue 1 for Carling et al.). The present study new speed sampling, with reduced and higher calibration speed ranges specified differences between playing positions as compared to previous studies. More specifically, it has been found that CDM covered less distance than CD from >18 to 21 km.h⁻¹ while they covered the same distances from >21 to 23 km.h⁻¹ whereas Lago et al^[23] did not find any differences from 19 to 23 km.h⁻¹. We also showed that FB, WM, and CAM covered more distances than CDM from >25 to 27 km.h⁻¹, and that FB, WM, and FW covered more over 27 km.h⁻¹ distance than CDM. Differences between studies could be explained by the different number of players' analysis (5938 for Dellal et al^[2] vs. 132 for the present study) and/or others variables such as environmental conditions, tactical aspects, quality of opponents and/or match importance. Nonetheless, it would be worthy to further analyse the effects of these

variables on distances covered at pre-sprinting (>25-27 km.h⁻¹) and sprinting (>27 km.h⁻¹) intensities in order to compare the effects with literature data.

Although the present study provides new findings of the physical activity at detailed thresholds of running speed during consecutive congested periods and according to the playing positions, it is important to note that Osgnach et al^[25] have stressed the importance of taking into account accelerations and decelerations when estimating energy expenditure and actual metabolic power. Their analysis showed that the total distance covered at high power represented 26% of total distance, corresponding to 42% of total energy expenditure. Therefore "high intensities" expressed as high power, were in fact two to three times larger than those based only on "running speeds". With this in mind, the present study compared motion analysis based on speeds, as did the majority of the literature studies, allowing comparison; even if this could be biased by the fact that accelerations and decelerations were not taken into account.

CONCLUSION

This study showed that congested match fixture over a prolonged period of 5 months divided in 4 periods did not influence physical activity among top-level European soccer players independent of their playing positions.

This study also presented a new activity profile of running intensity measured up to 27 km.h⁻¹ and higher, and especially showed that full-backs covered the most distance at these "very high intensities". Nowadays, the total distance covered at maximal and sub-maximal intensity is essential in modern soccer players because it varies according to the playing formation, the coach, the country and other variables. A new field of research has been started on running speed intensities close to maximal speed during official matches, and it would be interesting to study the effects of different variables such as climatic conditions, playing formation, opponent quality, amongst others, on these distances covered at maximal running intensities. With such

information, soccer training professionals can individualize the training program according to the needs of each playing position during congested fixture.

ACKNOWLEDGMENTS

We thank all the players involved in the study for their collaboration. The authors have no conflicts of interest that are directly relevant to the content of this article.

Conflict of interests: None

REFERENCES

- [1] Dellal, A. Analysis of the soccer player's physical activity and of its consequences in the training: Special reference to the high intensity intermittent exercises and the small sided-games. Thesis of Physiology of Exercise, Strasbourg University, France. 2008.
- [2] Dellal A, Chamari K, Wong DP, et al. Comparison of physical and technical performance in European match-play: FA Premier League and La Liga. *Eur J Sport Sci* 2011;11:51-9.
- [3] Dellal A, Wong DP, Moalla W, Chamari K. Physical and technical activity of soccer players in the French First League – with special reference to their playing position. *Int J Sports Med* 2010;11:278-90.
- [4] Di Salvo V, Baron R, González-Haro C, et al. Sprinting analysis of elite soccer players during European Champions League and UEFA cup matches. *J Sports Sci* 2010;28:1489-94.
- [5] Vigne G, Gaudino C, Rogowski I, et al. Activity profile in elite Italian soccer team. *Int Journal Sports Med* 2010;31:304-10.
- [6] Di Salvo V, Gregson W, Atkinson G, et al. Analysis of high intensity activity in Premier League soccer. *Int J Sports Med* 2009;30:205-12.
- [7] Di Salvo V, Baron R, Tschann H, et al. Performance characteristics according to playing position in elite soccer. *Int J Sports Med* 2007;28:222–227.
- [8] Barros RML, Misuta MS, Menezes RP, et al. Analysis of the distances covered by first division Brazilian soccer players obtained with an automatic tracking method. *J Sport Sci Med* 2007;6:233-42.
- [9] Bangsbo J, Norregaard L, Thorsoe F. Activity profile of competition soccer. *Can J Sport Sci* 1991;16:110-6.
- [10] Bradley PS, Sheldon W, Wooster B, et al. High-intensity running in English FA Premier League soccer matches. *J Sports Sci* 2009;27:159-68.
- [11] Carling C, Bloomfield J, Nelsen L, Reilly T. The role of motion analysis in elite soccer: Contemporary performance measurement techniques and work rate data. *Sports Med* 2008;38:839-62.
- [12] Özgünen KT, Kurdak SS, Maughan RJ, et al. Effect of hot environmental conditions on physical activity patterns and temperature response of football elite players. *Scand J Med Sci Sports* 2010;20:140-7.
- [13] Dellal A, Lago-Penas C, Rey E, et al. The effects of a congested fixture period on physical performance, technical activity and injury rate during matches in a professional soccer team. *Br J Sports Med* 2013;0:1-5.
- [14] Dupont G, Nedelec M, Mc Call A, et al. Effect of 2 soccer matches in a week on physical performance and injury rate. *Am J Sports Med* 2010;38:1752-8.
- [15] Stolen T, Chamari K, Castagna, C. Physiology of soccer: an update. *Sports Medicine* 2005;35:501-36.
- [16] Ascensao A, Leite M, Rebelo AN, et al. Effects of cold water immersion on the recovery of physical performance and muscle damage following a one-off soccer match. *J Sports Sci* 2011;29:217-25.
- [17] Buchheit M, Horobeanu C, Mendez-Villanueva A, et al. Effects of age and spa treatment on match running performance over two consecutive games in highly trained young soccer players. *J Sports Sci* 2011;29:591-8.
- [18] Leede J, Gissane C, Van Someren K, et al. Cold water immersion and recovery from strenuous exercise: a meta-analysis. *Br J Sports Med* 2012;46:233-40.
- [19] Carling C, Le Gall F, Dupont G. Are physical performance and injury risk in a professional soccer team in match-play affected over a prolonged period of fixture congestion? *Int J Sports Med* 2011;33:36-42.
- [20] Zubillaga A, Gorospe G. Match analysis of 2005-06 champions league final with Amisco system. *J Sports Sci Med* 2007;6(Suppl): 10.
- [21] Rey E, Lago-Penas C, Lago-Ballesteros J, et al. The effects of a congested fixture period on the activity of elite soccer players. *Biol Sport* 2010;27:181-5.
- [22] Odetoyinbo K, Wooster B, Lane A. The effect of a succession of matches on the activity profiles of professional soccer players. *J Sports Sci Med* 2007;10:s16-7.
- [23] Lago C, Rey E, Lago-Ballesteros J, et al. The influence of a congested calendar on physical performance in elite soccer. *J Strength Cond Res* 2011;25:2111-7.
- [24] Mohr M, Krstrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. *J Sports Sci* 2003;21:519-28.
- [25] Osgnach C, Poser S, Bernardini R, et al. Energy cost and metabolic power in elite soccer: a new match analysis approach. *Med Sci Sports Exerc* 2010;42:170-8.