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# Physical Activity and High-Intensity Running during Sided Games *vs.* Competitive Match-Play in Elite Soccer Players: A Comparative Study

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## Abstract

**Aim:** The aim of this study was to compare the physical activity of players within different sided games (SSG and LSG) and with those found among elite soccer match-play.

**Methods:** Fourteen elite soccer players (age: 23.1 years; height: 178.4 cm; weight: 73.7 kg and body fat mass 8.8%) participated in 3 competitive matches and their data were compared to the following sided games: 5 *vs.* 5 and 6 *vs.* 6, 7 *vs.* 7, and 9 *vs.* 9. Total distances covered/min (TDC), TDC/min at high intensity running (between 16 and 23 km/h$^{-1}$) and TDC/min at very high intensity running (>23 km/h$^{-1}$) were analyzed during all SSGs and official match-play with GPS technology (15 Hz).

**Results:** Post-hoc analysis indicated that the TDC/min was significantly higher during official match-play, 9 *vs.* 9, and 7 *vs.* 7 when compared to 6 *vs.* 6 and 5 *vs.* 5 (P<0.001). Moreover, the TDC/min, and the TDC/min at high and very high running intensity were significantly higher during the official match-play and large-sided games (9 *vs.* 9 and 7 *vs.* 7) than during the 6 *vs.* 6 and 5 *vs.* 5 SSG (P<0.001).

**Conclusion:** The present study showed that physical activity, and especially at very high intensity running, was similar in official match-play and in LSG (9 *vs.* 9 and 7 *vs.* 7) whereas SSG (5 *vs.* 5 and 6 *vs.* 6) induced lower solicitations at the speed thresholds analyzed. In this context, SSG seems not allow to fully recreate the physical match-play demands with a specific difference for the high intensity running activities.

**Keywords:** Small-sided games; Football; High-intensity running

## Introduction

Soccer performance is inclusive of a range of complex components requiring high levels of mental, technical, tactical, physical and physiological factors to be successful [1]. In order to become an elite professional soccer player it is imperative to develop these variants and key abilities both simultaneously and independently. Furthermore, each playing position requires different physical and technical activities [2] Rampinini et al. [3] demonstrated that midfielders (≈11748 m) cover greater distances than full-backs (≈11233 m), forwards (≈10233 m) and central defenders (≈9995 m). Numerous studies [4-7] have presented results concurring with Rampinini et al. [3] but recently, fitness training in soccer is more directed towards high intensity or high speed activities.

Gregson et al. [8] showed that the total distance covered at high and very high intensity running (HIR and VHIR) also change according to the playing position, which are influenced per tactical animations. In this context, Bradley et al. [9] showed that players from the English Premier League playing in 4-4-2 hence highlighting the difference tactical restraints have on physical outputs. Additionally, latter authors also found that midfielders (HIR≈3146 m; VHIR≈1118 m) covered greater distances than defenders (HIR≈2454 m and VHIR≈862 m) and forwards (HIR≈2250 m and VHIR≈950 m) both at high and very high intensities running.

Thus, it appears that individualized fitness training according to the playing position demand, potential tactical and style of match-play has become a key factor in elite soccer. Recent research has suggested that most professional coaches use small-sided games (SSG) as part of their weekly training structure in order to increase both physiological, physical and technical performances [6,10-14] in preparation for competition.

Several studies have shown that physiological responses, as well as technical and physical performance can be altered by the manipulation of the pitch size [15-18], number of players [14,19-21], number of bouts, bout duration and training regime [22,23], coach encouragement [24,25], and the games rules [19] inclusion of goalkeepers [26,27] and the number of ball touches allowed per individual possession [5].

However, it should be noted that few studies have investigated and checked if the physical activity during SSS is similar to that performed during official match-play [12,16,20]. Dellal et al. [6] showed that for each playing position, the total distance covered per minute at high intensity running and sprinting is more important during SSG (4 *vs.* 4) than friendly matches. Although SSGs are abundantly used in modern training soccer, it is still necessary to a better understanding of the physical demands if the SSG are really reflecting the physical activity performed within competitive matches.

Sometimes, players need to train as they play in real match conditions, and therefore, coaches and scientists need to know which sided games or exercises present close physical activity to competitive match play. In this context, the purpose of this study was therefore to analyze the physical activity of players within different sided games (large-sided games: LSG; small-sided games: SSG) in comparison with those found in competitive elite soccer matches, with a special reference to high intensity running. This research is aimed at helping coaches individualize physical training and to control the workload in order to optimize the physical performance of the players.

## Materials and Methods

### Subjects

14 elite players from the same French Ligue-1 team (age=23.1 ± 2.6 years; height=178.4 ± 3.1 cm; body mass=73.7 ± 4.8 kg; % body fat mass=8.8 ± 2.8%) including to minor (17.9 and 17.8 years) took part in this study. All the players involved have been playing or participating within competitive soccer for at least ten years. During the study, only players who participated in complete training duration and with no recent injury (>2 weeks to the closest date of return to full participation after an injury) were used for analysis. The study was conducted according to the principles of the Declaration of Helsinki and the local university ethics committee approved the study' protocol before the commencement of the assessments.

### Study design

The comparison of the physical activity during the competitive match-play and during the sided games (SSG and LSG) was conducted over the first period of the 2014-2015 seasons. All players participated in 3 competitive matches and performed training within LSG and SSG (i.e. SSG: 5 *vs.* 5 and 6 *vs.* 6; LSG: 7 *vs.* 7 and 9 *vs.* 9) using GPS (15 Hz) technology both during matches and training. Matches were separated per 6 days and sided-games were performed at least 2 days after each match-play.

Players were fully familiarized with the experimental procedures and the requirements of the SSG and LSG prior to the present study, and were extremely familiar with the use GPS units worn throughout. The weekly training content included 4-7 training sessions and 1 competitive match according to the time-play and the characteristics of each player because some of them make supplement physical training. Recovery strategies were applied after each competitive match and each specific days training session.

Both SSGs and competitive match-play were performed on the same type of pitch (natural grass) and same environment (26-29°C), whereas SSG and LSG were applied at the same time-slot of the day (18 h-19 h, at 26-29°C) to avoid any effect of circadian rhythms [28]. SSG, LSG and competitive matches were constituted by a standardized 20-30 minutes warm-up. Two parts composed the warm-up: the first part was general warm-up including athletic movements (hamstring, quadriceps, gastrocnemius, adductors, gluteus muscle and short sprint duration); and then, the second part was constituted by soccer specific technical exercises and accelerations.

## Methodology

### Physical activity

The physical activity was measured using portable global positioned system (GPS) device operating at a sampling frequency of 15 Hz (GPSsports SPI Elite, Canberra, Australia). The system uses signals from at least three earth-orbiting satellites to determine the position and calculate movement speeds and distances. The same units were used for each player in order to exclude the effects of inter-unit variability. Therefore, acceleration and deceleration were not analyzed and took in consideration. Units were placed in a harness on the player's upper back. After recording the whole activity of training or match-play, the data were downloaded to a PC and analyzed using the software package suited to the GPS device.

This system was previously validated in soccer for the monitoring of high-intensity and sprint activity but it underestimate these activities [1,29,30]. However, it concerned 1 Hz and 5 Hz. Buchheit et al. [31] have well showed that the GPS used in the present study allow to provide accurate data of different running speed categories but this not the case for the acceleration and deceleration. The data analyzed were the total distance covered per minute (TDC/min), the TDC/min at high intensity running (HIR: 16-23 km/h$^{-1}$) and the TDC/min at very high intensity running (VHIR: >23 km/h$^{-1}$) according to previous studies [6,27]. All data have reported in total distance covered per minute of game in each of the speed threshold previously described.

### Small-sided games (SSG) and large-sided games (LSG)

All players have participated within SSG (i.e. 5 *vs.* 5 and 6 *vs.* 6) and LSG (7 *vs.* 7 and 9 *vs.* 9) on specific dimension and pitch ratios, incorporating various rules and formats according to the traditional recommendations as presented in the Table 1. Each SSG and LSG was performed 2 times in the same conditions with the same team and opposition. Coaches set a large number of soccer balls around the perimeter of the playing area to aid in a rapid continuation of play. The order of play in which the game formats were played were randomly varied across the investigation period.

Team selections were designed by the head technical coach in order to achieve the best balance of opposition possible within the SSGs. Players were allowed to consume available drinks ad libitum during the recovery periods and instructed to maintain a similar nutritional intake over the period of the study. Nevertheless, accurate assessment of nutritional intake was not performed. All the sided games were performed on natural grass and the same time of the day in order to avoid circadian fluctuations. Furthermore, the coaches verbally

encouraged the players throughout the different SSGs to maintain a high work rate.

| Classification | Game | Game duration/ sequence | Pitch size (m) | Pitch ratio per player ($m^2$) | Rules |
|---|---|---|---|---|---|
| Official match-play | 11 *vs.* 11 | 2 x 45 min | 100 x 65 m | 295 | Opposition |
| Large-sided games | 9 *vs.* 9 | 2 x 8 min | 60 x 50 m | 167 | Opposition |
| | 7 *vs.* 7 | 3 x 6 min | 47 x 44 m | 147 | Opposition |
| Small-sided game | 6 *vs.* 6 | 3 x 6 min | 47 x 44 m | 172 | Conservation |
| | 5 *vs.* 5 | 8 x 3 min | 40 x 40 m | 160 | Conservation |

**Table 1:** Total distance covered (TDC) per minute of play (m/min) during the different sided-games (LSG and SSG) and competitive match-play.

## Match-play

In this study, 3 competitive soccer match-play registered under the organization of the F.F.F. (French Football Federation) and U.E.F.A. (European Union Association of Federarions) were analyzed. All match-play were played during the pre-season period of the 2014-2015 seasons. The pitch area (65 × 100 m), type of pitch (natural grass), duration of the game (2 × 45 min), and the time of day (end of the day) was standardized (18 h-19 h). The matches were refereed by the association of F.I.F.A and were played against opposition from the 1st French League 1, the English Championship, and the Spanish La Liga (1st division).

## Statistical analysis

Means ± standard deviations (SD) were used to describe variables. Before using parametric tests, the assumption of normality was verified using Kolmogorov-Smirnov test. A 2-way, repeated measures analysis of variance ANOVA (3 running intensity x 5 types of games) was used to determine if significant differences existed between the three running intensity (total distance covered overall, at high-intensities and at very-high intensities running) and types of game (Competitive game: OG, 9 vs. 9, 7 vs. 7, 6 vs. 6, 5 vs. 5).

If significant main effects or interactions were present, a Bonferroni post hoc analysis was performed. The effect size was calculated for all ANOVAs with the use of a partial eta-squared. Values of 0.01, 0.06 and above 0.15 were considered as small, medium and large, respectively [11]. Effect size (ES) were also calculated for all paired comparisons and evaluated with the method described by Cohen [32] (small<0.50, moderate=0.50–0.79 and large>0.80). Statistical analyses were performed using SPSS software statistical package (SPSS Inc., Chicago, IL, version. 16.0), and statistical significance was set at $p \leq 0.05$.

## Results

The 2-way ANOVA (running intensity x types of game) with repeated measures revealed a significant main effect for types of game ($F=86.71$; $p<0.001$; $\eta^2=0.67$), running intensity ($F=1726.03$; $p<0,001$; $\eta^2=0.99$), and a significant interaction effect ($F=58.45$; $p<0.000$; $\eta^2=0.67$) (Table 2). Subsequent Bonferroni post-hoc indicated that the total distance covered/min was significantly higher during competitive game, 9 *vs.* 9, and 7 *vs.* 7 when compared to 6 *vs.* 6 and 5 *vs.* 5.

Regarding the main effect of running intensity, Bonferroni post-hoc test indicated that the total distance covered/min during competitive matches (when all intensities were pooled) was significantly higher when compared to the TDC/min at high intensities and to very high intensities running. Furthermore, statistical analysis revealed that the TDC/min decreases with the type of game (ES=moderate to large). Variation of the total distance covered/min according to the intensity are shown in Figure 1, specifically showing that SSGs induced lower activities at high and very intensities than competitive match-play.

| | Running intensity | Competitive match-play | 9 vs. 9 | 7 vs. 7 | 6 vs. 6 | 5 vs. 5 | Main effect | Interactions |
|---|---|---|---|---|---|---|---|---|
| TDC/min | All Intensity | 121.73§ (-23.21) | 119.32§ (-11.99) | 123.48§ (-14.61) | 71.11 (-15.54) | 71.47 (-5.48) | R. I: F=2773.66 P<0.000 $\eta^2$=0.98 | PP x TOG: F=0.98 P<0.49 $\eta^2$=0.11 |
| | 16-23 km/$h^{-1}$ | 13.48§ (3.76) | 10.05§ (2.69) | 9.52§ (2.86) | 4.48 (1.80) | 6.14 (1.87) | P. P: F= 7.02 P<0.000 $\eta^2$= 0.18 | R I. x P.L: F=4.85 P<0.000 $\eta^2$=0.23 |
| | | | | | | | TOG: F=56.53 P<0.000 $\eta^2$=0.63 | TOG x RI: F=38.10 P<0.000 $\eta^2$=0.70 |
| | >23 km/$h^{-1}$ | 1.97¥ (0.96) | 1.76 (1.39) | 0.87 (0.71) | 0.26 (0.47) | 0.43 (0.46) | | TOG x RI x P.P: F=0.74 P<0.84 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | $\eta^2$=0.15 |
| §: Significant difference when compared with 5 *vs.* 5 and 6 *vs.* 6 (P<0.001) | | | | | | | | |
| ¥: Significant difference when compared with 5 *vs.* 5 and 6 *vs.* 6 (P<0.001) | | | | | | | | |

**Table 2:** Total distance covered (TDC) per minute of play (m/min) during the different sided-games (LSG and SSG) and competitive match-play.

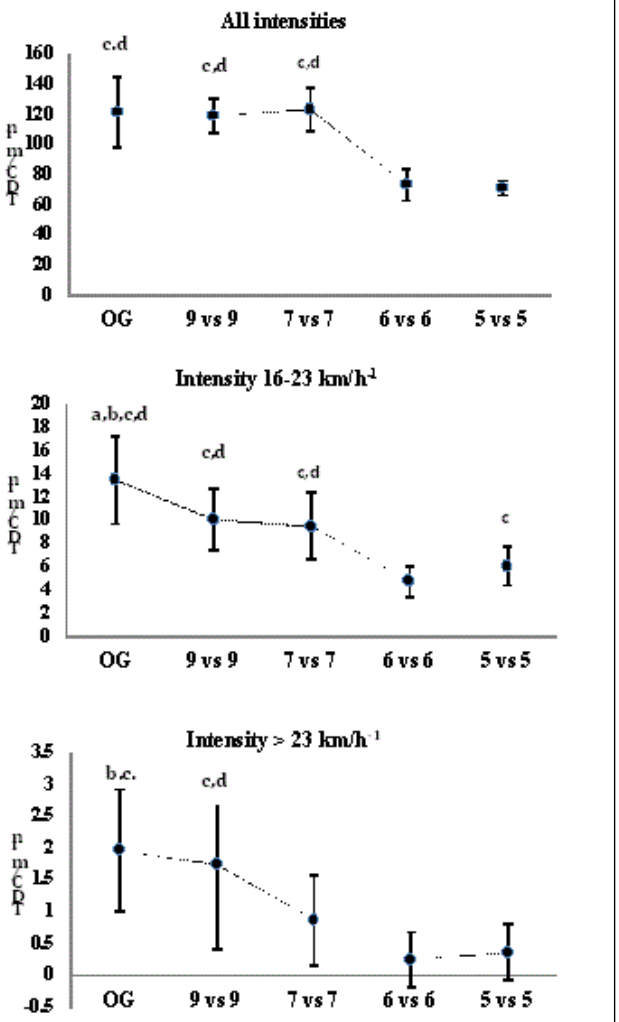


**Figure 1:** Variation of the total distance covered per minute (TDC) during sided-games (SSG and LSG) and official games (OG) according to the running intensity. [a]Significantly different from 9 *vs.* 9; [b]Significantly different from 7 *vs.* 7; [c]Significantly different from 6 *vs.* 6; [d]Significantly different from 5 *vs.* 5 (p<0.05)

## Discussion

The physical activity of elite professional soccer players during competitive match-play and sided games (SSG and LSG) has been well described in the reviewed literature [19] however limited research have been conducted on the relationship between both in the same investigation. Recent research has described how coaches use variants of SSGs to prepare professional soccer players as part of their training strategy due to the role they play in replicating certain elements of soccer performance when compared to competitive match-play [6,20,33]. Therefore, the aim of the present study was to analyze the physical activity of soccer players within different sided games (SSG and LSG) and compare to the data obtained within competitive soccer matches. The main findings from the investigation have shown that competitive matches induced greater physical demand than SSG, especially in high-speed running activities. Indeed, only the 9 *vs.* 9 and 7 *vs.* 7 were similar to data obtained within the competitive matches from a HIR and TDC perspective whereas 5 *vs.* 5 and 6 *vs.* 6 induced different high-intensity efforts.

The present study has shown how elite soccer players cover a greater distance per minute in competitive matches (121.73 m/min) than when compared to 9 *vs.* 9 (119.32 m/min), 6 *vs.* 6 (71.11 m/min) and 5 *vs.* 5 (71.47 m/min) respectively. However, a previous study presented different results than the present study. Dellal et al. [20] reported that players covered lower distances during competitive matches (124.14 m/min) in comparison with SSG (175.94 m/min), whereas the present study presented greater distances covered at HIR within competitive matches (13.48 m/min) in comparison with 9 *vs.* 9 (10.05 m/min), 7 *vs.* 7 (9.52 m/min), 6 *vs.* 6 (4.48 m/min) and 5 *vs.* 5 (6.14 m/min). Results from these two studies presented similar physical activities in match-play and confirmed those observed in the literature [2,4,7,34] while results from sided-games highly differed in its findings probably due to the sided-games characteristics.

Although the present study and Dellal et al. [6] used similar pitch ratio per players (273 $m^2$ *vs.* 295 $m^2$), the pitch ratio per players of sided games were greatly different (147-172 $m^2$ *vs.* 75 $m^2$), affecting directly the physical performance as mentioned by previous studies [16]. Additionally, the literature have well showed that the presence of goalkeepers and the rules affect the physical activities of soccer players [27,35]. Therefore, these differences of results in the present study could be because LSG and the match-play include goalkeepers with rules oppositions whereas the rule of SSG were only to keep the collective possession of the ball. It appears that results from the present studies are stronger due to the larger number of sided games used (from 9 *vs.* 9 to 5 *vs.* 5) while Dellal et al. [6] used only the comparison between 4 *vs.* 4 and competitive match play. Moreover, these differences could be explained by the fact that Dellal et al. [6] make the experimentation during the mid-season and just before an international competition, whereas the present studies concerned the pre-season period. The period of the season and the level of the opposition induced different physical activities both during SSG and competitive matches [24,36].

The study of Owen et al. [23] tried to apply similar experimentation in comparing different sided games from 4 *vs.* 4 to 11 *vs.* 11, considering the 11 *vs.* 11 as a match-play. They found greater total distance (in m/min) in 4 *vs.* 4 as compared to the simulated match-play but significantly less high-intensity efforts. However, although, the pitch size of the 11 *vs.* 11 was equivalent than in the present study, the

bouts duration was only 3 × 5 min which could not be considered to be extrapolated as a match-play condition.

Others authors have attempted to report the knowledge and relationship between SSG and match-play, with a new approach. Castellano et al. [37] were closed to the present study but these authors were only focus theirs analyses on acceleration. They showed that sided games (3 *vs.* 3, 5 *vs.* 5, 7 *vs.* 7) induced greater number of accelerations than competitive matches. These findings complete and confirmed those of the present study. Indeed, competitive match-play induce greater distance in high and very high intensity running due to the longer distance of running possible whereas the pitch ratio and distances rarely exceed 20-30 m during SSG that not allow to reach high percentage of maximal speed (>23 $km/h^{-1}$). The density is greater in SSGs and therefore, players should perform greater directional changes, actions and accelerations with higher peripheral component solicitations. Additionally to this specific short-intensive actions analysis, SSG present a shorter duration of recovery per minute between each effort and therefore, the density of the running is more important during the SSG [38].

Currently, most of coaches use the SSG as specific training in order to mimic the match conditions and to train the technical, physiological and certain physical components necessary for the top level. Nevertheless, it is important to know how SSG may reproduce some of the competition condition during training and the present study provides these essentials information. The manipulation of rules, format and regimes of SSG induce different physical characteristic but it has also induce an effect on the level of difference with match-play physical activities. To illustrate it, this investigation has shown that the number of soccer players allows recreate almost perfectly the physical outputs of HIR, VHIR and TDC. Indeed, only the 9 *vs.* 9 and 7 *vs.* 7 were similar to data obtained within the competitive matches from a HIR and TDC perspective whereas 5 *vs.* and 6 *vs.* 6 induced different high-intensity efforts.

Being able to compare competitive match data with SSG training data has its limitations due to the many tactical (formation and strategy, possession of the ball, playing position), psychological (stress, score of the match, stake of the match, presence of spectator in the stadium) and environmental factors (pitch area and climatic condition) which directly influence the match. Many studies have revealed how the tactical aspects of the match modify the physical activity during competitive match. Indeed, the soccer players covered various distances at HIR, VHIR and TDC as a direct result of playing position [7-9], tactical formation "4-4-2, 4-3-3 or 3-5-2" [9] and style of play (possession based or counter attacking) [8].

Furthermore, the psychological factor may significantly impact the output between competitive match and SSG, however, literature in this area is still limited. During the match, the evolution of the score and presence of spectator are a stress component for the soccer players [39,40] and observations have been shown between teams based on the score line. For example, the team in a losing position has been shown to cover more distance than the team who is winning [39] while the environmental (climatic condition and pitch area) factor influences directly the physical activity [41].

Recent studies analysis the physical activities both within SSG and match-play according to the distance covered per minute. This type of analyze improve the strength of the data. However, it appears that it should be more interesting and precise to use the distance covered per minute according to the minute of real play. Studies have showed that a match-play of 93-95 min represents in real between 53-68 min of real playing-time. Dellal et al. [42] had showed a great difference between physical activities during normal playing time (97 min) and the real effective playing time (58 min) with more than 30% of the total distance covered during the different no-play period corresponding to free-kick, throw-in, substitution, medical intervention on the pitch, etc. In this context, next experimentation needs to focus both on real playing time and real efforts do during the match but also during SSG, even if it should be sure that playing time are very close to the effective playing time within SSG.

## Conclusions

The present study has shown that competitive matches induced greater physical demand than SSG, especially in high-speed running activities. Indeed, only the 9 *vs.* 9 and 7 *vs.* 7 were similar to data obtained within the competitive matches from a HIR and TDC perspective whereas 5 *vs.* 5 and 6 *vs.* 6 induced different high-intensity efforts. Thus, it appears that SSG not allow to present similar physical activity than those observed during competitive matches, whereas large-sided games (LSG) induce equivalent physical solicitation. However, the number of recovery time between high-intensity efforts should be shorter in SSG, while the number of acceleration should be more important than competitive and competitive match-play. Although these findings will help coaches to design training and to include sided-games (SSG and LSG) in the schedule, it shows the limits of the SSG to recreate the match condition. Further studies will have to focus their analysis on maximal speed, acceleration and activities during real effective playing time.

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## References

1. Randers MB, Mujika I, Hewitt A, Santisteban J, Bischoff R, et al. (2010) Application of four different football match analysis systems: a comparative study. J Sports Sci 28: 171-182.
2. Dellal A, Chamari C, Wong DP, Ahmaidi S, Keller D, et al. (2011) Comparison of physical and technical performance in European professional soccer match-play: The FA Premier League and La LIGA. Eur J Sport Sci 11: 51-59.
3. Rampinini E, Coutts AJ, Castagna C, Sassi R, Impellizzeri FM (2007) Variation in top level soccer match performance. Int J Sports Med 28: 1018-1024.
4. Bradley PS, Di Mascio M, Peart D, Olsen P, Sheldon B (2010) High-intensity activity profiles of elite soccer players at different performance levels. J Strength Cond Res 24: 2343-2351.
5. Dellal A, Lago-Penas C, Wong DP, Chamari K (2011) Effect of the number of ball touch within bouts of 4 *vs.* 4 small-sided soccer games. Int J Sports Physiol Perform 6: 322-333.
6. Dellal A, Owen A, Wong DP, Krustrup P, Van Exsel M, et al. (2012) Technical and physical demands of small-sided games *vs.* match-play with a special reference to comparison of playing position in elite soccer. Hum Movement Sci 31: 957-969.
7. Vigne G, Dellal A, Gaudino C, Chamari K, Rogowski I, et al. (2013) Physical outcome in a successful Italian Serie A soccer team over three consecutive seasons. J Strength Cond Res. 27: 1400-1406.

8. Gregson W, Drust B, Atkinson G, Salvo VD (2010) Match-to-match variability of high-speed activities in premier league soccer. Int J Sports Med 31: 237-242.
9. Bradley PS, Carling C, Archer D, Roberts J, Dodds A, et al. (2011) The effect of playing formation on high-intensity running and technical profiles in English FA Premier League soccer matches. J Sports Sci 29: 821-830.
10. Aroso J, Rebelo AN, Gomes-Pereira J (2004) Physiological impact of selected game-related exercises. J Sports Sci 22: 522.
11. Dellal A, Hill-Haas S, Lago-Penas C, Chamari K (2011) Small sided-games in soccer: amateur *vs.* professional players' physiological responses, physical and technical activities. J Strength Cond Res 25: 2371-2381.
12. Dellal A, Drust B, Lago-Penas C (2012) Variation of activity demands in small-sided soccer games. Int J Sports Med 33: 370-375.
13. Hill-Haas SV, Dawson BT, Coutts AJ, Rowsell GJ (2010) Time-motion characteristics and physiological responses of small-sided games in elite youth players: the influence of player number and rule changes. J Strength Cond Res 24: 2149-2156.
14. Owen A (2004) Small sided games: physiological and technical effect of altering pitch size and players number. Insight FACA journal 7: 50-52.
15. Abrantes C, Numes MI, Maças VM, Leite NM, Sampaio JE (2012) Effects of the number of players and game type constraints on heart rate, rating of perceived exertion, and technical actions of small-sided soccer games. J Strength Cond Res 26: 976-981.
16. Casamichana D, Castellano J (2010) Time-motion, heart rate, perceptual and motor behaviour demands in small-sides soccer games: effects of pitch size. J Sports Sci 28: 1615-1623.
17. Dellal A, Jannault R, Pialoux V, Lopez-Segovia M (2011) Influence of the players numbers in the heart rate responses of youth soccer players within 2 *vs.* 2, 3 *vs.* 3 and 4 *vs.* 4 small-sided games. J Hum Kinet 28: 107-114.
18. Tessitore A, Meeusen R, Piacentini MF, Demarie S, Capranica L (2006) Physiological and technical aspects of "6-a-side" soccer drills. J Sports Med Phys Fitness 46: 36-43.
19. Hill-Haas SV, Dawson B, Impellizzeri FM, Coutts AJ (2011) Physiology of small-sided games training in football: a systematic review. Sports Med 41: 199-220.
20. Owen AL, Wong DP, Paul D, Dellal A (2014) Physical and technical comparisons between various-sided games within professional soccer. Int J Sports Med 35: 286-292.
21. Williams K, Owen A (2007) The impact of player numbers on the physiological responses to small-sided games. J Sports Sci Med 6: 99-102.
22. Fanchini M, Azzalin A, Castagna C, Schena F, McCall A, et al. (2011) Effect of bout duration on exercise intensity and technical performance of small-sided games in soccer. J Strength Cond Res 25: 453-458.
23. Owen AL, Wong del P, Paul D, Dellal A (2012) Effects of a periodized small-sided game training intervention on physical performance in elite professional soccer. J Strength Cond Res 26: 2748-2754.
24. Rampinini E, Impellizzeri FM, Castagna C, Abt G, Chamari K, et al. (2007) Factors influencing physiological responses to small-sided soccer games. J Sports Sci 25: 659-666.
25. Sampaio J, Garcia G, Macas V, Ibanez J, Abrantes C, et al. (2007) Heart rate and perceptual responses to 2 *vs.* 2 and 3 *vs.* 3 small-sided youth soccer games. J Sports Sci Med 6: 121-122.
26. Dellal A, Chamari K, Pintus A, Girard O, Cotte T, et al. (2008) Heart rate responses during small-sided games and short intermittent running training in elite soccer players: a comparative study. J Strength Cond Res 22: 1449-1457.
27. Mallo J, Navarro E (2008) Physical load imposed on soccer players during small-sided training games. J Sports Med Phys Fitness 48: 166-171.
28. Drust B, Waterhouse J, Atkinson G, Edwards B, Reilly T (2005) Circadian rhythms in sports performance--an update. Chronobiol Int 22: 21-44.
29. Coutts AJ, Duffield R (2010) Validity and reliability of GPS devices for measuring movement demands of team sports. J Sci Med Sport 13: 133-135.
30. Duffield R, Reid M, Baker J, Spratford W (2010) Accuracy and reliability of GPS devices for measurement of movement patterns in confined spaces for court-based sports. J Sci Med Sport 13: 523-525.
31. Buchheit M, Al Haddad H, Simpson BM, Palazzi D, Bourdon PC, et al. (2014) Monitoring accelerations with GPS in football: time to slow down? Int J Sports Physiol Perform 9: 442-445.
32. Cohen J (1998) Statistical power analysis for the behavioural sciences. 2nd edtn. Lawrence Erlbaum, Hillsdale, NJ, USA.
33. Owen AL, Wong DP, McKenna M, Dellal A (2011) Heart rate responses and technical comparison between small- *vs.* large-sided games in elite professional soccer. J Strength Cond Res 25: 2104-2110.
34. Di Salvo V, Baron R, Tschan H, Calderon Montero FJ, Bachl N, et al. (2007) Performance characteristics according to playing position in elite soccer. Int J Sports Med 28: 222-227.
35. Aguiar M, Botelho G, Lago C, Maças V, Sampaio J (2012) A review on the effects of soccer small-sided games. J Hum Kinet 33: 103-113.
36. Lago C, Martín R (2007) Determinants of possession of the ball in soccer. J Sports Sci 25: 969-974.
37. Castellano J, Casamichana D (2013) Differences in the number of accelerations between small-sided games and friendly matches in soccer. J Sports Sci Med 12: 209-210.
38. O'Donoghue PG, Boyd M, Lowler J, Bleakley EW (2001) Time-motion analysis of elite, semi-professional and amateur soccer competition. J Hum Movement Stud 41: 1-12.
39. Lago C (2009) The influence of match location, quality of opposition, and match status on possession strategies in professional association football. J Sports Sci 27: 1463-1469.
40. Lago-Peñas C, Lago-Ballesteros J, Dellal A, Gómez M (2010) Game-Related Statistics that Discriminated Winning, Drawing and Losing Teams from the Spanish Soccer League. J Sports Sci Med 9: 288-293.
41. Aldous JW, Chrismas BC, Akubat I, Dascombe B, Abt G, et al. (2015) Hot and hypoxic environments inhibit simulated soccer performance and exacerbate performance decrements when combined. Frontiers Physiol 6: 421.
42. Dellal A, Ignatowicz L, Dyon N (2009) Analysis of the activity of the high-level footballer: relationship between the distance traveled during the total playing time and the actual playing time-Preliminary study. In: Proceedings of the 3rd "Football and Research" Symposium, Eds Presse Universitaire de Valenciennes, France.