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) and TDC/min at very high intensity running (>23 km/h) 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. 8 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 SSS (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) and the TDC/min at very high intensity running (VHHR: >23 km/h) 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.

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

<table>
<thead>
<tr>
<th>Classification</th>
<th>Game</th>
<th>Game duration/sequence</th>
<th>Pitch size (m)</th>
<th>Pitch ratio per player (m²)</th>
<th>Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Official match-play</td>
<td>11 vs. 11</td>
<td>2 x 45 min</td>
<td>100 x 65 m</td>
<td>295</td>
<td>Opposition</td>
</tr>
<tr>
<td>Large-sided games</td>
<td>9 vs. 9</td>
<td>2 x 8 min</td>
<td>60 x 50 m</td>
<td>167</td>
<td>Opposition</td>
</tr>
<tr>
<td></td>
<td>7 vs. 7</td>
<td>3 x 6 min</td>
<td>47 x 44 m</td>
<td>147</td>
<td>Opposition</td>
</tr>
<tr>
<td>Small-sided game</td>
<td>6 vs. 6</td>
<td>3 x 6 min</td>
<td>47 x 44 m</td>
<td>172</td>
<td>Conservation</td>
</tr>
<tr>
<td></td>
<td>5 vs. 5</td>
<td>8 x 3 min</td>
<td>40 x 40 m</td>
<td>160</td>
<td>Conservation</td>
</tr>
</tbody>
</table>

Table 2: Variation of the total distance covered/min according to the intensity running. Furthermore, statistical analysis revealed that the TDC/min decreases with the type of game (Competitive game: OG, 9 vs. 9, 7 vs. 7, 6 vs. 6, 5 vs. 5).

### 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; η²=0.67), running intensity (F=1726.03; p<0.001; η²=0.99), and a significant interaction effect (F=58.45; p<0.000; η²=0.67) (Table 2). Subsequent Bonferroni post-hoc analysis 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.
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 m² vs. 295 m²), the pitch ratio per players of sided games were greatly different (147-172 m² vs. 75 m²), 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 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

**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
bouts duration was only $3 \times 5$ 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 ($3 \times 3$, 5 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. 5 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 effects 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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