Original Article

Analysis of External Load in Different Soccer Small-Sided Games Played with External Wildcard Players

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Abstract

The aim of this study was to compare the external load associated with different small-sided game formats played using external wildcard players. Twenty-two professional soccer players (24.7±3.9 years; 78.4±4.2 kg; 182.9±4.5 cm) performed the three formats (5vs5, 6vs6 and 7vs7) on a 60 x 35 m pitch and were monitored using GPS. Two-way ANOVA for repeated measures was performed to calculate the level of significance between the various parameters analyzed.

From the results it emerged that the greatest distance covered at high intensity was in the 5vs5 format ($p<0.0005$), which was also characterized by the greatest amount of high-power running ($>20\text{W/kg}$; $p<0.01$) and maximum-power running ($p<0.0005$). The time spent at low power was significantly greater in the 7vs7 format ($p<0.0005$). Maximum speed ($p<0.0005$) and maximum power were higher in the 5vs5 format (versus 6vs6, $p<0.0005$; versus 7vs7, $p<0.01$), whereas the 7vs7 format involved significantly higher values of maximum power compared with the 6vs6 ($p<0.05$). Peak values of maximum acceleration were measured in 6vs6; whereas the peak value relative to maximum deceleration was significantly greater in the 5vs5 compared with the 7vs7 format ($p<0.0005$). Significantly more acceleration events were detected in the 5vs5 format ($p<0.0005$), whereas the number of decelerations was significantly greater in the 6vs6 compared with the 7vs7 format ($p<0.05$).

Knowledge of the different levels of external load typical of the 3 different formats, as revealed here, permits coaches are better equipped to select the most appropriate format for each day of the weekly microcycle training program.

Key words: High intensity running, metabolic power, acceleration, deceleration, GPS, Soccer players.

Introduction

Soccer is a discipline defined as an 'alternating aerobic-anaerobic engagement sport'; it is characterized by the performance of high-intensity intermittent actions, including: kicking; jumping; accelerating in a straight line; sprinting with a change of direction; decelerating; and tackling (Hill-Haas et al., 2011; Stølen et al., 2005). Over the course of a game, a soccer player runs between 8000 and 14000 meters and makes approx. 1200 activity changes (equivalent to approx. 1 every 3-5 seconds), performed in an intermittent and non-cyclic manner (Aguar et al., 2012; Dellal et al., 2011a; Koklu et al., 2015a). Soccer is a sport that develops both aerobic and anaerobic fitness (Little & Williams, 2006). As a means to develop both aerobic and anaerobic capacities, exercises known as *small-sided games* (SSG) may be used, which can be performed with or without a ball. The multiple benefits derived from SSG training are well recognized (Aguar et al., 2012; Sampaio et al., 2007). Indeed, these exercises are used in the majority of the training sessions forming both professional and amateur weekly microcycle training programs; different formats of SSG are used according to the technical/tactical and physical objectives set by the technical staff. In addition to bringing about improvements in physical condition, SSG bring about improvements in the technical and tactical abilities of both adult and youth soccer players (Hill-Haas et al., 2008; Rampinini et al., 2007a, Sannicandro, 2015; Sannicandro&Cofano, 2017a; Clemente et al., 2012; Casamichana et al., 2013; Castellano et al., 2013; Dellal et al., 2011b; Fradua et al., 2013; Halouani et al., 2014; Hill-Haas et al., 2011; Impellizzeri et al., 2006; Owen et al., 2004; Rampinini et al., 2007a). In particular, recent studies have demonstrated how these exercises are able to stimulate improvements in both aerobic and anaerobic metabolism in professional soccer players (Dellal et al., 2011a), amateur soccer players (Clemente et al., 2014), young soccer players (Clemente et al., 2015) and young elite soccer players (Koklu et al., 2015b). Indeed, the literature is rich in studies that investigate and assess the use of SSG – which are essentially soccer games played on pitches of reduced dimensions, with a reduced number of players, simplified rules of play, with or without goalkeepers, employing an altered modality of play (continuous or intermittent) and with restrictions

placed on whether trainers or technical staff are allowed to direct encouragement at their players (Casamichana et al., 2013; Castellano et al., 2013; Dellal et al., 2011b; Fradua et al., 2013; Halouani et al., 2014; Hill-Hass et al., 2011; Impellizzeri et al., 2006; Owen et al., 2004; Rampinini et al., 2007a; Cihan, 2015; Praça et al., 2017). The analysis of internal or external load (Impellizzeri et al., 2004; Halson, 2014) relative to SSGs constitutes a topic of particular research interest at present. Multiple studies in the literature have examined and assessed the effects of SSGs on internal load, such as heart rate, hematic lactate and the rate of perceived exertion (RPE) when played on a traditional soccer pitch (Aroso et al., 2004; Casamichana & Castellano, 2010; Hill-Haas et al., 2009; Brandes et al., 2012; Bekris et al., 2012; Koklu et al., 2015a; Rampinini et al., 2007a; Aslan, 2013; Dellal et al., 2011c; Martone et al., 2017; Halouani et al., 2017; Sannicandro & Cofano, 2017b, 2017c; Sanchez-Sanchez et al., 2017) or on a closed pitch with barriers in place of perimeter lines – the so-called “cage” (Sannicandro et al., 2016). In more recent years, however, the majority of SSG studies have focused on quantifying the external load produced during a game through the use of Global Positioning Systems (GPS) (Gaudino et al., 2014b; Nevado-Garrosa & Suárez-Arrones, 2015; Joo et al., 2016); and some have quantified both internal and external load (Hodgson et al., 2014; Randers et al., 2014; Castellano et al., 2015; Arslan et al., 2017; Campos Vázquez et al., 2017; Sannicandro & Cofano, 2019).

An important topic that remains to be investigated, however, regards a specific type of SSG frequently used during training sessions; namely, SSG played with external wildcard players. Indeed, very few studies exist that have analyzed this format, which is played using a maximum of 4 external wildcard players (Castellano et al., 2016; Sanchez-Sanchez et al., 2017; Sanchez-Sanchez et al., 2018), and only a single study has monitored the effects of 8 weeks of this form of SSG training on the physical fitness of soccer players (Los Arcos et al., 2015). The aim of the present study was to investigate and quantify the external load produced by 3 SSG formats (5vs5, 6vs6, 7vs7) with the use of external wildcard players in professional adult soccer players.

Material & Methods

Participants

Twenty-two professional soccer players ($n = 14$ soccer players used in the SSG formats, $n = 2$ goalkeepers, and $n = 6$ external wildcard soccer players) participated in the study. Fourteen professional soccer players (mean age: 24.7 ± 3.9 years; mean weight: 78.4 ± 4.2 kg; and mean height: 182.9 ± 4.5 cm) participated in the SSG analyses. To be included in the study, athletes had to have been without injury and to have not incurred any training suspension during the previous 6 months. All players were familiarized with the use of the GPS (Global Positioning System) units and SSG formats. The research design and procedures complied with the standards set out in the Declaration of Helsinki.

Procedure

Players performed the 3 different SSG formats (table 1) on three different training days, at the same time of day (16.00) and at same temperature (22°C). Before initiating the SSG, a standardized 15-minute warm-up was completed (low-intensity running at $60\%\text{FC}_{\text{max}}$, joint mobility exercises and dynamic stretching). At the end of the warm-up, the SSG was immediately commenced. During the SSG, all players were monitored using GPS units. All SSG were played in the absence of external encouragement.

Table 1 reports the characteristics of the SSG used in this study. The SSGs were played on a natural grass-turf pitch measuring 60×35 m with two small goals (5×2 m), and involved 2 goalkeepers (GK), 6 external wildcard soccer players (EW) placed immediately outside the perimeter of the field: $n = 2$ soccer players next to each goal and $n = 1$ soccer player on each side line of the field; a size 5 football was used placed outside the field (figures 1, 2 and 3).

The SSGs were played in 4 periods of 3 min, interspersed by 1 min of passive recovery. The SSGs were played with goalkeepers, without touch limits. All the standard rules of 11-a-side soccer were followed with the exception of the offside rule. All SSGs were played without coach encouragement (Rampinini et al., 2007a).

Table 1. The SSG formats used in the study

	5vs5	6vs6	7vs7
Number of bouts	4	4	4
Bout duration (min)	3	3	3
Resting duration (min)	1	1	1
Pitch dimension (m x m)	60 x 35	60 x 35	60 x 35
Relative pitch size (m^2)	1:210	1:175	1:150
Goalkeeper	SI	SI	SI
Specific rules	NO	NO	NO
Coach encouragement	NO	NO	NO

Figure 1: 5vs5 + 2 goalkeepers + 6 external wildcard players

Figure 2: 6vs6 + 2 goalkeepers + 6 external wildcard players

Figure 3: 7vs7 + 2 goalkeepers + 6 external wildcard players

Instruments

The players' physical activity during each SSG was monitored using portable GPS technology at 18.18 Hz (GPEXE® SYSTEM, EXELIO Srl, Udine, Italy). The use of 18 Hz GPS for this purpose was recently validated (Hoppe et al., 2018). The following activities were calculated during each drill: total distance covered (m); maximum speed (peak in Km/h); maximum power (peak in W/Kg); maximum acceleration (m/sec^2); maximum deceleration (m/sec^2); number of high acceleration and high deceleration events ($\geq 2.50 \text{ m/sec}^2$ and $\leq -2.50 \text{ m/sec}^2$, respectively); and total equivalent distance (m; representing the total distance that the athlete would have covered at constant speed using the total energy consumed during a training session or time interval). Furthermore, the distance covered at different speeds was monitored: walking ($<7.30 \text{ km/h}$); low-intensity running ($7.30\text{-}14.50 \text{ km/h}$); moderate-intensity running ($14.50\text{-}19.90 \text{ km/h}$); and high-intensity running ($19.90\text{-}25.20 \text{ km/h}$) (Rampinini et al., 2007b; Di Salvo et al., 2013). The time spent and the distance covered at three power categories (low power $<20.00 \text{ W/Kg}$; high power $20.00\text{-}55.00 \text{ W/Kg}$; maximum power $> 55.00 \text{ W/Kg}$) were also monitored according to parameters present in the literature (Osgnach et al., 2010). High power running was defined as running for which $W \geq 20 \text{ W/Kg}$ (Osgnach et al., 2010) and used as an indicator of high intensity (Gaudino et al., 2013, 2014a).

Statistical analysis

The results are presented as means $\pm$ standard deviations (M $\pm$ SD). A two-way ANOVA for repeated measures was performed to calculate the level of significance between the various parameters analyzed. Statistical analyses were performed using the software Statistical Package for Social Sciences (SPSS 15.0 for Windows) and the significance level was set at $p < 0.05$.

Results

The results are reported in table 2. The total distance covered during the 5vs5 SSG was greater than in the other two formats; however, the difference was only significant with respect to the 7vs7 format. Regarding the distances covered at different intensities, the distance covered at a walk was significantly greater in the 7vs7 format ($p < 0.0005$); the distance covered at low-intensity running was significantly greater in the 6vs6 compared with both the 5vs5 ($p < 0.05$) and the 7vs7 formats ($p < 0.0005$); the distance covered at moderate intensity was significantly greater in the 5vs5 format compared with both the 6vs6 ($p < 0.01$) and the 7vs7 formats ($p < 0.0005$); this was also the case for the distance run at high intensity ($p < 0.0005$ for both comparisons). However, when the distances run at the different power levels are taken into consideration, a different picture emerges. The distance run at the low power level (< 20 W/Kg) was greatest, although not significantly, in the 7vs7 ($P = \dots$). At high power (20.00-55.00 W/Kg), significantly greater distances were revealed for the 5vs5 compared with the 7vs7 format ($p < 0.01$), whereas the distances run at maximum power (> 55.00 W/Kg) were significantly greater in the 6vs6 and 7vs7 formats with respect to 5vs5 ($p < 0.0005$). A significant difference in the distance run at maximum power was also evident between the 6vs6 and 7vs7 formats ($P \dots$), with the former/latter characterized by the greater distance.

With respect to the relative time soccer players spent at the different power levels, the following results emerged: more time was spent at low power in the 7vs7 format compared with both other formats ($p < 0.0005$); similarly, more time was spent at low power in the 6vs6 format compared with the 5vs5 format ($p < 0.0005$). However, soccer players spent more time at high power in the 5vs5 format compared with 7vs7 ($p < 0.01$) as well as more time at maximum power compared with both 6vs6 and 7vs7 ($p < 0.0005$). However, the time spent at maximum power in the 7vs7 format was significantly greater ($p < 0.05$) than that recorded for 6vs6. With regards to peak maximum velocity, players exhibited significantly greater values in both the 5vs5 and 7vs7 formats compared with the 6vs6 format ($p < 0.0005$). Regarding peak maximum power, the greatest value was seen in 5vs5 format (cf. 6vs6, $p < 0.0005$; cf. 7vs7, $p < 0.01$), and those recorded for the 7vs7 format exceeded those produced in the 6vs6 format ($p < 0.05$).

From the analysis of the acceleration and deceleration phases, it emerged that the highest value relative to maximal acceleration was detected in the 6vs6; the highest mean value relative to maximal deceleration was observed in the 5vs5 format, although it was only significantly greater with respect to the 7vs7 format; the number of acceleration events was significantly greater in the 5vs5 format ($p < 0.0005$), whereas the number of decelerations observed was significantly higher in the 6vs6 compared with the 7vs7 format ($p < 0.05$).

Table 2. Results of external load recorded in the three SSG formats

	5vs5 + 2 GK + 6 EW	6vs6 + 2 GK + 6 EW	7vs7 + 2 GK + 6 EW
Total distance (m)	1658.4 $\pm$ 101.7	1603.8 $\pm$ 178.5	1575.3 $\pm$ 156.6
Maximum speed (km/h)	26.3 $\pm$ 1.1	23.1 $\pm$ 0.8***	25.4 $\pm$ 2.1###
Maximum acceleration (m/s ²)	3.79 $\pm$ 0.1	3.88 $\pm$ 0.3	3.8 $\pm$ 0.1
Maximum deceleration (m/s ²)	-4.68 $\pm$ 0.2	-4.47 $\pm$ 0.2	-4.09 $\pm$ 0.5***
Maximum power (W/kg)	86.6 $\pm$ 13.1	71.1 $\pm$ 10.6***	74.7 $\pm$ 4.3** #
Acceleration (n°)	8.4 $\pm$ 1.5	3.6 $\pm$ 2.5 ***	3.2 $\pm$ 1.2 ***
Deceleration (n°)	9.4 $\pm$ 4.2	10.4 $\pm$ 4	6.7 $\pm$ 3#
Equivalent distance (m)	1946.8 $\pm$ 108	1848.7 $\pm$ 214.2	1801.4 $\pm$ 193.2 *
Walking (m)	622 $\pm$ 54.3	630.3 $\pm$ 35.5	724.1 $\pm$ 40.7*** ###
Low-intensity running (m)	630.8 $\pm$ 62.5	718.6 $\pm$ 108.4*	617.7 $\pm$ 99.7 ###
Moderate-intensity running (m)	302.3 $\pm$ 59.8	221.5 $\pm$ 75.8 **	177 $\pm$ 77.9 ***
High-intensity running (m)	92.2 $\pm$ 21.1	33.3 $\pm$ 22.1 ***	43.1 $\pm$ 22.7 ***
Time low-power (s)	765.8 $\pm$ 10.8	796 $\pm$ 27.3***	872.5 $\pm$ 17*** ###
Time high-power (s)	106.6 $\pm$ 8.9	99.2 $\pm$ 25.4	85.2 $\pm$ 21.6 **
Time maximum power (s)	6.8 $\pm$ 1.3	2 $\pm$ 1.7***	3.5 $\pm$ 1.9*** #
Distance low-power (m)	1203 $\pm$ 65	1237.2 $\pm$ 104	1245.1 $\pm$ 60.8
Distance high-power (m)	420.9 $\pm$ 45.6	355.2 $\pm$ 104.9	312.4 $\pm$ 94.1**
Distance maximum power (m)	34.6 $\pm$ 7	11.3 $\pm$ 8 ***	17.8 $\pm$ 8.9*** #

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.0005$ versus 5vs5

$p < 0.05$; ## $p < 0.01$; ### $p < 0.0005$ versus 6vs6

EW: external wildcard player

Discussion

The total distances calculated for the 3 SSG formats (for low, high and maximum power) were greatest in the 5vs5, but statistical significance was not achieved. This was also observed in the study by Randers and colleagues in which the same formats as used in this study were compared, but with the difference that no goalkeepers or external wildcard players were used (Randers et al., 2017).

The peak speeds achieved by the soccer players were greater in the 5vs5 and 7vs7 formats than in the 6vs6 format. In the 5vs5 format, this seems to reflect the requirement for each athlete to cover a larger area of the pitch; whereas in the 7vs7 format the peak velocities could have been influenced by the need to cover smaller spaces in very little time, and thus engaging high intensity actions in order to avoid losing possession of the ball. We can compare the peak values obtained from this present study, equal to 26.3 ± 1.1 , 23.1 ± 0.8 and 25.4 ± 2.1 km/h for the 5vs5, 6vs6 and 7vs7 formats, respectively, with those obtained in a recently published study occupied with the analysis of the maximum speeds obtained during different SSG formats and normal soccer matches in elite players in France (Djaoui et al., 2017). The maximum speed in the 5vs5 format of the present study was greater than that observed for 5vs5 performed with goalkeepers or with mini goal posts and ball possession in the French study ($26.3 \pm 1.1 > 23.08 \pm 2.88$, 21.12 ± 2.58 and 22.69 ± 3.36 km/h). The maximum speed obtained in the 6vs6 in our study, on the other hand, was slower than that observed for this format in the French study performed with goalkeepers on either a 50x60 m or a 40x40 m pitch (which compared the mean values for all players) with the exception of the results for central defenders and, in part, the 50x60 m pitch (Djaoui et al., 2017).

On the other hand, the higher maximum speed values we obtained for the 6vs6 format played with goalkeepers and external wildcard players were higher than those observed in other studies that also used the 6vs6 format but without the use of goalkeepers and external wildcard players, with and without touch limits, and on a larger pitch (Casamichana et al., 2014) or without goalkeepers and wildcard players (Campos Vázquez et al., 2017).

The mean maximum speed we observed in the 7vs7 format, performed with goalkeepers, was again higher than that obtained in the study of French elite players ($25.4 \pm 2.1 > 22.54 \pm 1.97$; $25.4 \pm 2.1 > 19.94 \pm 2.14$ km/h), performed in the absence of goalkeepers (Djaoui et al., 2017). Coherent with this difference, the mean values regarding distances run at high intensity and time spent at maximum power (> 55 W/kg) follow the same trend. In the high-power category (20-55 W/kg), the format that revealed the highest mean values (for time and distance run), and that were also statistically significant (although only partially with respect to the 7vs7), was the 5vs5. Indeed, if we consider the indicators of very high intensity, we can clearly conclude that it is the 5vs5 format that evokes the highest values, followed by the 7vs7 format. The values obtained are coherent with the results of other studies present in the literature (e.g., Randers et al., 2017).

The use of the 7vs7 format with external wildcard players and goalkeepers produced higher values in relation to low-, moderate- and high-intensity running compared with those for the 7vs7 performed in the traditional way (Rojas-Valverde et al., 2017). The parameters relative to maximum power, the number of acceleration events and equivalent distance support this interpretation.

The values for low-intensity running were significantly higher in the 6vs6 format compared with both the 5vs5 and 7vs7 formats. By contrast, significantly higher values were observed in the 7vs7 format for distances walked, leading us to think that this type of format demands bursts of speed associated with periods of very low intensity. The 6vs6 format, on the other hand, does not seem to demand very fast maximum speeds from the players; however, it does seem to require greater amounts of running at low and moderate intensity compared with the 7vs7 format. The values obtained here using external wildcard players were greater compared with those in an analogous study that analyzed the 6vs6 format played with goalkeepers, although playing times were longer in the latter study (Fransson et al., 2018). The same considerations are valid for running at high intensity (Fransson et al., 2018).

The significantly higher number of decelerations in the 6vs6 format leads us to think that running is more frequently interrupted in the 6vs6 than in the other formats. The number of decelerations recorded is in line with the results of other studies using the 6vs6 format with goalkeepers but without external wildcard players (Christopher et al., 2016). The values for maximum acceleration are indistinguishable between the 3 formats used, whereas the values for maximum deceleration are higher in the 5vs5 and 6vs6 formats compared with the 7vs7 format.

Conclusions

In conclusion, considering the values obtained in the 3 formats and their performance requirements, this study enables technical staff to understand how the formats can be best applied and therefore plan for their use on different training days and during sessions with different physical performance objectives. Indeed, the results indicate that the 5vs5 format with 2 goalkeepers and the presence of external wildcard players would be most beneficial on the first day of post-match training for the players who did not play in the match (or for only part of it), or for all players in the technical/tactical session on the second day of the weekly training program.

The 6vs6 format, on the other hand, considering the levels of low- and moderate-intensity running, seems to entail mostly aerobic intermittent exercise and, as such, would be most beneficially applied on either the first or third post-match training day. Finally, the 7vs7 format, considering the maximum speeds and significantly higher distances covered at a walking pace, would appear to be most useful if used just before a match; for example, on the fifth training day.

Authors' contribution

Italo Sannicandro contributed to the experimental design, statistical analysis, the interpretation of the results and the revision of the study; Gaetano Raiola contributed to data surveying; Rosa Anna Rosa contributed to the statistical analysis; Giacomo Cofano contributed to the experimental design, data surveying and the interpretation of the results; and Dario Colella contributed to experimental design and revision of the study.

Conflicts of interest – There are no conflicts of interest to declare.

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