Journal of Human Kinetics volume 78/2021, 187-196 DOI: 10.2478/hukin-2021-0037
Section III – Sports Training

Influence of Pitch Size on Short-Term High Intensity Actions and Body Impacts in Soccer Sided Games

by

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The aim of this study was to compare external training loads between small-sided games (SSGs) and large-sided games (LSGs) in soccer players. Twenty outfield soccer players (14.8 ± 0.6 years old) who competed in the Spanish U16 Provincial Division and belonged to the same team participated in the study. The soccer sided games were played at different individual interaction space (IIS) per player (i.e., SSG = 100 m^2 and LSG = 200 m^2) and were disputed in the same format (five-a-side plus goalkeepers) on two different pitch sizes (i.e., 38 x 26 vs. 53 x 37 m) defending an official soccer-goal. The sided games' duration was 4 bouts of 6 min with 2 min rest intervals between bouts. The results of this study showed no meaningful differences in the total distance and intensity of accelerations and decelerations between SSGs and LSGs except for the lower distance covered at medium intensity (2.5 - 4 $m \cdot s^{-2}$) observed during LSGs (-10.2%; ES (effect size): -0.51). Players registered greater sprints, maximum velocity (Vel_{max}) and body impacts at different intensities (i.e., I5-6g, I6-6.5g, I6.5-7g, I7-8g, I8-10g,) in LSGs in comparison to SSGs. These findings suggest that an increase in the pitch size (i.e., IIS per player) can induce higher external loads for soccer players.

Key words: *soccer, quantification, external loads, individual interaction space, neuromuscular.*

Introduction

Soccer coaches usually use sided soccer games to periodize the weekly microcycle (Bujalance-Moreno et al., 2018) because these training drills can resemble the specific stimulus similar to real match-play in terms of the presence of teammates and opposition, rules, goalkeepers, score and limited duration (Castillo, Raya-Gonzalez, Weston et al., 2019). In addition, previous literature has demonstrated that the use of these training drills improves physical fitness of players (Bujalance-Moreno et al., 2018; Owen et al., 2012) as well as their technical and tactical abilities (Hammami et al., 2018). Considering that sided soccer games induce different physical responses, it could be relevant to quantify the external training loads to facilitate the development of specific training processes aimed at maximizing on-field performance (Mujika, 2013).

One of the main variables that influence external training loads during the development of sided soccer games is pitch size in terms of pitch proportions and goal objectives (Casamichana and Castellano, 2010; Kelly and Drust, 2009; López-Fernández et al., 2017). In this line, it is necessary to understand the individual interaction space (IIS), calculated by dividing the total pitch area by the number of players, considering that an ISS of approximately 300 m^2 corresponds to each player during soccer match-play (Caro et al., 2019). Likewise, it is necessary to consider that the

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Authors submitted their contribution to the article to the editorial board.
Accepted for printing in the Journal of Human Kinetics vol. 78/2021 in April 2021.

dynamics of the collective organization is conducive to smaller individual playing areas (82-94 m^2) per player if one only considers the rectangle covering all outfield players during official matches (Fradua et al., 2013). Possibly because of this concept, previous studies have established that an IIS of around 100 m^2 corresponds to small-sided games (SSGs), while an IIS of 200 m^2 corresponds to large-sided games (LSGs) (Clemente et al., 2019; Owen et al., 2014; Sanchez-Sanchez et al., 2019). These aforementioned differences, focused on IIS, show a higher total running distance, high-intensity running and number of sprints during LSGs in comparison to SSGs (Casamichana and Castellano, 2010).

The ability of a player to perform high-intensity actions over short distances (i.e., accelerations, decelerations and sprints) can be linked to common soccer-specific requirements such as tackling, players when in defense or to create space during possession, with sprints being the most frequent action preceding a goal (Buchheit et al., 2014; Cochrane and Monaghan, 2018; Mara et al., 2017). Researchers have shown that sided soccer games understimulate sprinting actions (Casamichana et al., 2012; Owen et al., 2014) and overstimulate short-term and high-intensity actions (i.e., accelerations, decelerations, changes of direction) in comparison to match-play (Beenham et al., 2017; Casamichana et al., 2012; Clemente et al., 2019). Otherwise, research is inconclusive regarding the effect on the number and intensity of accelerations and decelerations when varying the pitch size during sided soccer games (Sanchez-Sanchez et al., 2019). While some authors have observed a higher number of accelerations and decelerations when a smaller IIS is implemented (Clemente et al., 2019), other researchers have shown greater accelerations and decelerations in sided soccer games contested in larger pitch sizes rather than smaller ones (Hodgson et al., 2014). The information is not only inconclusive regarding accelerations and decelerations when the IIS is varied, as no studies have analyzed how varying the pitch size affects the acceleration and deceleration intensities.

Another interesting variable to quantify during training sessions is body impact, which could provide relevant information regarding the mechanical stresses arising from the kinetic demands of all forces imposed on players during acceleration/deceleration, related changes of direction and impacts from both the player-to-player collision and contact with the ground (Cummins et al., 2013; McLean et al., 2010; Vanrenterghem et al., 2017). In fact, body impacts have been demonstrated to be a useful variable to assess match-related fatigue (Russell et al., 2016), to understand training and match loads rather than other external loads (Abade et al., 2014; Arruda et al., 2015), to predict the training load measured by the rating of perceived moderate exertion (Gaudino et al., 2015), to provide specific soccer position profiles (Wellman et al., 2016) and to quantify the external load during sided soccer games. Thus, using body impacts as an external load variable would be interesting for coaches in order to widely understand the physical demands of the different soccer sided games.

The understanding of how sided games may be related to the conditions of physical impact, measured in the form of acceleration/deceleration intensities and body impacts, is a requirement to identify the best adjustments to make in order to standardize the stimulus to the player's needs. In fact, this is the necessary approach needed to qualify the physical demands, beyond just quantifying the extent of running by the players. Therefore, the aim of this study was to compare external training loads between small-sided games (SSGs) and large-sided games (LSGs) in soccer players. We hypothesized that LSGs would induce greater external loads, caused by the pitch size, than SSGs.

Methods

Participants

Twenty outfield soccer players (age = 14.8 ± 0.6 years; body height = 173 ± 7 cm; body mass = 60.6 ± 8.1 kg; training experience in the club = 3.8 ± 2.6 years) who competed in the Spanish U16 Provincial Division and belonged to the same team participated in the study. A typical training session included a warm-up (general mobility games, technical-tactical drills), practice of specific game situations, small-sided games and practice of formal game situations (Sanchez-Sanchez et al., 2017). Each player was monitored four times in different sided games, thus a total of 80 observations were recorded for further analysis.

All participants (i.e., 2 central defenders, 4 wingers, 2 midfielders and 2 forwards) trained for two hours, three days per week and were involved in official matches once per week, resulting in a total soccer practice time of 7.5 h per week. Players of the team with the most minutes played during matches and without injury in the month prior to the investigation were selected to participate. Coaches, players and parents or tutors were informed of the research procedures, requirements, benefits and potential risks before providing written informed consent. The study was performed in accordance with the Declaration of Helsinki (2013), approved by Ethics Committee under the code M10/2016/079.

Procedures

The study was conducted over a 2-week period at the middle of the competitive season. A previous week was used for familiarization with the study protocol including the use of Global Positional System (GPS) units and the same sided soccer games performed during the investigation period. The sided soccer games were played at different IIS: SSG = 100 m^2 per player and LSG = 200 m^2 per player (Castellano et al., 2016). Each sided soccer game was performed twice with all games played within a period of 4 days, with an interval of 48 h after the last high load training session and/or official match, under similar weather conditions (18-22 C°, 70-75% humidity), on the same third-generation artificial pitch and with players wearing their normal soccer boots. Prior to the sided soccer games, players undertook a 20 min standardized warm-up, consisting of 7 min of slow jogging and strolling locomotion followed by 10 min of specific soccer drills, finishing with 3 min of progressive sprints and accelerations. During the study, players and their parents were instructed to maintain their usual habits, which included 8 h of night-time sleep before each data collection session, and adequate hydration and carbohydrate intake over the 24 h prior to each experimental sided game (Sanchez-Sanchez et al., 2018).

Sided soccer games

Each SSG and LSG was contested in the same format (five-a-side plus goalkeepers) on two different pitch sizes (i.e., IIS of 100 m^2 per player = 38 x 26 m vs. IIS of 200 m^2 per player = 53 x 37 m) playing with directionality and with the implications of the soccer rules. The sided soccer games' duration was 4 bouts of 6 min each with a 2 min rest interval between bouts. Although sided soccer games were played on different IIS (i.e., 100 vs. 200 m^2 per player), the relative pitch proportions were held constant with the same ratio (i.e., length/width = 1.46) as a soccer match. The teams were organized according to playing positions (i.e., one goalkeeper, one central defender, two wingers, one midfielder and one forward), technical-tactical levels, competitive experience, aerobic fitness and coach qualitative evaluation and they were faced all times (Casamichana and Castellano, 2010). The teams were the same (including the same players) during each experimental protocol. Coaches did not provide any strategic or tactical feedback during the process. Only verbal encouragement was provided to ensure a high commitment level of players during the matches. Goalkeepers were not included in further analyses due to their specific role. In addition, minor rule modifications were applied, such as restarting the game after a goal by the goalkeeper and kick-ins awarded to the opposing side from that of the player who last touched the ball (Rebelo et al., 2016). When the ball left the playing field, the coach always re-introduced balls immediately during all the sided soccer games (Owen et al., 2012). We respected the off-side rule with the aim of not changing the real structure of the game.

Measures

Measures were assessed with GPS devices (WIMU PROTM, RealTrack Systems, Almería, Spain) operating at a sampling frequency of 10 Hz (Muñoz-Lopez et al., 2017). Microsensor units were harnessed within a tight-fitting vest that was worn by soccer players during the study. The microsensor devices were activated 15 min before the start of each testing session, in accordance with the manufacturer's recommendations. Data were downloaded post-intervention protocol to a computer and analyzed using a customized software package (WIMU SPRO, Almería, Spain). The total distance covered while accelerating (Acc) and decelerating (Dec) was taken as a key outcome measures with further distance measures derived for different intensity categories (Castillo, Rodriguez-Fernandez et al., 2019): low-intensity acceleration (LAcc; 1-2.5 m·s^{-2}), medium-intensity acceleration (MAcc; 2.5-4 m·s^{-2}), high-intensity acceleration (HAcc; >4 m·s^{-2}), low-intensity deceleration (LDec; -1/-2.5 $m \cdot s^{-2}$), medium-intensity deceleration (MDec; -2.5/-4 $m \cdot s^{-2}$), and high-intensity deceleration (HDec; <-4 $m \cdot s^{-2}$). The number of sprints (>21 $km \cdot h^{-1}$) and the maximum velocity (Vel_{max}) achieved were registered as indicators of the external load (Castillo et al., 2016). In addition, the GPS devices were coupled with a 100 Hz triaxial accelerometer that allowed for the estimation of body impact data provided in "g" force. An impact was counted by the system if the force applied was more than five g force units (5 g). The software displayed the total impact counts from collisions, the intensity, as well as the time during the game or training drill where the impact occurred. A scaling system between 5-10+g for grading the impacts (I) was used: I5-6g: light impact, hard acceleration/deceleration/change of direction; I6-6.5g: light to moderate impact (player collision, contact with the ground); I6.5-7g: moderate to heavy impact; I7-8g: heavy impact; I8-10g: very heavy impact (scrum engagement); and I10+g: severe impact/tackle/collision. Impacts above 10g were used to report on the number of severe impacts that the players received during games (Wellman et al., 2016). The equipment presented good levels of validity and reliability in linear, circular and zig-zag courses (Bastida-Castillo et al., 2018; Muñoz-Lopez et al., 2017). Data were collected during what were considered to be good weather and satellite conditions for the GPS (number of satellites = 10.1 ± 0.2).

Statistical analysis

Results are presented as mean ± standard deviations (SD). Normal distribution and homogeneity of variances were tested using the Shapiro-Wilk and Levene tests. All analyzed variables had a normal distribution, and parametric techniques were applied. A t-test for paired samples was used to analyze the differences in external responses between SSGs and LSGs. Statistical significance was set at $p < 0.05$. Data analysis was performed using the Statistical Package for Social Sciences (version 21.0 for Windows, SPSS Inc, Chicago, IL, USA). We elected to use effect sizes (ES), with uncertainty of the estimates shown as 90% confidence limits (CL), to quantify the magnitude of the differences between playing in SSGs (i.e., 100 m^2 per player) and LSGs (i.e., 200 m^2 per player) in external load variables (i.e., Acc, Dec, LAcc, MAcc, HAcc, LDec, MDec, HDec, Vel_{max}, sprints and number and intensities of body impacts). The ES was classified as trivial (<0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2-2.0), very large (2.0-4.0) and extremely large (>4.0) (Hopkins et al., 2009). A threshold value of 0.2 between-subject standard deviations was set as the smallest worthwhile change, and inference was then based on the disposition of the CL for the mean difference to this smallest worthwhile effect; the probability (percentage chances) that the true difference between tests is substantial (beneficial/detrimental) or trivial was calculated as per the magnitude-based inference (MBI) approach (Batterham and Hopkins, 2006). The percentage chances were then qualified via probabilistic terms and assigned using the following scale: 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely (Hopkins et al., 2009). Inference was classified as unclear if the 90% CL overlapped the thresholds for the smallest worthwhile positive and negative effects (Hopkins et al., 2009). Given the relatively small size of our study, in both the number of players and the number of sessions, we employed a conservative approach to inference whereby only ES ≥ moderate was deemed meaningful.

Results

No significant differences ($p > 0.05$; unclear to possibly small) were found in the total distance and intensities of accelerating and decelerating between SSGs and LSGs (Table 1).

Players completed a greater number of sprints ($p < 0.001$; most likely very large) and achieved higher Vel_{max} ($p < 0.001$; most likely large) in LSGs in comparison with SSGs (Figure 1).

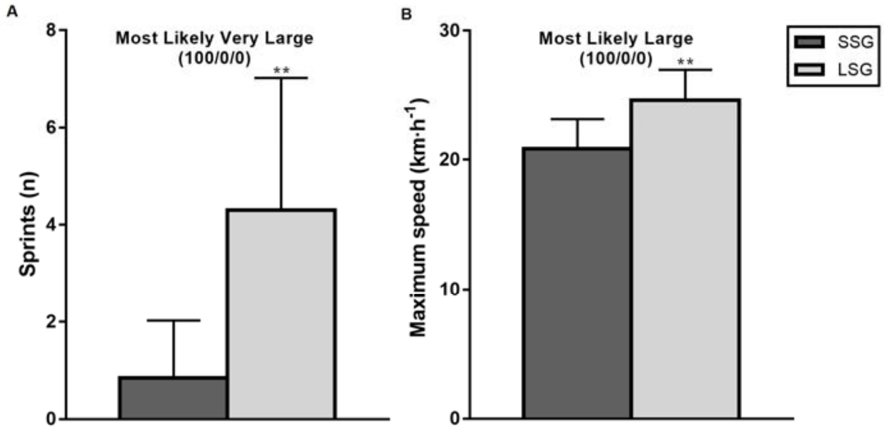
Players were exposed to greater ($p < 0.001$; very likely moderate) body impacts in LSGs compared to SSGs. Also, players registered more body impacts at I5-6g intensity in LSGs than in SSGs ($p < 0.001$; most likely moderate to likely small). However, no significant differences ($p > 0.05$) were found at I6-6.5g, I-6.7g, I7-8g, 8-10g and I>10+g between the mentioned pitch sizes.

Table 1

Results (mean differences ± SD) of the number and intensity of accelerations and decelerations between small-sided games (SSGs) and large-sided games (LSGs) along with effect sizes (ES) and qualitative inferences

Variables	SSG	LSG	Mean difference; ±90% CL	p	ES; ±90% CL	Qualitative Inference	Rating
Acc (m)	409.40 ± 47.11	402.70 ± 57.12	-2.0; ±4.7	0.56	-0.17; ±0.41	Unclear	7/47/46
Dec (m)	352.55 ± 51.63	360.70 ± 53.13	2.4; ±4.7	0.38	0.15; ±0.29	Possibly Trivial	39/59/3
LAcc (m)	307.25 ± 41.71	310.10 ± 50.64	0.4; ±5.1	0.75	0.03; ±0.37	Unclear	22/63/15
MAcc (m)	88.10 ± 18.32	79.35 ± 15.35	-10.2; ±8.4	0.06	-0.51; ±0.44	Likely Small	1/11/88
HAcc (m)	14.05 ± 6.81	13.25 ± 6.86	-4.6; ±21.4	0.54	-0.08; ±0.40	Unclear	12/57/31
LDec (m)	266.90 ± 40.31	277.05 ± 47.13	3.4; ±5.2	0.20	0.21; ±0.31	Possibly Small	52/46/2
MDec (m)	70.30 ± 13.07	66.75 ±12.73	-4.8; ±7.7	0.22	-0.25; ±0.41	Possibly Small	4/38/58
HDec (m)	15.35 ± 5.91	16.90 ± 5.87	11.0; ±19.3	0.29	0.27; ±0.45	Possibly Small	61/35/4

CL = confident limits; SD = standard deviation; Acc = total distance covered accelerating; Dec = total distance covered decelerating; LAcc = distance covered accelerating between 1 and 2.5 $m\cdot s^{-2}$; MAcc = distance covered accelerating between 2.5 and 4 $m\cdot s^{-2}$; HAcc = distance covered accelerating at above 4 $m\cdot s^{-2}$; LDec = distance covered decelerating between -2.5 and -1 $m\cdot s^{-2}$; MDec = distance covered decelerating between -4 and -2.5 $m\cdot s^{-2}$; HDec = distance covered decelerating at less than -4 $m\cdot s^{-2}$



** Significant level set at $p < 0.001$

Figure 1

Practical differences in sprints number (A) and maximum speed (B) between small-sided game (SSG) and large-sided game (LSG).

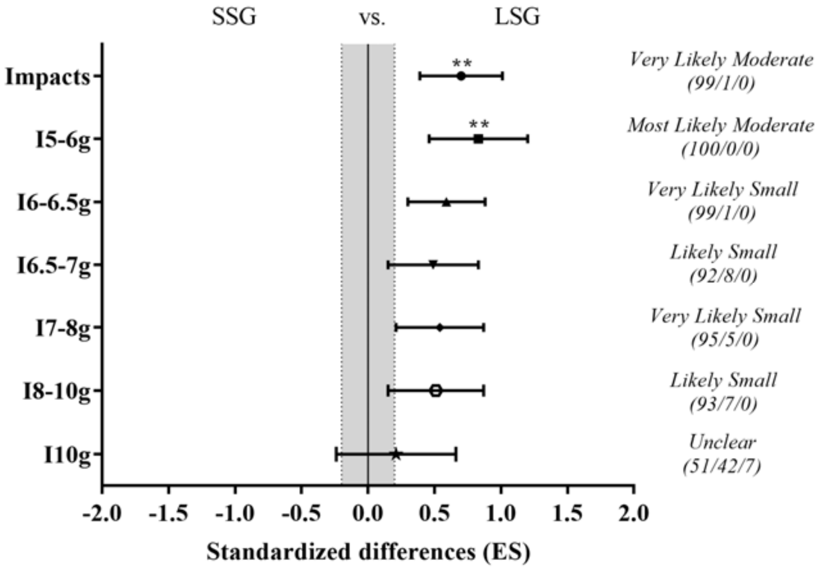


Figure 2

Practical differences between small-sided game (SSG) and large-sided game (LSG) in impact variables. Impacts = total impacts; I5-6g = light impact, hard acceleration/deceleration/ change of direction; I6-6.5g = light to moderate impact (player collision, contact with the ground); I6.5-7g = moderate to heavy impact; I7-8g = heavy impact; I8-10g = very heavy impact (scrum engagement); >I10g = severe impact/ tackle/ collision.

** Significant level set at $p < 0.001$

Discussion

The aim of this study was to compare external training loads between SSGs and LSGs in soccer players. This is the first study which has provided information about ranges of short-term and high-intensity actions depending on the pitch size in sided soccer games. The results of this investigation showed that although no substantial differences were present in total distance and intensities for accelerating and decelerating between SSGs and LSGs, players registered a greater number of sprints, higher Vel$_{max}$ and a greater number of body impacts and body impacts at I5-6g intensity during LSGs in comparison to SSGs.

Short-term and high-intensity actions have been demonstrated to be decisive in soccer, as these actions may have a specific impact on the outcome of the matches and physical performance of players (Cochrane and Monaghan, 2018). The literature has shown contradictory results regarding the number of accelerations and decelerations when coaches use different pitch sizes. On the one hand, higher acceleration sums were reported in SSGs (i.e., IIS = 120 m2 per player) as compared to LSGs (i.e., 194 m2 per player) (Clemente et al., 2019). On the other hand, Hodgson et al. (2014) observed greater distances for accelerations (SSGs = 230 ◎ 111 vs. LSGs = 327 ◎ 70 m) and decelerations (SSGs = 198 ◎ 89 vs. LSGs = 298 ◎ 68 m) in LSGs (i.e., IIS = 200 m2) than in SSGs (i.e., IIS = 60 m2). In addition, these authors also reported greater distances for accelerating and decelerating at low, moderate and high intensities (Hodgson et al., 2014). However, our results do not coincide with any of these previous studies as no significant differences were found in the distance covered at different intensities of accelerations and decelerations between SSGs and LSGs. These differences could be due to the characteristics of sided games in terms of duration, the off-side rule, presence of goalkeepers, the number of players and IIS. Therefore, further studies focused on the influence of pitch size on accelerations and decelerations should be developed to clarify the aforementioned controversy.

In addition to the accelerations and decelerations covered at different intensities, it has been demonstrated that the analysis of sprinting actions in soccer is crucial to optimize performance, mainly due to the fact that sprinting is the most frequent action preceding a goal (Faude et al., 2012). Thus, understanding the sprinting demands of each training drill in order to replicate them during training periodization is an important challenge of soccer coaches. In this sense, our results are consistent with previous studies which showed that a greater number of sprints and Vel_{max} values are achieved during LSGs than during SSGs (Casamichana and Castellano, 2010; Clemente et al., 2019; Hodgson et al., 2014). In this sense, it seems that an increase of the pitch size, holding constant the relative pitch proportions with the same ratio (i.e., length/width = 1.46) as a soccer match, would be a useful strategy to enhance the number of sprints and the Vel_{max} achieved by young soccer players. However, the number of sprints registered in the present study in sided soccer games played with a higher IIS per player (i.e., LSGs) was lower (◎4 vs. ◎10 sprints) than observed in other studies (Clemente et al., 2019; Hodgson et al., 2014), mainly due to the inclusion of the off-side rule and the age-group effect. Considering these differences, it seems that sprinting actions and Vel_{max} may not be influenced only by the ISS per player, but also by other decisive factors such as the pitch proportions, the number of players and/or the modification of some rules of the game (i.e., offside). The acquired knowledge of the external loads imposed upon players during sided soccer games in relation to pitch size could be interesting for coaches in order to understand the impact of sided soccer games.

Despite the scarce literature focused on body impacts in soccer, it seems that the quantification of this variable could be interesting in order to implement appropriate training strategies (Abade et al., 2014; Arruda et al., 2015). To date, although some authors have reported information about the number and intensities of body impacts during official soccer games (Russell et al., 2016; Wellman et al., 2016), only one study has provided data during training drills (Castillo, Raya-Gonzalez, Clemente et al., 2019). In line with this investigation, the results of our study showed that greater body impacts were registered in LSGs compared to SSGs. In addition, players registered higher body impacts at I5-6g intensity in LSGs rather than SSGs. Thus, it seems that playing at a higher ISS per player induces greater body impacts. In this sense, it would be advisable to quantify the physiological and neuromuscular effects caused by the body impacts experienced by players during sided soccer games (Arruda et al., 2015; Wellman et al., 2016). Further research should investigate whether higher body impacts during training drills can induce training-related neuromuscular fatigue or risk of injury, or on the contrary, whether this variable can be beneficial to enhance chronic adaptations for maximizing the players' physical performance. Given that differences have been found in body impacts, but no differences were reported regarding accelerations and decelerations, it would be convenient to quantify both variables during specific training drills in order to acquire greater knowledge of the sided soccer game demands. Further research could investigate the association of body impacts with other external loads. These findings provide novel quantification of sided soccer games and may indicate that body impacts can be used to increase the specificity of training programs.

This study is not without limitations, with the main one being a small sample size. Besides, understanding the soccer games-related fatigue as previous studies have analyzed (Castillo, Rodriguez-Fernandez et al., 2019; Rebelo et al., 2016), it would be interesting for further investigations to extend the knowledge of the training process including this information. In addition, considering the inclusion of the offside rule during the soccer sided games, this fact could influence the dynamics of the game, so it would be advisable to replicate this study without the application of the offside. Finally, for future investigations, it would be interesting to determine the characteristics of body impacts encountered during match-play in order to organize the weekly loads and to inspect the relationships between tactical behaviors and collective patterns of play both in youth and senior soccer players.

Conclusions

While no meaningful differences were found in the total distance and intensities during accelerations and decelerations between SSGs and LSGs, a greater number of sprints, Vel_{max} and body impacts were performed during LSGs in comparison with SSGs. These results suggest that an increase in the pitch size (i.e., IIS per player) can induce higher external loads for the soccer player. These findings provide insightful knowledge that can be used to design specific training drills in soccer, and that the quantification of body impacts could be used to increase the specificity of training programs.

Acknowledgments

The authors gratefully acknowledge the support of a Spanish government subproject Mixed method approach on performance analysis (in training and competition) in elite and academy sport [PGC2018-098742-B-C33] (2019-2021), from Ministerio de Ciencia, Innovación y Universidades (MCIU), Agencia Estatal de Investigación (AEI), and Fondo Europeo de Desarrollo Regional (FEDER), that is part of the coordinated project New approach of research in physical activity and sport from mixed methods perspective (NARPAS_MM) [SPGC201800X098742CV0].

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