Time-motion, heart rate, perceptual and motor behaviour demands in small-sides soccer games: Effects of pitch size

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Time-motion, heart rate, perceptual and motor behaviour demands in small-sides soccer games: Effects of pitch size

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Abstract

The aim of this study was to examine physical, physiological, and motor responses and perceived exertion during different soccer drills. In small-sided games, the individual playing area (≈275 m², ≈175 m², and ≈75 m²) was varied while the number of players per team was kept constant: 5 vs. 5 plus goalkeepers. Participants were ten male youth soccer players. Each session comprised three small-sided game formats, which lasted 8 min each with a 5-min passive rest period between them. A range of variables was recorded and analysed for the three drills performed over three training sessions: (a) physiological, measured using Polar Team devices; (b) physical, using GPS SPI elite devices; (c) perceived exertion, rated using the CR-10 scale; and (d) motor response, evaluated using an observational tool that was specially designed for this study. Significant differences were observed for most of the variables studied. When the individual playing area was larger, the effective playing time, the physical (total distance covered; distances covered in low-intensity running, medium-intensity running, and high-intensity running; distance covered per minute; maximum speed; work-to-rest ratio; sprint frequency) and physiological workload (percent maximum heart rate; percent mean heart rate; time spent above 90% maximum heart rate), and the rating of perceived exertion were all higher, while certain motor behaviours were observed less frequently (interception, control and dribble, control and shoot, clearance, and putting the ball in play). The results show that the size of the pitch should be taken into account when planning training drills, as it influences the intensity of the task and the motor response of players.

Keywords: Soccer, small-sided games, time-motion analysis, heart rate, perceived exertion, notation analysis

Introduction

Small-sided games are widely used by coaches to develop technical and tactical skills (Jones & Drust, 2007), as well as to improve the endurance of soccer players (Hill-Haas, Dawson, Coutts, & Rowsell, 2009b; Impellizzeri et al., 2006), and as part of generic training (Hill-Haas, Coutts, Rowsell, & Dawson, 2009a). This is particularly advantageous in the case of young players, as improvement in specific skills is closely related to the frequency of practice (Impellizzeri et al., 2006). During small-sided games, players experience similar situations to those they encounter in competitive matches (Owen, Twist, & Ford, 2004), the only differences being fewer players, a reduced playing surface, and/or the addition or modification of certain rules (Little, 2009).

Ways to quantify the physical and physiological demands of small-sided games in soccer training were first proposed more than 20 years ago (MacLaren, Davids, Isokawa, Mellor, & Reilly, 1988). More recently, advances in – and greater access to – a range of technological resources (heart rate monitors, lactate analysers, portable global positioning system (GPS) devices, etc.) have made the evaluation and monitoring of the demands in small-sided games more accessible, reliable, and accurate (Castagna et al., 2007; Gabbet & Mulvey, 2008; Jensen, Randers, Krstrup, & Bangsbo, 2009; Reilly, 2005; Reilly & White, 2004; Sassi, Reilly, & Impellizzeri, 2004). The GPS devices are widely adopted because they are light, small and relatively cheap, and they also enable rapid data entry through the automatic analysis of multiple players simultaneously, the analysis itself being easy to perform (Aughey & Fallon, 2010; Edgecomb & Norton, 2006; MacLeod, Morris, Nevill, & Sunderland, 2009). GPS technology thus provides a practical method for recording time–motion characteristics (such as distance, speed, and sprints) during all forms of soccer training (Hill-Haas et al., 2009b).

If the use of small-sided games is to be effective as a conditioning stimulus, it is necessary to develop a better understanding of their expected effects at the
physiological and motor levels, in terms of perceived exertion (Hill-Haas et al., 2009b), and regarding socio-motor ability (Parlebas, 2001). Several studies to date have systematically investigated the effects on players of altering different variables or game rules, including pitch size (Kelly & Drust, 2009; Owen et al., 2004; Tessitore, Meeusen, Piacentini, Demarie, & Capranica, 2006), the inclusion/exclusion of specific attack and defence zones (Dellal et al., 2008; Mallo & Navarro, 2008; Sassi et al., 2004), the number of players (Katis & Kellis, 2009), and the duration of the game formats (Tessitore et al., 2006). Other authors have used a combination of these variables (Aroso, Rebelo, & Gomes-Pereira, 2004; Hill-Haas et al., 2009b; Jones & Drust, 2007, Rampinini et al., 2007; Williams & Owen, 2007). Some studies have also included variables such as coach encouragement, rule modifications (such as limiting the number of touches allowed per player or the scoring method) (Martínez de Santos, Blanco-Villaseñor, Sánchez, & Los Arcos, 2009) and different work regimes (Hill-Haas, Rowsell, Dawson, & Coutts, 2009c).

A key concept in the present study is the “individual playing area”, which is defined (Parlebas, 2001) as the theoretical pitch area that corresponds to each player and is calculated by dividing the total pitch area by the number of players. Research is inconclusive regarding the effect of varying the pitch size (keeping the pitch area per player constant), since some studies have found that small-sided games played on larger pitches are more intensive than those played on smaller ones (Owen et al., 2004; Rampinini et al., 2007), while other authors report no significant differences in task intensity according to pitch size (Kelly & Drust, 2009). Furthermore, some studies have found that small-sided games played on small pitches are more intensive (Tessitore et al., 2006). With the aim of providing new insight in this regard, we studied the effects of physical variables (distances covered by players at different speeds, recorded using GPS devices) and physiological variables (by recording heart rate and perceived exertion, as in Hill-Hass et al., 2009b), and complemented this with the observation of motor behaviour during play. As far as we are aware, these variables have not previously been analysed simultaneously and, moreover, the research that does exist has only modified the variable “individual playing area”. We also sought to conduct a preliminary analysis of the “effective playing time” in small-sided games. To the best of our knowledge, no published report has studied the duration of player participation when considering only the time that the ball is in play. We believe that this variable could influence the workload undertaken by players, since the same duration but a different pitch size might lead to a different effective playing time.

We are also unaware of any studies that have examined the influence of decreasing the relative pitch area per player on physiological, physical, and perceptual responses, as well as on the behaviour of young soccer players in small-sided games. Therefore, the aim of the present study was to examine the physical, physiological, and motor responses as well as perceived exertion of players during small-sided games played on three pitch sizes: large, medium, and small. Specifically, we sought to analyse the effects on players of varying the individual playing area in the same type of training drill, and thus determine whether there were any differences between these three formats as regards effective playing time. We also studied the relationship between the effective playing time and the physical, physiological, perceptual, and motor responses of players.

**Methods**

**Participants**

Participants were ten male youth soccer players (age: 15.5 ± 0.5 years; height: 1.74 ± 0.07 m; weight: 62.9 ± 3.7 kg; performance on the Yo-Yo intermittent recovery test level 1: 1816 ± 505 m). All players were members of the same team (youth category) that competed at regional level, with a mean of 7.5 years of experience in federation soccer. The players and their parents were informed about the research design and its benefits and risks, and their informed consent was obtained before testing began. The Ethics Committee of the University of the Basque Country approved the study protocol.

To avoid any potential imbalance between the teams, certain individual and collective aspects were taken into account in their creation: player position, tactical/technical level, physical aptitude, and participation in competitive matches. The players’ technical/tactical level was established according to the subjective evaluation of their coach, who awarded a score of 1 to players with the lowest level and 5 to those with the highest level. The number of minutes played in competitive matches (prior to the study date) was also used to categorize players: a score of 1 was given to players with the fewest number of minutes played and 5 to those who had played the most minutes. Scores on the Yo-Yo intermittent recovery test level 1 were used in the same way: players who covered the least distance were given a score of 1 and those who covered the most ground were awarded a score of 5. The total score for each player was the sum of scores for the coach’s evaluation of technical/tactical level, the number of minutes played before the study began, and performance on the Yo-Yo intermittent recovery test level 1.
The participants' usual playing position in the team (defender, midfielder, and forward) was also taken into account. Two teams were created that were similar in terms of the coach's subjective evaluation, the number of minutes played, and performance on the Yo-Yo intermittent recovery test level 1. Team A included the goalkeeper with the highest total score, the second- and third-ranked defenders, the first- and fourth-ranked midfielders, and the second-ranked forward. Team B comprised the second-ranked goalkeeper, the first- and fourth-ranked defenders, the second- and third-ranked midfielders, and the first-ranked forward.

**Independent variable: playing area**

The independent variable was the same small-sided game format (five-a-side plus goalkeepers) played on three different pitch sizes, with three matches on each. All the small-sided game formats were performed outdoors, on a natural grass soccer pitch. Although the size of the pitch was varied, we held constant the relative proportions (length/width) of the playing surface, the division of the playing area, and the rule that possession should be determined by the run of play rather than coach instructions. The largest playing area (i.e. the large-format small-sided game) had the same individual playing area as the standard pitch used by the team for its competitive home matches. For the other two formats used (medium and small pitches), the individual playing area was reduced by around 100 m each time – to 175 m² and ~75 m² of the individual playing area, respectively (Table I). Individual playing area does not take into account goalkeepers.

**Dependent variables**

**Effective playing time.** This is the duration of play after subtracting the time taken up by stoppages (fouls, goals, throw-ins, goal kicks, injuries, etc.); that is, the amount of time during which the ball is stationary.

**Physiological profile: heart rate.** The parameter used to evaluate the physiological component was heart rate, which was recorded at 5-s intervals during each small-sided game by means of telemetry (Polar Team Sport System, Polar Electro Oy, Finland). The heart rate monitors were also worn during the Yo-Yo intermittent recovery test level 1 (Bangsbo, Iaia, & Krustrup, 2008) to determine the maximum heart rate of each player (Krustrup et al., 2003). The Yo-Yo intermittent recovery test level 1 was performed outdoors on a natural grass soccer pitch with players wearing soccer boots. The participants completed the test at the same time of day and in similar sunny conditions (19°C). As in previous studies (Hill-Haas et al., 2009b), maximum heart rate (HR
\text{max}) was used as a standard against which to define four intensity zones (<75% HR
\text{max}, 75–84% HR
\text{max}, 85–89% HR
\text{max}, and >90% HR
\text{max}). We quantified the percentage of time spent within each intensity zone during the small-sided games, as well as the percentages of maximum heart rate (%HR
\text{max}) and mean heart rate (%HR
\text{mean}) with respect to that achieved in the Yo-Yo intermittent recovery test level 1.

**Physical profile: speed and distance covered.** Player motion during the small-sided games was measured using a portable GPS device (SPI-elite, GPSports, Canberra, ACT, Australia). This model offers acceptable accuracy and reliability (MacLeod et al., 2009) for most of the relevant measures taken in team sports that involve short demands and non-linear intermittent sprints. However, some authors (Coutts & Duffield, 2010) have suggested that it may offer poor reliability for high-intensity activities (coefficient of variation [CV] = 11.2% for high-intensity running of more than 14.4 km · h⁻¹, and

<table>
<thead>
<tr>
<th>Variables</th>
<th>CM format standard pitch</th>
<th>Small-sided game format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SSG_L</td>
</tr>
<tr>
<td>Duration</td>
<td>2 × 40 min</td>
<td>8 min</td>
</tr>
<tr>
<td>Pitch size</td>
<td>88 × 62 m</td>
<td>62 × 44 m</td>
</tr>
<tr>
<td>Playing area</td>
<td>9456 m²</td>
<td>2728 m²</td>
</tr>
<tr>
<td>Grid ratio (length-to-width)</td>
<td>1.4:1</td>
<td>1.4:1</td>
</tr>
<tr>
<td>Ratio per player</td>
<td>272.8 m²</td>
<td>175 m²</td>
</tr>
<tr>
<td>Goalkeepers</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rules</td>
<td>As in the 11-a-side game</td>
<td>Yes</td>
</tr>
<tr>
<td>Coach encouragement</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Availability of balls</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table I. Established characteristics of the three small-sided game formats (SSG_L = large pitch, SSG_M = medium pitch, SSG_S = small pitch) and of official competitive matches (CM).
CV = 15.4% for very high-intensity running of more than 20 km · h⁻¹.

The speeds and distances covered were recorded at 1 Hz. To analyse the data, four speed categories were established: stationary/walking (0–6.9 km · h⁻¹), low-intensity running (7.0–12.9 km · h⁻¹), medium-intensity running (13.0–17.9 km · h⁻¹), and high-intensity running (>18 km · h⁻¹). The speed and motion categories were similar to those used in previous studies (Hill-Haas et al., 2009b; Impellizzeri et al., 2006).

The variables recorded included total distance covered, distance covered per minute of play, maximum speed reached, distance covered in each of the speed categories (stationary/walking, low-intensity running, medium-intensity running, and high-intensity running), the work-to-rest ratio (estimated using the distance covered at a speed of 0–6.9 km · h⁻¹ as “rest”, while all categories with speeds greater than 6.9 km · h⁻¹ were considered as work), and frequency of sprints.

Rating of perceived exertion. A perceived exertion rating scale was completed by each player immediately after each small-sided game during the 5-min rest period. The scale used was the CR-10 (Foster, 1998). All participants were familiar with this scale before its use in the present study. The scale has been validated as an indicator of training intensity in intermittent tasks of small-sided games (Coutts, Rampinini, Marcora, Castagna, & Impellizzeri, 2009).

Motor response. The small-sided games were filmed using a video-camera (Supratech Supracam Zelus HD, 1/2.5" CMOS, 5.0 megapixels) placed approximately 10 m from the goal line at a height of 10 m. An ad hoc observational tool was developed to register the players’ behaviour, which was similar to those used in other studies (Gabbet & Mulvey, 2008; Jones & Drust, 2007; Kelly & Drust, 2009; Mallo & Navarro, 2008; Owen et al., 2004; Tessitore et al., 2006). The behaviours that were observed, coded, and registered were as follows: tackle, interception, control, dribble, pass, first-touch pass, shot, header, clearance, and putting the ball in play. The Measuring and Observation Tool in Sport (MOTS) software (Castellano, Perea, Alday, & Hernández-Mendo, 2008) was selected as the platform for the computerized analysis of players’ behaviour.

To assess intra- and inter-observer reliability, the data were compared across two observation sessions of the same large-format small-sided games during the first training drill. Only the behaviours of one team were recorded. The results showed very good stability across observations, as kappa was above 0.88 for all criteria and 0.95 for the session as a whole (Bakeman & Quera, 1996).

Procedures

The study was conducted over a 2-week period in February during the 2008–2009 competitive season. The first week was used to familiarize players with the GPS and telemetry devices and the small-sided game formats, as well for application of the Yo-Yo intermittent recovery test level 1 to all players. The second week was dedicated to the small-sided games, which were all played by the same team line-ups and immediately after a standard 15-min warm-up. The players refrained from intense physical activity on the 2 days preceding the test sessions. Water ingestion was allowed during the rest period between small-sided game formats. Each session comprised the three small-sided game formats (different individual playing areas), which lasted 8 min each with a 5-min passive rest between them. Small-sided games were played at the same time of day under cloudy conditions (17 ± 2°C). There were no stoppages for injury. The order in which the game formats were played was randomly varied across the three sessions.

Statistical analysis

The data are presented as means, standard deviations (s), and 95% confidence intervals (95%CI). Levene’s test was applied to assess the homogeneity of variances, while one-way analysis of variance (ANOVA) was used to test for significant differences in each of the dependent variables. The independent variables were the three individual playing areas of each small-sided game (large, medium and small), and the post-hoc Bonferroni test was applied whenever any significant difference was found between them. Pearson’s correlation coefficients were then used to assess the relationship between effective playing time and the physical and physiological variables, perceived exertion, and motor response. All statistical analyses were performed using SPSS v.16.0 for Windows. Statistical significance was set at P < 0.01 and P < 0.05.

Results

Effective playing time

There were variations in effective playing time according to the different small-sided game formats. As pitch size was reduced, there was a concomitant decrease in the effective playing time, with the shortest duration corresponding to the small pitch (325 ± 17 s; medium pitch: 364 ± 9 s; large pitch:
394 ± 33 s). Effective playing time on the small pitch was significantly different from that on both the large pitch and medium pitch (post-hoc Bonferroni test: there were significant differences for small pitch vs. medium pitch and large pitch, \( P < 0.05 \), but not for medium pitch vs. large pitch, \( P = 0.1 \)).

**Physiological responses**

Table II shows the physiological characteristics associated with the small-sided games played with different individual playing areas. While there were no significant differences between the large and medium pitches, both these formats showed significant differences versus the small pitch on all the variables (%HR\(_{\text{max}}\) and %HR\(_{\text{mean}}\): large and medium pitches > small pitch; >90% HR\(_{\text{max}}\): large pitch > small pitch; 75–84% HR\(_{\text{max}}\): large and medium pitches < small pitch) except for the percentage of time played at <75% HR\(_{\text{max}}\) and the percentage of time at 84–89% HR\(_{\text{max}}\).

**Ratings of perceived exertion**

Means, standard deviations, and confidence intervals (95%CI, in parentheses) for the ratings of perceived exertion given by players in the different small-sided game formats were: 6.7 ± 0.8 (5.8–7.5) on the large pitch, 6.7 ± 0.8 (5.8–7.5) on the medium pitch, and 5.7 ± 1.0 (4.6–6.7) on the small pitch. Significant differences were observed only for the small pitch with respect to both the large and medium pitches (post-hoc Bonferroni test: large pitch > small pitch; medium pitch > small pitch; \( P < 0.05 \) in all cases). The correlation with effective playing time was \( r = 0.374 \) (\( P < 0.01 \)).

**Physical responses**

Table III shows the total distance covered, distance covered per minute of play, maximum speed reached, distance covered in each of the speed categories during the different small-sided games, the work-to-rest ratio, and sprint frequency. The data are expressed as absolute values (metres). There were significant differences between the large and small pitches for all the variables studied except the distance covered at a speed of 0–6.9 km · h\(^{-1}\). Differences were observed between the medium and small pitches with respect to the total distance covered, distance covered at 13.0–17.9 km · h\(^{-1}\), and the work-to-rest ratio. The only significant difference between the large pitch and medium pitch concerned the total distance covered. Finally, the only variable that showed no significant difference between the different individual playing area formats was the total distance covered at 0–6.9 km · h\(^{-1}\). There was a strong and positive correlation between almost all the physical variables (total distance, distance covered per minute of play, distance covered in low-intensity running, distance covered in medium-intensity running, and work-to-rest ratio) and effective playing time. However, the correlation was negative between total distance covered when stationary/walking and effective playing time.

**Motor responses**

Table IV shows the various motor behaviours for the different individual playing area formats. Most of the behaviours studied increased in frequency as the individual playing area became smaller, without there being any significant differences between the large and medium pitches, except for control and dribble. There were significant differences between small and medium pitches for control and shoot, clearance, and putting the ball in play, as well as significant differences between small and large pitches for interception, control and dribble, clearance, and putting the ball in play. There were negative correlations between interception, control

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**Table II.** Means (± standard deviations) and 95% confidence intervals (in parentheses) for the physiological variables of players in the different small-sided game formats: The final column shows the correlations between effective playing time (EPT) and each of the physiological variables.

<table>
<thead>
<tr>
<th>SSG(_L)</th>
<th>SSG(_M)</th>
<th>SSG(_S)</th>
<th>Correlation with EPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>%HR(_{\text{max}})</td>
<td>94.6 ± 4.3 (90.1 to 99.2)(^b)</td>
<td>94.6 ± 3.4 (91.0 to 98.2)(^c)</td>
<td>93.0 ± 5.7 (87.0 to 99.0)</td>
</tr>
<tr>
<td>%HR(_{\text{mean}})</td>
<td>88.9 ± 3.9 (84.8 to 93.0)(^b)</td>
<td>88.5 ± 4.9 (83.3 to 93.7)(^c)</td>
<td>86.0 ± 5.8 (79.3 to 92.1)</td>
</tr>
<tr>
<td>&lt;75% HR(_{\text{max}})</td>
<td>3.3 ± 4.5 (–1.3 to 8.0)</td>
<td>2.7 ± 5.3 (–2.8 to 8.3)</td>
<td>5.6 ± 8.7 (–3.5 to 14.7)</td>
</tr>
<tr>
<td>75–84% HR(_{\text{max}})</td>
<td>10.0 ± 14.7 (–5.4 to 25.5)</td>
<td>19.4 ± 22.7 (–4.4 to 43.2)</td>
<td>27.9 ± 36.1 (–9.9 to 65.8)(^d,e)</td>
</tr>
<tr>
<td>84–89% HR(_{\text{max}})</td>
<td>35.8 ± 23.1 (11.6 to 60.0)</td>
<td>20.8 ± 14.3 (5.8 to 35.8)</td>
<td>25.2 ± 17.5 (6.8 to 43.5)</td>
</tr>
<tr>
<td>&gt;90% HR(_{\text{max}})</td>
<td>50.8 ± 34.4 (14.7 to 86.9)(^f)</td>
<td>57.0 ± 36.0 (19.3 to 94.8)(^g)</td>
<td>41.3 ± 36.0 (3.5 to 79.0)</td>
</tr>
</tbody>
</table>

**Note:** SSG\(_L\) (large pitch), SSG\(_M\) (medium pitch), SSG\(_S\) (small pitch), HR\(_{\text{max}}\) (maximum heart rate), %HR\(_{\text{max}}\) (percentage of maximum heart rate), %HR\(_{\text{mean}}\) (percentage of mean heart rate).  
Post-hoc Bonferroni test: \(^{b}\)SSG\(_L\) > SSG\(_M\); \(^{c}\)SSG\(_M\) > SSG\(_S\); \(^{d}\)SSG\(_S\) > SSG\(_L\); \(^{e}\)SSG\(_L\) > SSG\(_S\) (\( P < 0.05 \) in all cases).  
Pearson’s correlation coefficients: \(* P < 0.05; ** P < 0.01.\)
Table III. Means (+ standard deviations) and 95% confidence intervals (in parentheses) for the physical variables of players in the different small-sided game formats: correlations between effective playing time (EPT) and each of the physical variables.

<table>
<thead>
<tr>
<th>Format</th>
<th>Total distance (m)</th>
<th>Distance covered per minute (m)</th>
<th>Maximum speed (km/h)</th>
<th>Distance stationary/walking (0–6.9 km/h) (m)</th>
<th>Distance low-intensity running (7.0–12.9 km/h) (m)</th>
<th>Distance high-intensity running (4–18 km/h) (m)</th>
<th>Work-to-rest ratio</th>
<th>Sprint frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSG L</td>
<td>995.6 ± 50.0a</td>
<td>125.0 ± 2.6b</td>
<td>23.1 ± 2.6b</td>
<td>388.3 ± 67.2b</td>
<td>366.3 ± 54.0b</td>
<td>74.2 ± 58.9b</td>
<td>1.7 ± 0.3</td>
<td>0.8 ± 3.0</td>
</tr>
<tr>
<td>SSG M</td>
<td>908.9 ± 30.6a</td>
<td>87.0 ± 4.6b</td>
<td>20.4 ± 1.9b</td>
<td>390.0 ± 30.4b</td>
<td>238.9 ± 54.0b</td>
<td>28.5 ± 58.9b</td>
<td>1.3 ± 0.2</td>
<td>0.7 ± 0.2</td>
</tr>
<tr>
<td>SSG S</td>
<td>695.8 ± 30.6c</td>
<td>0.683**</td>
<td>0.677**</td>
<td>0.577**</td>
<td>50.2 ± 21.0b</td>
<td>0.787**</td>
<td>0.118</td>
<td>0.158</td>
</tr>
</tbody>
</table>

Note: SSGs (large pitch), SSGm (medium pitch), SSGs (small pitch). Pearson’s correlation coefficients: *P < 0.05; **P < 0.01.

and dribble, and putting the ball in play with effective playing time.

Discussion

The main aim of this study was to determine the effect of altering the individual playing area of small-sided games on the physiological, physical, and motor responses as well as perceived exertion of field soccer players. Significant differences were observed for most of the variables studied: when the individual playing area was largest, the physical and physiological workloads and the ratings of perceived exertion were all higher, while certain motor behaviours were observed less frequently. Moreover, the effective playing time was also higher when the individual playing area was larger.

In line with other studies (Owen et al., 2004; Rampinini et al., 2007), we found that for the same small-sided games an increase in the individual playing area led to a concomitant increase in the physical and physiological workloads and ratings of perceived exertion. It should be noted, however, that not all research has reported this trend (Kelly & Drust, 2009; Tessitore et al., 2006).

Average figures for the immediate physiological effects of drills ranged between 86% \( \text{HR}_{\text{max}} \) for the small pitch to 89% \( \text{HR}_{\text{max}} \) for the large pitch, these values being very similar to those observed by other authors using a 5 vs. 5 format: 91% \( \text{HR}_{\text{max}} \) (Hoff, Wisloff, Engen, Kemi, & Helgerud, 2002), 89–91% \( \text{HR}_{\text{max}} \) (Kelly & Drust, 2009), 89–90% \( \text{HR}_{\text{max}} \) (Little & Williams, 2006), 89% (Little & Williams, 2007), and 86–89% \( \text{HR}_{\text{max}} \) (Rampinini et al., 2007). These figures are also close to those required to improve oxygen consumption \( \text{VO}_{2\text{max}} \) (90–95% \( \text{HR}_{\text{max}} \)) (Helgerud, Engen, Wisloff, & Hoff, 2001; Impellizzeri et al., 2006), as well as the anaerobic threshold (85–90% \( \text{HR}_{\text{max}} \)). In this regard, it seems that the small-sided games used here are useful for improving the aerobic endurance of young soccer players. With respect to the percentage of time spent at more than 90% \( \text{HR}_{\text{max}} \) on both the large and medium pitches players spent more than half their total activity time within this intensity zone, which is of considerable interest in terms of improving \( \text{VO}_{2\text{max}} \).

Ratings of perceived exertion appear to be a good indicator of the overall intensity of the activity when compared with heart rate and lactate concentration in small-sided games (Coutts et al., 2009). In the present study, the lowest ratings of perceived exertion corresponded to the small pitch, which reflects the pattern observed for the physiological and physical responses and effective playing time with the same format. Similar results have been reported by others (Rampinini et al., 2007).
As regards the physiological response, the results are in line with those obtained for the physiological parameters analysed. The large and medium pitches were similar to one another, and both showed significant differences compared with the small pitch. To compare the present findings with those of other studies of small-sided games of different duration, or with competitive matches, we believe that the variable “distance covered per minute” is more representative of the general intensity of the activity and can be used as a global index of task intensity. The total distances covered per minute of play ranged from 87 m · min⁻¹ on the small pitch to 125 m · min⁻¹ on the large pitch. This is consistent with findings for young Brazilian soccer players, who covered 118, 105, and 109 m · min⁻¹ in the under-15, under-17, and under-19 category, respectively (Pereira, Kirkendall, & Barros, 2007), as well as with the 100 m · min⁻¹ achieved by Spanish pre-adolescent players (Barbero-Álvarez, Barbero-Álvarez, & Granda, 2007).

One variable that provides overall information about the pattern of activity is the work-to-rest ratio. In line with previous findings in competitive matches (Barbero-Álvarez et al., 2007), the lowest work-to-rest ratios were obtained on the small pitch, indicating highly intermittent activity in which high-intensity tasks are interspersed with moments of play that enable the player to recover while stationary, walking or jogging. Note that the work-to-rest ratio was >1 on the large and medium pitches, which indicates that the activity pattern in these formats prioritizes activity over recovery – that is, they are tasks in which greater distances are covered at high intensity (work) than at low intensity (rest). With respect to maximum speed and sprint frequency, both these variables had the lowest values on the small pitch, something that needs to be taken into account when proposing training drills.

As regards the motor response, the frequency of behaviours increased as the individual playing area was reduced, this being consistent with previous findings (Kelly & Drust, 2009; Owen et al., 2004; Tessitore et al., 2006). However, these earlier studies only reported a significant difference for the behaviours tackle and shoot, whereas in the present study there were significant differences for the number of interceptions, control and dribble, control and shoot, clearance, and putting the ball in play. It would appear, therefore, that the size of the pitch largely determines players’ behaviours in small-sided games.

In addition, we believe that the effective playing time could offer a potential explanation for the differences in the physiological, physical, and perceived exertion variables studied in the small-sided games: as the individual playing area was reduced, the frequency of motor behaviours increased, with a concomitant decrease in the effective playing time (since a greater number of rule-related interruptions leads to a shorter effective playing time). At the same time, the players cover less ground, spending more time stationary or walking, which leads to a lower physiological workload and lower ratings of perceived exertion. Thus we believe that the effective playing time must be evaluated in an attempt to explain the physical workload in this kind of training drill. Although the results are presented in absolute terms (i.e. without making them relative to the effective playing time), we consider that effective playing time should be taken into account because many of the variables studied were highly correlated with effective playing time. The difference in the amount of time during which the ball is in play is one of the factors that influences the variables studied.
This study is the first to describe the time–motion characteristics associated with different pitch sizes while keeping the number of players consistent. However, one limitation of the present study concerns the interpretation of the time–motion results, because the sampling rate of the GPS units was 1 Hz, the reliability of which for high-intensity running is relatively poor.

Conclusions

The present results suggest that small-sided games can be used to develop soccer players’ endurance in a specific way. In this respect, the individual playing area is a variable that coaches should not overlook when designing training drills, as it enables the intensity of all aspects of soccer to be modulated. Larger pitches can be used to increase task intensity and smaller ones to reduce it. Moreover, effective playing time might influence the workload achieved by players and this can be determined by pitch size.

In addition, greater attention needs to be paid to the effects on play itself (i.e. a focus on players’ motor responses). The main aim of soccer drills is to enable players to increase their technical and tactical options. We believe that the key lies in designing training activities to develop this aspect, with only secondary emphasis being placed on improving the players’ physical performance.

In conclusion, the individual playing area should be taken into account when designing training drills because it affects the physical, physiological, and motor responses of players.

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