

Influence of numerical superiority and players' tactical knowledge on perceived exertion and physical and physiological demands in soccer small-sided games

Gibson M. Praça¹, Sarah G.T. Bredt², Juliana O. Torres³, Igor J. O. Custódio⁴, André G. P. Andrade⁵,
Juan C. P. Morales⁶, Mauro H. Chagas⁷ y Pablo J. Greco⁸

Influence of numerical superiority and players' tactical knowledge on perceived exertion and physical and physiological demands in soccer small-sided games

Abstract

This study aimed to investigate the influence of numerical superiority and tactical knowledge on players' physical and physiological demands and RPE during soccer SSGs. Eighteen male soccer players were divided into two groups with 9 athletes (G1 with 3 defenders, 3 forwards and 3 mid-fielders with the highest score in the Procedural Tactical Knowledge Test - PTKT and G2 with 3 athletes of each position with the lowest score in the PTKT). Each group was split into three teams with one athlete of each position. HR, total distance covered (TD), distance covered at different speeds and accelerations were recorded using a HR monitor and a GPS during 3vs.3 and 4vs.3 SSGs with goalkeepers (two 4-minute games with 4-minutes rest). RPE were obtained using Borg 6-20 Scale. Results suggest that soccer SSGs with numerical superiority induce a decrease in variables such as percentage of total distance covered at 7.3-14.4 km/h ($p=0.031$), mean HR ($p=0.001$), and RPE ($p=0.001$) compared to numerical equality. Players with higher PTK presented higher TD and percentage of total distance covered at 14.4-21.5 km/h ($p=0.026$). These results indicate the influence of different factors on athletes' RPE and physical and physiological demands during soccer SSGs.

Keywords: Soccer, small-sided games, numerical superiority, tactical knowledge, time-motion

Small-sided games (SSGs) are used in many team sports because they simultaneously combine the game's tactical, technical, physical, physiological, and perceptual (rate of perceived exertion – RPE) aspects (Aguiar, Botelho, Gonçalves and Sampaio, 2013). Different game components, such as number of players (Aguiar, Gonçalves, Botelho, Lemmink and Sampaio, 2015), pitch size (Casamichana and Castellano, 2010), number of ball touches (Dellal, Lago-Penas, Wong and Chamari, 2011), and presence of additional players (Hill-Haas, Coutts, Dawson and Rowsell, 2010) can be altered in order to generate specific demands on the game's tactical, technical, and physiological aspects, and also on the rate of perceived exertion. Some studies have used heart rate (HR), blood lactate concentration (Aguiar et al., 2013; Randers, Nielsen, Bangsbo and Krstrup, 2014), and Borg's RPE (Brito, Krstrup and Rebelo, 2012; Randers et

al., 2014) to describe SSGs demands. On the other hand, others have reported the total distance covered, distances covered in different speed zones, and number of acceleration actions to quantify the physical demands (Hodgson, Akenhead and Thomas, 2014).

Majority of these studies have investigated the responses of the dependent variables in SSGs with the same number of players in each team (i.e. 3vs.3 and 4vs.4). However, during a 11vs.11 standard game, numerical imbalance between the teams occasionally occurs, which establishes situations of superiority and inferiority (Hill-Haas et al., 2010) and requires players to adapt their tactical behaviours. Among the few studies that have analysed SSGs with numerical superiority, Bekris, Sambanis, Milonys, Sarakinos and Anagnostakos (2012) found that the inclusion of an additional attacker player inside the playing area decreased exercise intensity,

1 Escola de Educação Física, Fisioterapia e Terapia Ocupacional, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

2 Escola de Educação Física, Fisioterapia e Terapia Ocupacional, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

3 Instituto de Ciências Biológicas e da Saúde, Universidade Federal de Viçosa. Florestal, Brazil

4 Escola de Educação Física, Fisioterapia e Terapia Ocupacional, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

5 Escola de Educação Física, Fisioterapia e Terapia Ocupacional, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

6 Escola de Educação Física, Fisioterapia e Terapia Ocupacional, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

7 Escola de Educação Física, Fisioterapia e Terapia Ocupacional, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

8 Corresponding author: Pablo Juan Greco, Professor of the Sport Department of the Escola de Educação Física, Fisioterapia e Terapia Ocupacional - Avenida Antônio Carlos, 6627 - Pampulha, Belo Horizonte, MG - Brasil. CEP: 31 270 901. Phone: +55 (31) 3409 2329. E-mail: pablojgreco@gmail.com

evidenced by a shorter time spent in higher heart rates (HR) compared to that in SSGs with numerical equality (Bekris et al., 2012). Corroborating this study, numerical superiority led to an increase in players' distance covered in lower intensities and to a decrease in distance covered in higher intensities when an additional player was added permanently to one of the teams (Sampaio, Lago, Gonçalves, Maças and Leite, 2014). Considering the limited available data on the influence of numerical superiority, knowledge about the impact of the inclusion of additional players on physical and physiological demands in SSGs is not consolidated. Therefore, studies that aim to simultaneously investigate physical and physiological demands and RPE could support the prescription of different SSGs.

The context of action in team sports, including soccer, is characterized by unpredictability, randomness, and complexity (Garganta, 2009). Therefore, players' actions cannot be completely predicted, which lead to the importance of decision-making to solve tactical problems (Weigel, Raab and Wollny, 2015). Decision-making is based on the cognitive processes of perception, attention and memory (Afonso, Garganta and Mesquita, 2012), which allow players to extract information from the environment to support their decisions (bottom-up processes) and to call on their tactical knowledge (top-down processes) to evaluate options of "what to do" and "how to do" during the game (Raab, 2007; Shih, 2008). In team sports, the tactical knowledge refers to the selection of an appropriate action within the context of game play (McPherson and Thomas, 1989). Therefore, it is expected that athletes with a higher level of tactical knowledge to be more able to perceive the different relevant cues present at the different task conditions. In this sense, difference in players' tactical knowledge could result in changes in players' movements. However, the influence of tactical knowledge on players' movements during different task conditions, including numerical superiority and numerical equality, remains unknown.

Gabbett, Carius and Mulvey (2008) found that in women's soccer SSGs with numerical equality, elite athletes showed no changes in physical demands due to improvement of tactical knowledge (decision-making). Notwithstanding, data from this study do not allow inferences on the influence of tactical behaviour in different SSGs (e.g. numerical superiority). Similarly, it is not possible to take any conclusions on players' physiological responses and RPE. Therefore, these results indicate the need of a deeper understanding of how tactical knowledge may influence physical and physiological demands in soccer SSGs.

In summary, literature about numerical superiority in soccer SSGs and the influence of tactical knowledge on physical and physiological demands and RPE is inconclusive. Data on these aspects can provide valuable information for coaches on planning different SSGs. Therefore, this study aimed to investigate the influence of numerical superiority and tactical knowledge on players' physical and physiological demands and RPE during soccer SSGs.

Methods

Participants

Eighteen Brazilian young male soccer players (age: 16.4±0.4 years, weight: 68.4±8.0 Kg, body fat percentage: 10.8±1.8) from a professional club participated in this study (6 defenders, 6 mid-fielders, and 6 forwards). The Local Ethics Committee approved this study in accordance with international standards. Players and legal guardians were notified about the research design and signed an informed consent form.

Procedures

On the first day, the Procedural Tactical Knowledge Test (PTKT) (Greco, Morales, Aburachid and Silva, 2015) was carried out to stratify athletes into levels of procedural tactical knowledge (PTK). To perform the PTKT, athletes were divided into 3 groups of 6 athletes with the same playing position (e.g. 6 mid-fielders). Each of these groups was then randomly divided into two teams (e.g. 3 mid-fielders and 3 mid-fielders). These two teams played two games against each other. From the PTKT results, a ranking was established for each playing position, according to individuals' performance. Based on the ranking positions, the sample was divided into Group 1 (G1), which comprised the 3 athletes of each position with the highest score in the PTKT (3 defenders, 3 mid-fielders, and 3 forwards; n = 9), and Group 2 (G2), comprising the 3 athletes of each position with the lowest score in the PTKT (n = 9). Groups 1 and 2 presented significant differences in the procedural tactical knowledge ($\chi^2 = 3.84$, p = 0.05).

Each of these groups, G1 and G2, was split into 3 teams (A, B, and C) with 3 athletes (1 defender, 1 midfielder, and 1 forward). In order to form balanced teams, a team could not be composed of two athletes who had the same position in the ranking. Teams A, B, and C within each group played against each other, but teams from G1 did not play against teams from G2, in order athletes' responses with different levels of procedural tactical knowledge.

Along six sessions, the teams played two different SSGs: 3vs.3 (goalkeeper + three players in each team) and 4vs.3 (goalkeeper + three players in each team and an additional "floater" player, who played for the teams during attack), both played as two games of four minutes interspersed with four-minute rest intervals. Each team played only one type of SSG in each session, at the same time of the day and after a standard ten-minute warm-up. Two coaches gave verbal encouragement during all the sessions. SSGs were carried out so that all teams played the same number of SSGs of each type. Players were previously familiarized with both SSGs.

The 3vs.3 SSG was chose for investigation because it allows all the decisional possibilities present in the formal match and an effective participation of players in the centre of game (Costa, Garganta, Greco, Mesquita and Maia, 2011). The 4vs.3 SSG represented the offensive numerical

superiority situation. This player was allowed to perform all offensive actions, including shooting on goal, but not free kicks, throw ins, and corner kicks. If the team lost ball possession, the additional player was automatically transferred to the other team. Both SSGs were played on a 36x27 meters field area with two goals sized 6x2 meters. Four extra balls were placed around the playing area, in order to quickly restart the game after the ball went out of play. The rules were the same as the standard game, including the offside rule.

Procedural Tactical Knowledge Test (PTKT)

The PTKT was elaborated based on the psychometric principles proposed by Pasquali (2010). In the validation process, it presented a content validity coefficient greater than 0.80 (Greco, Morales, Aburachid and Silva, 2015), achieving the recommended levels of language clarity, practical relevance and theoretical relevance (Hernández-Nieto, 2002). The exploratory factorial analysis identified two dimensions, defense and offense, and the percentage of total explained variance of the final model was 67,3% (Greco, Morales, Aburachid, and Silva, 2015). The test of Bartlett sphericity indicated significant correlations between variables ($\chi^2 = 405.682$, $P = 0.0001$) and that the model is pertinent (Greco, Morales, Aburachid and Silva, 2015). All items presented levels of reliability (ICC 0.67 - 0.69) classified as satisfactory (Szklo and Nieto, 2000). Based on content and construct validity, as well as reliability of PTKT, it is able to differentiate levels of tactical skills among players of invasion team sports, such as soccer.

The PTKT is carried out in a 9x9 meters area and lasts four minutes (Greco, Morales, Aburachid and Silva, 2015). It is a game between two teams with three players each. The team with ball possession (team in attack), must make as many passes as possible. In the present study, each team was composed by players of the same playing position (e.g. 3 defenders) performed the PTKT twice, with a four-minute rest between games. All games were filmed with a digital camera. Two observers, experts in the PTKT, classified the athletes in levels of PTK, based on the absolute frequency of observations of the following tactical actions: (1) "Player moves around the playing area to receive the ball"; (2) "Player passes the ball to a free teammate and prepares to receive the ball again"; (3) "Player supports his teammates in defense (defensive covering) when they are overcome by the opponent"; (4) "Player supports a teammate in defense when the opponent has difficulty to control the ball"; and (5) "Player induces the opponent to the corners of the playing area". The individual scores were determined as the sum of the five tactical actions described above.

The Cohen's kappa coefficient presented satisfactory values of 0.844 and 0.806 for intra and inter-observer reliability, respectively. To calculate Cohen's kappa coefficient, 21.2% of the athletes (higher than the 10% recommended by literature) (Tabachnick and Fidell, 2007) were reevaluated by the observers after 21 days from the end of analysis (Robinson and O'Donoghue, 2007).

Physical demands

The physical demands during the SSGs were recorded by a 15Hz Global Positioning System (GPS) (GPSports Systems, SPI Pro X2) coupled with a triaxial 100Hz accelerometer, placed between players' shoulder blades. Validity and reliability of the devices are reported in previous studies (Köklü, Arslan and Duffield, 2015). The variables related to physical demands were the total distance covered (TD) and the percentage of total distance covered at speeds 0–7.2 km/h (%D0–7.2), 7.3–14.3 km/h (%D7.3–14.3), 14.4–21.5 km/h (%D14.4–21.5), as described elsewhere (Owen, Wong, Paul and Dellal, 2014). In addition, acceleration data was recorded and presented as the number of accelerations and percentage of total distance covered above 2.0 m/s².

Physiological Demands

In the present study, HR was recorded at 1hz by heart rate monitors (Polar®, FS1, Kempele, Finland) compatible with the GPS interface during the SSGs. HR data from the recovery periods were excluded from analysis. The dependent variables were maximum heart rate ($HR_{MAX\%}$) and mean heart rate ($HR_{MEAN\%}$), both analyzed in terms of percentage of maximum heart rate recorded during the Yo-Yo Intermittent Recovery Test Level 2 (Krustrup et al., 2006). $HR_{MEAN\%}$ was calculated as the mean of all values recorded during the four-minute SSG. $HR_{MAX\%}$ was considered the highest HR value recorded during the SSGs.

Rate of Perceived Exertion

The sports club used the 6-20 Rate of Perceived Exertion (RPE) (Borg, 1982) as their training load monitoring tool in all categories (from U-13 to professional). Therefore, the U-17 athletes that participated in this study were considered familiarized with this instrument. Players indicated their perceived exertion after each SSG.

Statistical Analyses

All statistical analyses, except for effect size (ES), were carried out using SPSS Statistical Analysis Software (SPSS Version 20.0 for Windows, SPSS Inc., Chicago, IL, USA). Data are reported as mean \pm SD. For the physical demands' variables, each player's mean of the four-minute SSGs were considered. Before using parametric tests, data normality (Shapiro-Wilk's), homocedasticity (Levene's), and sphericity (Mauchly's) were verified. The variables TD and %D0–7.2 showed significant deviations from sphericity. Hence, the Greenhouse-Geisser (Schutz and Gessaroli, 1987) correction was subsequently adopted. After normality assumptions were confirmed, a two-way ANOVA with two factors — Group (two levels – G1 and G2) and SSG (two levels – 3vs.3 and 4vs.3) — was carried out to compare the means. The LSD post-hoc test was used to make multiple paired comparisons and identify the significant differences. Effect sizes r were calculated (Fritz, 2012) and considered small (0.37), moderate (0.24), or large (0.10) (McGraph and Meyer, 2006). Statistical significance was set at 0.05.

Results

The two-way ANOVA did not show any significant interactions between factors Group (G1 and G2) and SSGs (3vs.3 and 4vs.3), for any of the physical, physiological, or RPE variables. Therefore, data were presented in Table I and Table II with the main effect of each factor on the investigated variables.

TD and %D14.4-21.5 by G1 was significantly higher than by G2 (6.6%). Moreover, %D0-7.2 by G1 was lower.

The TD in the 3vs.3 was significantly larger than that in the 4vs.3 SSGs (7.3%). In addition, %D0-7.2 in the 3vs.3 was lower than that in the 4vs.3 SSGs, while %D7.3-14.3 was higher in the 4vs.3 than in the 3vs.3 SSGs. For the number of accelerations above 2.0 m/s², the 3vs.3 indicated higher values than the 4vs.3 SSGs. Similarly, mean HR_{MEAN%}, HR_{MAX%}, and RPE presented higher values in the 3vs.3 SSGs.

Table 1

Mean values (standard-deviation) of physical and physiological demands and RPE for groups with higher (G1) and lower (G2) scores in the PTKT during SSG.

| | G1 | G2 | p | ES |
|-----------------------------|------------------|----------------|-------|------|
| TD | 427.86 (45.25) * | 399.41 (48.30) | 0.010 | 0.29 |
| %D0-7.2 | 40.19 (7.46) * | 44.07 (7.69) | 0.028 | 0.25 |
| %D7.3-14.3 | 42.96 (6.35) | 41.43 (5.59) | 0.273 | 0.12 |
| %D14.4-21.5 | 15.46 (3.94) * | 13.33 (4.00) | 0.026 | 0.26 |
| N.Ac. > 2.0m/s ² | 7.43 (2.20) | 7.51 (2.14) | 0.864 | 0.02 |
| %D.Ac > 2.0m/s ² | 17.77 (5.11) | 17.50 (4.73) | 0.818 | 0.02 |
| HR _{MEAN%} | 84.11 (5.00) | 84.79 (5.52) | 0.350 | 0.06 |
| HR _{MAX%} | 93.70 (4.09) | 93.89 (4.02) | 0.841 | 0.00 |
| RPE | 8.74 (1.04) | 8.33 (1.31) | 0.055 | 0.17 |

Note: TD = total distance; %D0-7.2, %D7.3-14.3, %D14.4-21.5 = percentage of total distance covered at 0-7.2 km/h, 7.3-14.3 km/h and 14.4-21.5 km/h, respectively; N.Ac.>2.0m/s² and %D.Ac.>2.0m/s² = number of accelerations above 2.0 m/s² and percentage of total distance covered at accelerations above 2.0 m/s², respectively; HR_{MEAN%} = mean heart expressed as percentage of maximum heart rate; HR_{MAX%} = maximum heart rate expressed as percentage of maximum heart rate; RPE = rate of perceived exertion; G1 = group of athletes with higher score in the PTKT; G2 = group of athletes with lower score in the PTKT; ES = effect size r.

* significant difference between groups.

Table 2

Mean values (standard-deviation) of physical and physiological demands and RPE of 3vs.3 and 4vs.3 SSGs.

| | 3vs.3 | 4vs.3 | p | ES |
|-----------------------------|------------------|----------------|-------|------|
| TD | 427.11 (43.65) * | 400.16 (50.18) | 0.014 | 0.27 |
| %D0-7.2 | 39.96 (6.80) * | 44.30 (8.17) | 0.015 | 0.27 |
| %D7.3-14.3 | 43.71 (5.24) * | 40.67 (6.38) | 0.031 | 0.25 |
| %D14.4-21.5 | 15.01 (4.26) | 13.78 (3.87) | 0.193 | 0.15 |
| N.Ac. > 2.0m/s ² | 8.21 (2.21) * | 6.74 (1.85) | 0.003 | 0.34 |
| %D.Ac.>2.0m/s ² | 18.77 (5.28) | 16.50 (4.24) | 0.051 | 0.23 |
| HR _{MEAN%} | 86.76 (4.78) * | 82.52 (4.97) | 0.001 | 0.40 |
| HR _{MAX%} | 95.08 (4.24) * | 92.50 (3.39) | 0.006 | 0.32 |
| RPE | 9.25 (1.08) * | 7.82 (0.82) | 0.001 | 0.60 |

Note: TD = total distance; %D0-7.2, %D7.3-14.3, %D14.4-21.5 = percentage of total distance covered at 0-7.2 km/h, 7.3-14.3 km/h and 14.4-21.5 km/h, respectively; N.Ac.>2.0m/s² and %D.Ac.>2.0m/s² = number of accelerations above 2.0 m/s² and percentage of total distance covered at accelerations above 2.0 m/s², respectively; HR_{MEAN%} = mean heart expressed as percentage of maximum heart rate; HR_{MAX%} = maximum heart rate expressed as percentage of maximum heart rate; RPE = rate of perceived exertion; 3vs.3 = 3vs.3 small-sided game; 4vs.3 = 4vs.3 small-sided game; ES = effect size r. * significant difference between small-sided games.

Discussion

Effect of tactical knowledge on RPE and physical and physiological demands

In the present study, the group with a higher score in the PTKT (G1) presented higher values of TD and %D14.4-21.5, as well as lower values for %D0-7.2 than the group with a lower score in the PTKT (G2). A possible explanation for the higher physical demand presented by G1 is related to tactical knowledge. A higher tactical knowledge could have allowed these athletes to better read the game and better occupy the available spaces, possibly increasing their number of actions without the ball. These dynamics resulted in a higher TD and in a higher number of high intensity actions. This rationale is based on the understanding that a player can only present a determined effective behaviour if he uses his knowledge of the game (Kannekens, Elferink-Gemser and Visscher, 2009). This expectation is reinforced by previous studies in which more experienced players presented a better ability to predict opponents' actions in a given situation (Johnson and Raab, 2003), as well as a better judgment and decision making than beginners (Memmert and Furley, 2007). Therefore, the different responses presented by experienced and novice players might be related to the specific tactical knowledge they possess (Kannekens et al., 2009).

Regarding physiological and perceptual demands, it seems that the increase found for high intensity activities (%D14.4-21.5) in G1 (~2% of TD) may have been insufficient to promote a significant alteration in HR or RPE responses.

Data from this study differ from the results presented in the study of Gabbett et al. (2008) which showed that the increase in the tactical skills (decision-making) of women soccer players did not result in an increase of physical and physiological demands in a 45-minute SSG (Gabbett et al., 2008). The difference between these results may be attributed to the different protocols used to evaluate tactical knowledge. In the study of Gabbett et al. (2008), the decision-making ability was assessed through the protocol proposed by French and Thomas (1987), which includes only actions with the ball (shooting, passing, dribbling). In the present study, the test used to classify athletes in two groups assessed decision-making in actions with and without the ball, in defense and offense (Greco, Morales, Aburachid and Silva, 2015). Considering that the tactical principles (Costa et al., 2011) without the ball require a better management of space and represent the majority of actions during the game, these actions would induce a higher displacement and would be more sensitive to detect relationships between tactical skills and physical responses. Besides, actions with and without the ball are based on information carried by different cues in the environment and, therefore, represent different tactical knowledge on each game situation. Thus, the improvement in decision-making

in the study of Gabbett et al. (2008) might not represent an improvement the global tactical ability, being insufficient to change physical responses as in the present study.

Effect of SSG settings on RPE and physical and physiological demands

The SSG with numerical superiority (4vs.3) presented lower physical and physiological demands and RPE compared to the SSG with numerical equality (3vs.3). This study found a higher distance covered in the 3vs.3 compared to the 4vs.3 SSGs. Corroborating these results, (Sampaio et al., 2014)) found that numerical superiority (permanent addition of a player to one of the teams) promoted a decrease in the distance covered at high intensities (16.0–17.9 km/h) and in the total distance covered, and an increase in the distance covered at lower speeds (0–9.9 km/h). On the other hand, Hill-Haas et al. (2010) found that SSG with an additional floater player (4vs.3 and 6vs.5) increased players' distance covered compared to a fixed numerical superiority situation (permanent addition of a player to one of the teams). Thus, the addition of a floater player might induce different responses depending on the comparison between SSG (numerical equality or another type of numerical superiority). Therefore, this discussion indicates that coaches and physical trainers should consider the specificities of each SSG to reach effective responses during training (e.g. higher physical demand).

While total distance covered has often been used to quantify players' physical demands during SSGs (Casamichana, Suarez-Arrones, Castellano and Román-Quintana, 2014; Hodgson et al., 2014; Sampaio et al., 2014), few data are available on the different intensities of acceleration executed by players during these games (Hodgson et al., 2014). This information can provide data to support the use of SSGs, including those task conditions with numerical superiority (Hill-Haas et al., 2010). This study found a decrease of the total number of accelerations above 2.0 m/s² due to the inclusion of an additional floater player, which might be explained by players' tactical behavior. In situations with offensive numerical superiority, players can conduct the ball more easily and create appropriate conditions to shooting on goal. This requires a minor engagement in actions without the ball and a lesser need to generate imbalance in the opponents' defense. Based on this reasoning, changing the configuration of SSG (i.e., numerical superiority) created different tactical problems, which required players to perceive the new situation (task) and adapt their behavior (Nitsch, 2009), resulting in a different (i.e. decreased) physical demand.

From another perspective, the relative area per player, which is reduced when a player is included, might also have influenced the physical demands. Although few studies have shown an increase in physical demands (i.e. distance covered in higher intensities) due to the increase in the number of players in SSGs with numerical equality (Aguiar et al., 2013; Brandes, Heitmann and Müller, 2012), in the

present study, the increase in the number of players (4vs.3) resulted in lower values for physical demands. Nevertheless, in those studies, the number of players and pitch size were increased, keeping the same relative area per player. Although the area per player was kept the same, the increase in the pitch's absolute length and width allowed players to develop speed over a longer time inside the available space. Therefore, athletes could reach higher speeds more often, which resulted in higher distances covered at higher intensities. In the present study, the inclusion of an additional player inside the playing area was not accompanied by an increase in pitch size, which resulted in a smaller area per player in the 4vs.3 SSGs. Therefore, a decrease in physical demands due to the inclusion of an additional player corroborates previous studies that associate a smaller area per player with an decrease in the number of accelerations and distance covered at high intensities (Hodgson et al., 2014).

In line with the decrease in physical demands in the SSGs with numerical superiority, there was also a reduction in RPE, $HR_{MEAN\%}$, and $HR_{MAX\%}$. It is likely that in SSGs with numerical equality, the number of duels is higher, which requires a higher number of fakes, changes of direction, and changes in the rhythm of displacement. This would result in a higher physiological impact and in an increase in athletes' RPE. The rationale developed to explain the increase in the physical demands could also be used to explain the increase in both physiological demands and RPE during the 3vs.3 compared to the 4vs.3 SSGs.

An issue to be considered in this study is the fact that numerical superiority was created by adding a floater player who could play for both teams during the offensive phase. Therefore, it is not known how long each team played in

offense. Considering that the duration of the temporary inferiority/superiority during the defensive/offensive phases might influence players' responses, we suggest future studies to investigate the impact of time spent during offense/defense on the physical, physiological and RPE demands when playing with an additional floater player.

Conclusions

The results of this study suggest that soccer SSGs with numerical superiority require players to perceive and adapt their behavior to the context, decreasing perceptual, physical, and physiological demands compared to SSGs with numerical equality. In addition, the larger physical demand presented by players with a higher level of tactical knowledge suggest that these players can better read the game context and perceive more opportunities to play. These results indicate the influence of cognition factors (tactical knowledge) and SSG settings on athletes' RPE and physical and physiological demands during soccer SSGs. These data can be useful to coaches for planning training load when using SSGs as a means of training.

Acknowledgements

This study was funded by the Fundação de Amparo à Pesquisa do estado de Minas Gerais and the Conselho Nacional de Desenvolvimento Científico e Tecnológico. We are also grateful to Clube Atlético Mineiro and to the members of the Center of Studies in Action and Cognition for supporting data collection.

Influencia de la superioridad numérica e del conocimiento táctico de los atletas en la percepción subjetiva del esfuerzo y las demandas físicas y fisiológicas en pequeños juegos en el fútbol

Resumen

Este estudio objetivó investigar la influencia de la superioridad numérica y del conocimiento táctico en la PSE y en las exigencias físicas y fisiológicas durante juegos reducidos (JR) en el fútbol. Dieciocho jugadores de fútbol fueron divididos en dos grupos de 9 jugadores (G1 - 3 defensores, 3 atacantes y 3 medio-campos con la puntuación más alta en el test de conocimiento táctico procedimental - TCTP y G2 - 3 atletas de cada posición con la puntuación más baja en TCTP). Cada grupo fue dividido en tres equipos con un jugador de cada posición. FC, distancia total recorrida (DT), distancia recorrida en diferentes velocidades y aceleraciones se registraron usando un monitor de frecuencia cardiaca y un GPS en JR 3vs.3 y 4vs.3 con porteros (dos series de 4 minutos con 4 minutos de intervalo). La PSE se obtuvo utilizando la escala de Borg 6-20. Resultados sugieren que JR con superioridad numérica inducen a una disminución de variables como el porcentaje de la distancia total entre 7,3 y 14,4 km/h ($p=0,031$), FC media ($p=0,001$) y PSE ($p=0,001$), en comparación con JR con igualdad numérica. Jugadores con mayor CTP mostraron mayor DT y mayor porcentaje de la distancia total recorrida entre 14.4 y 21.5 km/h ($p=0,026$). Estos resultados indican la influencia de diferentes factores en la PSE y en las exigencias físicas y fisiológicas de JR en el fútbol.

Palabras clave: Fútbol, juegos reducidos, superioridad numérica, conocimiento táctico, demanda física

Influência da superioridade numérica e do conhecimento tático dos atletas na percepção subjetiva do esforço e nas demandas físicas e fisiológicas em pequenos jogos no futebol

Resumo

O objetivo deste estudo foi investigar a influência da superioridade numérica e do conhecimento tático sobre a PSE e as demandas físicas e fisiológicas durante Pequenos Jogos (PJ) no futebol. Dezoito jogadores de futebol foram divididos em dois grupos de 9 atletas (G1 3 defensores, 3 atacantes e 3 meio-campistas com a maior pontuação no Teste de Conhecimento Tático Processual - TCTP e G2 - 3 jogadores de cada posição com a menor pontuação na TCTP). Cada grupo foi dividido em três equipes com um jogador de cada posição. FC, distância total percorrida (DT), distância percorrida em diferentes velocidades e acelerações foram registradas utilizando um monitor de FC e um GPS durante PJ 3vs.3 e 4vs.3 com goleiros (dois jogos de 4 minutos com 4 minutos de intervalo). A PSE foi obtida utilizando a escala de Borg 6-20. Os resultados sugerem que PJ com superioridade numérica induzem a uma diminuição de variáveis como o percentual da distância total percorrida entre 7.3 e 14.4 km/h ($p=0.031$), FC média ($p=0.001$) e PSE ($p=0.001$), comparados a PJ com igualdade numérica. Jogadores com maior CTP apresentaram maior DT e percentual da distância percorrida entre 14.4 e 21.5 km/h ($p=0.026$). Estes resultados indicam a influência de diferentes fatores sobre a PSE e as demandas físicas e fisiológicas durante PJ no futebol.

Palavras-chave: Futebol, pequenos jogos, superioridade numérica, conhecimento tático, perfil motor

References

- Afonso, J., Garganta, J. and Mesquita, I. (2012). Decision-making in sports: the role of attention, anticipation and memory. *Revista Brasileira de Cineantropometria E Desempenho Humano*, 14(5), 592-601.
- Aguiar, M., Botelho, G., Gonçalves, B. and Sampaio, J. (2013). Physiological responses and activity profiles of football small-sided games. *Journal of Strength and Conditioning Research*, 27(5), 1287-1294.
- Aguiar, M., Gonçalves, B., Botelho, G., Lemmink, K. and Sampaio, J. (2015). Footballers' movement behaviour during 2-, 3-, 4- and 5-a-side small-sided games. *Journal of Sports Sciences*, 1-8.
- Beck, T. W. (2013). *The importance of a priori sample size estimation in strength and conditioning research*. *Journal of Strength and Conditioning Research* (Vol. 27).
- Bekris, E., Sambanis, M., Milonys, E., Sarakinos, A. and Anagnostakos, K. (2012). The physiological and technical-tactical effects of an additional soccer player's participation in small sided games training. *Physical Training*. Retrieved from www.ejmas.com/pt/2012pt/ptart_bekris_2_1210.html
- Borg, G. A. V. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise*, 14(5), 377-381.
- Brandes, M., Heitmann, A. and Müller, L. (2012). Physical responses of different small-sided game formats in elite youth soccer players. *Journal of Strength and Conditioning Research*, 26(5), 1353-1360.
- Brito, J., Krustup, P. and Rebelo, A. (2012). The influence of the playing surface on the exercise intensity of small-sided recreational soccer games. *Human Movement Science*, 31(4), 946-956.
- Casamichana, D. and Castellano, J. (2010). Time-motion, heart rate, perceptual and motor behavior demands in small-sided soccer games: Effects of pitch size. *Journal of Sports Sciences*, 28(14), 1615-1623.
- Casamichana, D., Suarez-Arrones, L., Castellano, J. and Román-Quintana, J. S. (2014). Effect of number of touches and exercise duration on the kinematic profile and heart rate response during small-sided games in soccer. *Journal of Human Kinetics*, 8(41), 113-123.
- Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale: Lawrence Erlbaum Associates Publishers.
- Costa, I. T., Garganta, J., Greco, P. J., Mesquita, I. and Maia, J. (2011). System of tactical assessment in Soccer (FUT-SAT): Development and preliminary validation. *Motricidade*, 7(1), 69-83.
- Dellal, A., Lago-Penas, C., Wong, D. P. and Chamari, K. (2011). Effect of the number of ball contacts within bouts of 4 vs. 4 Small-Sided Soccer Games. *International Journal of Physiology and Performance*, 6(3), 322-333.
- French, K. E. and Thomas, J. R. (1987). The relation of knowledge development to children's basketball performance. *Journal of Sport Psychology*, 9(1), 15-32.
- Fritz, C. O., Morris, P. E. and Richler, J. J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology: General*, 141(1), 2-18.
- Gabbett, T. J., Carius, J. and Mulvey, M. J. (2008). Does improved decision-making ability reduce the physiological demands of game-based activities in field sport athletes? *Journal of Strength and Conditioning Research*, 22(6), 2027-2035.
- Garganta, J. (2009). Trends of tactical performance analysis in team sports: bridging the gap between research, training and competition. *Revista Portuguesa de Ciência Do Desporto*, 9(1), 81-89.
- Greco, P. J., Morales, J. C. P., Aburachid, L. M. C. and Silva, S. R. (2015). Evidência de validade do teste de conhecimento tático processual para orientação esportiva - TCTP: OE (Evidence of validity of the Procedural Tactical Knowledge Test for sport orientation - PTKT: SO). *Revista Brasileira de Educação Física e Esporte*, 29(2), 313-324.

- Hernández-Nieto, R. A. (2002). *Contributions to statistical analysis*. Mérida: Universidad de Los Andes.
- Hill-Haas, S. V., Coutts, A. J., Dawson, B. T. and Rowsell, G. (2010). Time-motion characteristics and physiological responses of small-sided games in elite youth players: the influence of player number and rule change. *Journal of Strength and Conditioning Research*, 24(8), 2149–2156.
- Hodgson, C., Akenhead, R. and Thomas, K. (2014). Time-motion analysis of acceleration demands of 4v4 small-sided soccer games played on different pitch sizes. *Human Movement Science*, 33(1), 25–32.
- Johnson, J. G. and Raab, M. (2003). Take the first - Option-generation and resulting choices. *Organizational Behavior and Human Decision Processes*, 91(2), 215–229.
- Kannekens, R., Elferink-Gemser, M. and Visscher, C. (2009). Tactical skills of world-class youth soccer teams. *Journal of Sports Sciences*, 27(8), 807–812.
- Köklü, Y., Arslan, Y. and Duffield, R. (2015). Accuracy and reliability of SPI ProX global positioning system devices for measuring movement demands of team sports. *Journal of Sports Medicine and Physical Fitness*, 55(2), 1–2.
- Krustrup, P., Mohr, M., Nybo, L., Jensen, J. M., Nielsen, J. J. and Bangsbo, J. (2006). The Yo-Yo IR2 Test: Physiological Response, Reliability, and Application to Elite Soccer. *Medicine and Science in Sports and Exercise*, 38(9), 1666–1673.
- McGrath, R. E. and Meyer, G. J. (2006). When effect sizes disagree: The case of r and d . *Psychological Methods*, 11(4), 386–401.
- McPherson, S. L. and Thomas, J. R. (1989). Relation of Knowledge and Performance in Boys' Tennis: Age and expertise. *Journal Of Experimental Child Psychology*, 48(2), 190–211.
- Memmert, D. and Furley, P. (2007). "I spy with my little eye!": breadth of attention, inattentive blindness, and tactical decision making in team sports. *Journal of Sport Exercise Psychology*, 29(3), 365–381.
- Nitsch, J. (2009). Ecological approaches to Sport Activity: a commentary from an action-theoretical point of view. *International Journal of Sports Psychology*, (40), 152–176.
- Owen, A. L., Wong, D. P., Paul, D. and Dellal, A. (2014). Physical and technical comparisons between various-sided games within professional soccer. *International Journal of Sports Medicine*, 35(4), 286–292.
- Pasquali, L. (2010). Testes referentes a construto: teoria e modelo de construção (Test referring to construct: theory and construction). In *Instrumentação psicológica: fundamentos e práticas (Psychological instrumentation: fundamentals and practice)* (pp. 165–198). Porto Alegre: Artmed.
- Raab, M. (2007). Think SMART, not hard. *Physical Education & Sport Pedagogy*, 12, 1–22.
- Randers, M. B., Nielsen, J. J., Bangsbo, J. and Krustrup, P. (2014). Physiological response and activity profile in recreational small-sided football: No effect of the number of players. *Scandinavian Journal of Medicine and Science in Sports*, 24(suppl 1), 130–137.
- Robinson, G. and O'Donghue, P. (2007). A weighted kappa statistic for reliability testing in performance analysis of sport. *International Journal of Performance Analysis in Sport*, 7(1), 12–19.
- Sampaio, J. E., Lago, C., Gonçalves, B., Maçãs, V. M. and Leite, N. (2014). Effects of pacing, status and unbalance in time motion variables, heart rate and tactical behaviour when playing 5-a-side football small-sided games. *Journal of Science and Medicine in Sport*, 17(2), 229–233.
- Shih, S. I. (2008). The attention cascade model and attentional blink. *Cognitive Psychology*, 56(3), 210–236.
- Schutz, R. and Gessaroli, M. (1987). The analysis of repeated measures designs involving multiple dependent variables. *Research Quarterly for Exercise and Sport*, 58(2), 132–149.
- Sklo, M. and Nieto, F. J. (2000). *Epidemiology: beyond the basics*. Gaithersburg: ASPEN.
- Tabachnick, B. and Fidell, L. (2007). *Using multivariate statistics* (5th ed.). Nova York: Harper and Row.
- Weigel, P., Raab, M. and Wollny, R. (2015). Tactical Decision Making in Team Sports — a model of cognitive processes. *International Journal of Sports Science*, 5(4), 128–138.