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original article

Numerical superiority changes the physical demands of soccer players during small-sided games

Superioridade numérica altera a demanda física de jogadores de Futebol durante Pequenos Jogos

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Abstract – Small-sided games are used for the training of soccer athletes because they replicate the physical and technical demands in a game-related context. Different game configurations are possible, such as differences in the number of players, i.e., 3vs.3 or 4vs.4. However, unbalanced situations are common during a competition, but have been little studied in small-sided games. This study compared the physical demands of 3vs.3, 4vs.3 (additional player in the attacking team) and 3vs.3+2 (two supporting players around the field). Eighteen young male soccer players participated in the study. Data were obtained with a 15-Hz GPS unit equipped with a 100-Hz triaxial accelerometer. Thirty-six small-sided games were observed and each session consisted of two 4-minute small-sided games and 4 minutes of passive rest. The Shapiro-Wilk normality test, one-way ANOVA for repeated measures and paired t-test were used to analyze the data. A reduction in physical demands was observed for small-sided games performed in unbalanced situations (4vs.3), including a shorter total distance covered, distance covered at higher intensities, and acceleration demands. Similar results were observed for additional players compared to regular players. In conclusion, the presence of additional players changed the physical demands of soccer players. This result permits coaches to adjust training configurations to their intentions during each session.

Key words: Physical education and training, Soccer, Task performance and analysis

Resumo – *Utilizam-se Pequenos Jogos no treinamento de atletas de Futebol para vivência de demandas físicas e técnicas em um contexto tático próximo ao jogo formal. Neles manipulam-se diferentes configurações, como o número de jogadores, i.e. 3vs.3 e 4vs.4. Contudo, o jogo formal apresenta situações no campo de jogo nas quais as relações entre os jogadores são desbalanceadas e pouco investigadas em Pequenos Jogos. Neste estudo, comparou-se a demanda física em Pequenos Jogos nas estruturas 3vs.3, 4vs.3 e 3vs.3+2. Dezoito jovens atletas de Futebol do sexo masculino participaram do estudo. Obtiveram-se dados referentes à distância percorrida, distâncias em intervalos de intensidade e o perfil de acelerações a partir de um equipamento de GPS de 15Hz com acelerômetro triaxial de 100Hz. Coletaram-se dados em 36 Pequenos Jogos, sendo que cada sessão de coleta compreendeu duas séries de quatro minutos com quatro minutos de pausa passiva. Analisaram-se os dados a partir do teste de normalidade de Shapiro-Wilk e da ANOVA One-way de medidas repetidas para comparação entre os protocolos e teste t pareado para comparação do perfil motor dos jogadores adicionais e regulares. Observou-se redução na demanda física nos Pequenos Jogos praticados na configuração 4vs.3, com menor distância percorrida, maior distância em menor intensidade e menores distâncias em intensidades superiores, bem como uma similar redução na comparação de jogadores adicionais e regulares. Conclui-se que se alterou a demanda física dos jogadores a partir da inclusão de jogadores adicionais, o que permite aos treinadores ajustarem a configuração da sessão de treino às intencionalidades do treino.*

Palavras-chave: *Análise e desempenho de tarefas; Educação física e treinamento; Futebol.*

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INTRODUCTION

In soccer training, the maximum benefits of exercise are obtained when the training stimuli are similar to the competitive demands generated by the activity, in this case the game itself[1,2]. Within this context, small-sided games (SSGs) have been proposed with the objective to replicate the demands of a game and to train in an integrated manner the technical, tactical, physical-physiological and psychological components of soccer performance[3-8].

Technical[4], tactical[9], physical[10] and physiological responses[8] in SSGs have been investigated using different configurations, i.e., different field sizes, different numbers of players and touch limitations. In those studies, the manipulation of the game configurations proposed mainly refers to situations of numerical equality, i.e., 3vs.3 and 4vs.4. However, a formal game exhibits situations in the field in which the relationships between players are often unbalanced, i.e., the numerical superiority of one team or the other[11]. Manipulation of the difference in the number of players between teams represents a space-time constraint, in addition to permitting defenders to improve their capacity to defend, occupying and protecting spaces in front of the goal[9,12].

Studies investigating the use of numerical superiority have shown that in SSGs with additional players the athletes spent less time at higher heart rates when compared to a game in numerical equality[3], indicating a reduction of physical effort in this configuration. With respect to physical demands, additional players were found to perform a significantly larger number of sprints and to cover a greater total distance than players who did not exert the additional function (regular players)[13]. Finally, the game in numerical superiority resulted in an increase in the distance covered at lower intensities and in a reduction in the distance covered at higher intensities when compared to the configuration of numerical equality[12]. Despite these findings, two important gaps can be pointed out: first, the acceleration pattern is unknown for SSGs performed in numerical superiority, a variable characterized for other configurations.

Despite the results cited above regarding numerical superiority in SSGs, the use of GPS units with a low sampling rate and without accelerometers limits access to data of physical demands in these configurations and consequently the application of this tool to soccer training. Furthermore, studies investigating situations of numerical superiority in SSGs are sparse. Therefore, the objective of the present study was to compare the physical demands of soccer players during SSGs in situations of numerical superiority and to compare the physical demands of additional and regular players.

METHODOLOGICAL PROCEDURES

The study was approved by the Ethics Committee of the Federal University of Minas Gerais (Permit No. 29215814.8.0000.5149). All participants and legal guardians signed the free informed consent form.

Experimental approach

This study was conducted over a period of 4 weeks from April to May 2014. All SSG formats consisted of 3vs.3 plus the goalkeeper. The players were familiarized with the SSG configurations with additional players (in the field and as supporting players outside the field) and the data collection equipment during week 1. In weeks 2 to 4, the players participated in SSGs conducted in numerical equality (3vs.3), with supporting players around the field (3vs.3+2), and with an additional player inside the field (4vs.3). The games were performed three times per week, with an interval of at least 48 ours between games, on a natural grass field at the same times of the day to avoid the effects of circadian rhythm[14]. The order of the SSGs was randomized and balanced. The data were collected over a period of 9 days, with each team performing two sessions of SSGs per day. Each game lasted 4 minutes, with a 4-minute interval between sessions.

Subjects

Eighteen young male soccer players (age: 16.4 ± 0.7 years), who belonged to the same soccer team engaged in national competitions, participated in the study. The soccer players had been participating in Soccer Federation competitions for an average of 4.2 years. Standard training involves 6-8 sessions per week (with a duration of approximately 90 minutes), in addition to competitive games.

Composition of the teams

Differences in physical behaviors during soccer games have been reported in the literature[15]. Therefore, the teams were balanced in terms of the position of origin of the players. Each team consisted of a goalkeeper (not evaluated), a defender, a midfielder, and an attacker. A second criterion adopted in the composition of the teams was the level of procedural tactical knowledge of the players. This knowledge was assessed using the Procedural Tactical Knowledge Test: Sports Orientation (PTKT-SO)[16], which was applied in the first data collection session. The observations followed procedures of inter- and intraobserver reliability, with 21.2% of the players being reevaluated within an interval of one week. Cohen's kappa coefficients were 0.844 and 0.806 for intra- and interobserver agreement, respectively. Next, the athletes were divided into three groups according to position of origin (defenders, midfielders, and attackers) and a ranking was established in each group according to performance in the PTKT-SO. Finally, the 18 players were allocated to six teams, with the three best players according to position (n=9) being allocated to teams A1, B1 and C1 and the three players with the lowest tactical performance (n=9) to teams A2, B2 and C2 (Box 1).

In view of the reported difference in the behavior of players when encountering lower level teams[17], the teams of group 1 only played SSGs against the teams of group 1. The same reasoning was applied to group 2.

Box 1. Composition of the teams.

Group 1			
Team A1	D[1]	M[3]	A[2]
Team B1	D[2]	M[1]	A[3]
Team C1	D[3]	M[2]	A[1]
Group 2			
Team A2	D[4]	M[6]	A[5]
Team B2	D[5]	M[4]	A[6]
Team C2	D[6]	M[5]	A[4]

D: defender; M: midfielder; A: attacker. Superscript numbers indicate the final position in the PTKT-SO in relation to positional status.

Procedures

Each session started with 15 minutes of standard preparatory activity consisting of running, accelerations and contact with the ball, followed by four sessions of one of the SSG formats, with a duration of 4 minutes and 4 minutes of passive rest. Both groups performed two sessions of SSGs with 4 minutes of duration and 4 minutes of passive rest. During the resting periods, the athletes were allowed to drink water *ad libitum*. At the end, 36 SSGs were performed, 12 in the 3vs.3 configuration, 12 in the 3vs.3+2 configuration, and 12 in the 4vs.3 configuration. The order of the SSGs was randomized across the data collection sessions and the number of each SSG format was balanced as shown in Box 2.

Box 2. Balancing and randomization of the data collection sessions.

Week	Day	Game	Configuration
1	Monday	PTKT	-
	Wednesday	Familiarization	-
	Friday	Familiarization	-
2	Monday	AxB	3vs.3
	Wednesday	AxC	3vs.3+2
	Friday	BxC	4vs.3
3	Monday	AxB	4vs.3
	Wednesday	AxC	3vs.3
	Friday	BxC	3vs.3+2
4	Monday	AxB	3vs.3+2
	Wednesday	AxC	4vs.3
	Friday	BxC	3vs.3

3vs.3: game in numerical equality; 3vs.3+2: game with supporting players around the field; 4vs.3: game in numerical superiority inside the field.

Small-sided games

The three SSG formats were performed in a field measuring 36 x 27m, with goals of 6 x 2 m, as described previously[18]. During the SSG, all rules

governing formal games, including impediment, were followed. In the 3vs.3 games, the configuration was used without any additional structure. In the 4vs.3 configuration, the additional player was allowed to perform all actions shared by the remaining players, including shooting at goal. The function of this player, marked with a vest of different color, was to always act for the attacking team, i.e., switching teams at each change of ball possession and moving around the field without any restrictions. In contrast, in the 3vs.3+2 configuration, the two athletes positioned around the field could only perform two consecutives touches during individual ball possession. These players also always acted for the attacking team and their movements were restricted to the sides of the soccer field. Figure 1 illustrates the configurations with additional players.

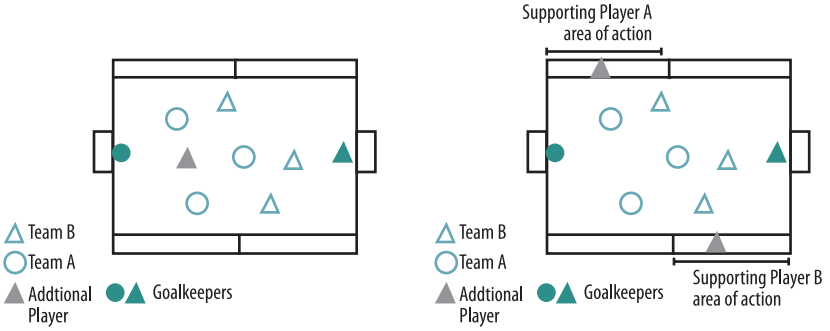

Figure 1. Configuration of the small-sides games with additional players. Left: 4vs.3; right: 3vs.3+2.

Physical demands

The use of global positioning systems (GPS) for the quantification of physical demands has been extensively discussed in the literature[19,20]. GPS units of up to 5 Hz have shown low validity for nonlinear movements, acceleration/deceleration actions and high-speed actions[21,22]. More recently, in addition to the increase in the acuity of GPS units – permitting to obtain positional data at frequencies of 15 Hz – triaxial accelerometers have been incorporated which permit access to information associated with the acceleration pattern of players of up to 100 Hz[23,24]. In this respect, the incorporation of 15-Hz units contributes to minimize problems related to data reliability, permitting a more correct application of the results to soccer training.

An individual GPS unit (SPI-Pro X2, GPSports, Canberra, Australia), which contains a 100-Hz triaxial accelerometer, was used. This unit monitors distances and positions at a frequency of 15 Hz, showing sufficient accuracy for the measurement of acceleration actions and distance covered[24]. The GPS unit was attached to the athlete's chest with specific straps. The following variables were considered for the analysis of physical demands: total distance covered; percentage of total distance covered at speeds of 0-7.2 km/h (TD1), 7.3-14.3 km/h (TD2), 14.4-21.5 km/h (TD3), and > 21.5 km/h (TD4), similar to previously adopted measures[25]; total acceleration actions above 2 m/s² (level 1) and 2.5 m/s² (level 2), and percentage of total distance covered at accelerations above 2 m/s² (level 1) and 2.5 m/s² (level 2).

Data analysis

First, the Shapiro-Wilk test was applied to determine whether the data showed a normal distribution. Since there was no indication of significant deviation from normality, one-way ANOVA for repeated measures was used to compare means between the three game configurations. For the variables total distance and TD1, the Mauchly sphericity test revealed differences between distributions and Greenhouse-Geisser correction was therefore applied. Paired multiple comparisons were made using the Bonferroni test. Cohen's f was also calculated as a measure of effect size using the GPower software as described in the literature[26].

A paired t-test was used to compare physical demands between additional players (in the 4vs.3 configuration) and regular players (in the 3vs.2 configuration). The same players were considered for this analysis, comparing their behaviors when they exerted the function of additional player (in 4vs.3) and when they exerted the function of regular player (in 3vs.3). The bootstrap approach was used for this comparison because of the small number of samples (12 per configuration). Posterior calculation of the effect size was performed using the GPower software according to the literature[26].

All analyses, except for effect size calculation, were performed using the IBM SPSS Statistics software (version 20; SPSS, Inc., Chicago, IL, USA). A level of significance of 5% was adopted in all analyses.

RESULTS

Table 1 shows the results of comparison of physical demands between the three SSG configurations. Significant differences were observed for total distance between the three configurations (F=16.04, p=0.000), with the distance in the 4vs.3 game being significantly shorter compared to the other configurations. This configuration also exhibited a higher percentage of total distance covered between 0 and 7.2 km/h (TD1) (F=11.85 p=0.000) and a lower percentage of total distance covered between 7.3 and 14.4 km/h (TD2) (F=9.555, p=0.000) compared to the other two configurations. No differences between SSG configurations were observed for distances covered at speeds higher than 14.4 km/h.

With respect to accelerations, the 3vs.3+2 game exhibited a smaller number of acceleration actions (F=6.816, p=0.001) and a lower percentage of distance covered during level 1 accelerations (F=3.934, p=0.022) than the 3vs.3 configuration. The latter also showed a larger number of accelerations compared to the other two configurations (F=4.972, p=0.008) and a higher percentage of total distance covered during level 2 accelerations (F=3.861, p=0.028) compared to the 4vs.3 game, demonstrating greater physical demands of this configuration when compared to situations of numerical superiority.

Table 2 shows the comparison of physical demands between additional and regular players in two SSG configurations (3vs.3 and 4vs.3).

Table 1. Physical demands in the three small-sided game configurations.

Variable		3X3		3X3+2		4X3				
	Division	Mean	SD	Mean	SD	Mean	SD	p	Bonferroni test	f
Distances	Total	427.1	48.94	420.3	46.36	386.3	51.84	.001*	4X3<3X3/3X3+2	0.47
	TD1	40.08	7.40	41.17	6.90	45.87	8.70	.001*	4X3>3X3/3X3+2	0.41
	TD2	43.63	6.44	43.68	5.66	39.6	6.55	.001*	4X3<3X3/3X3+2	0.37
	TD3	14.97	5.04	14.32	5.28	13.24	5.37	.136	-	0.17
	TD4	1.32	1.84	0.83	1.39	1.29	2.15	.199	-	0.15
Acceleration	ACEL 1 act	8.21	2.44	7.32	2.69	6.53	2.53	.001*	4X3<3X3	0.31
	ACEL 1 dist	18.76	6.27	16.46	6.11	16.05	5.91	.022*	4X3<3X3	0.26
	ACEL 2 act	4.11	1.62	3.21	1.91	3.28	1.86	.008*	3X3>3X3+2/4X3	0.24
	ACEL 2 dist	9.77	4.42	7.54	4.55	8.65	5.20	.028*	3X3>3X3+2	0.23

TD1: Percentage of total distance covered at speeds of 0 to 7.2 km/h; TD2: percentage of total distance covered at speeds of 7.3 to 14.3 km/h; TD3: percentage of total distance covered at speeds of 14.4 to 21.5 km/h; TD4: percentage of total distance covered at speeds higher than 21.6 km/h.

Table 2. Comparison of physical demands between additional and regular players.

Variable	Description	Additional player	Regular player	p-value
Distance	Total	363.4917	431.9875	0.001
	Level 1	0.4785	0.3803	0.002
	Level 2	0.3904	0.4366	0.020
	Level 3	0.1234	0.1578	0.108
	Level 4	0.0077	0.0253	0.022
Acceleration	Total actions level 1	6.0833	9.2500	0.023
	% Total distance level 1	0.1429	0.2231	0.016
	Total actions level 2	0.0924	0.1170	0.218
	% Total distance level 2	3.5833	4.7917	0.164

Significant differences were observed in the six variables related to physical demands. Specifically, additional players covered a shorter total distance and exhibited a higher percentage of distance covered at the lower intensity and a lower percentage of distance covered at the higher intensities. Furthermore, these players performed significantly fewer acceleration actions at level 1 and the percentage of total distance covered during level 1 acceleration actions was lower when compared to regular players.

DISCUSSION

The analysis of physical demands in SSGs frequently uses parameters of distance covered to quantify the physical effort of players and few studies have evaluated acceleration demands in different game configurations[10]. Furthermore, the scarcity of studies on physical demands in situations of numerical inequality in SSGs renders the use of this configuration poorly substantiated[11]. In this respect, the present study adds important data by providing acceleration patterns based on the use of additional players in different SSG configurations.

The main finding of this study was the reduction in physical effort when an extra player is added inside the field, compared to the 3vs.3 and 3vs.3+2 configurations. In this respect, in a study involving additional players, Hill-Hass et al.[6] indicated that teams encountering a situation of numerical equality (3vs.3 and 5vs.5) covered a greater distance during SSGs than teams that always had an additional player (a team of 6 players in a game against 5 opponents and a team of 4 players against 3 opponents). Another study demonstrated a reduction in the distance covered at high intensity (16 to 17.9 km/h) and in total distance for numerically superior teams, as well as an increase in the distance covered at lower speeds (0 to 9.9 km/h)[12]. This result agrees with the present finding that the inclusion of additional players reduces physical demands in SSGs.

An increase in the number of players has been shown to result in an increase in parameters related to physical demands, namely the number of sprints and distances covered at higher intensities[23,27]. However, in those studies the increase in the number of players implied an increase in the size of the soccer field in order to maintain the same relative area per athlete. Although the area per player is maintained, the absolute increase in width and depth permits to develop high-speed actions over a longer period of time without the space of the field ending. This greater time/space availability for the development of high-speed actions permits athletes to more frequently achieve higher speeds, resulting in greater distances at higher intensities. In the present study, the inclusion of an additional player inside the field was not accompanied by an increase in the size of the field, with the area per player thus being reduced. Since an increase in the number of accelerations and distances covered at high intensity is reported for games with a larger area per player[10,28], a reduction in physical demands was expected for games in numerical superiority.

The use of supporting players around the field has been reported in different studies[29,30]. However, there is no study comparing the physical demands of regular players after the inclusion of supporting players during SSGs. In the present study, analysis of the distances covered showed a greater total distance covered and higher percentage of distance between 7.3 and 14.3 km/h for 3vs.+2 games compared to the 4vs.3 configuration. However, the 3vs.3+2 configuration exhibited significantly fewer acceleration actions at 2.5 m/s² and a lower percentage of distance covered during accelerations at this intensity. Hence, in terms of distance, the 3vs.3+2 configuration resembles the 3vs.3 format, while in terms of accelerations it resembles the 4vs.3 format.

With respect to the comparison of physical demands between additional and regular players, Hill-Haas et al.[11] observed an increase in the total distance of additional players when compared to regular players, particularly for the smaller game formats (3vs.3), and more high-intensity actions (> 18 km/h) for the larger formats (5vs.5). This result is contrary to the observations of the present study which showed a reduction in total distance, an increase in the percentage of distance covered at low speeds

and a reduction in the percentage of distance covered at high speeds, as well as a decrease in the number and percentage of distance covered during acceleration actions at 2 m/s^2. It should be noted that in another study, Hill-Hass et al.[6] found no differences in distances covered between additional and regular players belonging to teams with three players, a proposal resembling that of the present study. The authors also observed no differences in mean heart rate or blood lactate concentration and did not measure the acceleration pattern. Furthermore, the study cited adopted a game duration of 24 minutes, a fact that may have reduced the intensity of effort of all players due to the effect of fatigue, thus reducing the differences reported in the present study for a duration of 4 minutes. Thus, we suggest that the present results be added to those obtained by the cited authors[11]. Also, further studies will help understand the differences in physical demands between regular and additional players.

We understand that the action in team sports games is the result of the interaction of elements related to the individual, the task and the environment. In this respect, the training process should permit the occurrence of stimuli specific for the discipline[23], although varying by guaranteeing to each subject the ability to adapt to the different situational demands emerging during the game[9]. The use of situations of numerical superiority/equality should therefore reflect the intentions of the coaching staff for each training session, but should also permit athletes to expand their playing ability by varying the situational conditions inherent to the task.

CONCLUSIONS

It can be concluded that physical demands are reduced in SSGs performed in situations of numerical superiority. Specifically, the presence of an addition player inside the field reduced the total distance covered and distance covered between 14.4 and 21.5 km/h, in addition to reducing the incidence of acceleration actions and the total distance covered during accelerations. Furthermore, the physical demands of athletes were reduced when they exerted the function of an additional player compared to situations in which they performed games in numerical equality. At this point, reductions were observed in both parameters of distance covered and accelerations.

The findings will assist coaches and athletic trainers to adapt training contents for soccer players. In this respect, training sessions designed to increase physical demands, particularly at distant moments of a game, should be held in configurations of numerical equality. On the other hand, if the objective of the coaching staff is to reduce physical demands without eliminating the training session, such as periods near a game or during recovery training, situations of numerical superiority are useful for training organization.

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