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Reliability of physical, physiological and tactical measures in small-sided soccer Games with numerical equality and numerical superiority

Confiabilidade das medidas de demanda física, fisiológica e tática em pequenos jogos com superioridade e igualdade numérica no futebol

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Abstract – The aim of this study was to investigate the physical, physiological (HR) and tactical demands of small-sided soccer games (SSG) with numerical equality (3x3) and numerical superiority (4x3). Eighteen male players of a soccer team played against each other both types of SSG, both played as two 4-minute bouts interspersed with 4-minute rest. Physical (distances, velocities and accelerations) and HR demands were recorded by a GPS system (15hz) and a heart rate monitor during SSG. The individual tactical behaviors proposed by the System of Tactical Assessment in Soccer were registered by an observer who analyzed the SSG videos. Reliability was verified calculating the intraclass correlation coefficient (ICC) and the absolute and percentage standard error of measurement (SEM and %SEM, respectively), both considering athletes' individual scores in each SSG bout. As a result, higher number of variables related to physical and physiological demands presented significant ICC values, being classified as moderate to excellent in relation to variables related to tactical demands. Considering these variables that presented significant ICC values in both SSG, the SEM% values found for physical and physiological variables ranged from 3.0 to 42.0%, while those found for the tactical variables ranged from 31.6 to 75.0%. It could be concluded that several variables related to physical and physiological demands present moderate to excellent reliability. Differently, the majority of variables related to tactical demands were not reliable in both types of SSG.

Key words: Reliability; Soccer; Task performance analysis.

Resumo – *O objetivo do presente estudo foi investigar a confiabilidade das demandas física, fisiológica (FC) e tática em configurações de pequenos jogos (PJ) em igualdade (3x3) e superioridade numérica (4x3) no futebol. Dezoito jogadores do sexo masculino de uma equipe de futebol jogaram entre si os dois tipos de PJ, com duas séries de 4 minutos e 4 minutos de pausa entre elas. Durante os jogos, as variáveis relacionadas à demanda física (distâncias, velocidades, acelerações) e fisiológica foram registradas utilizando-se um equipamento de GPS (15hz) e um cardiofrequencímetro. Os comportamentos táticos individuais propostos pelo Sistema de Avaliação Tática no Futebol foram registrados por um avaliador partir da análise da filmagem dos jogos. A confiabilidade das medidas foi verificada considerando os valores individuais de cada atleta em cada série de PJ, por meio do coeficiente de correlação intraclasse (CCI) e do erro padrão de medida absoluto e percentual (EPM e EPM%, respectivamente). Como resultado, um maior número de variáveis relacionadas às demandas física e fisiológica apresentaram valores de CCI significativos com classificação moderada a excelente em relação às variáveis relacionadas à demanda tática. Considerando as variáveis com valores de CCI significativos em ambas as configurações de jogo, o EPM% variou entre 3,0 e 42,0% para as variáveis físicas e para a FC, e de 31,6 a 75,0% para as variáveis relativas à demanda tática. Conclui-se que diversas variáveis relacionadas às demandas física e fisiológica apresentaram confiabilidade moderada à excelente. Diferentemente, a maioria das medidas relacionadas à demanda tática não foi confiável em ambos PJ.*

Palavras-chave: *Análise de desempenho e tarefas; Confiabilidade; Futebol.*

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INTRODUCTION

Small-sided games (SSG), as a means of training in soccer, enables technical, physical and physiological demands to occur associated to tactical demands similar to those found in the formal game[1]. Researching the reliability of the different variables that represent these demands provides data for understanding the variability of responses when athletes are exposed to the same training condition. Reliability refers to the consistency or reproducibility of a measure when the individual performs a repeated test condition[2]. Thus, knowledge on the variability of responses in SSG supports the prescription of this type of training.

Previous studies have investigated the reliability of variables related to physiological and physical demands of soccer SSG[3-5]. In these, heart rate (HR) showed high reliability, while blood lactate concentration and rate of perceived exertion showed low to moderate reliability[3-6]. In terms of physical demand, the distance traveled at low speeds shows high reliability[5,6]. However, actions of acceleration and displacements at high speeds have low reliability in soccer SSG[4,5], possibly due to the low sampling frequency of GPS receivers[7,8], the natural variation of these responses between exercise bouts and training sessions[9] and differences among SSG configurations[10].

The reliability of physical and physiological demands has been observed only in configurations with numerical equality (1x1 to 6x6)[3,4,6,10]. However, considering that the formal game presents situations with numerical unbalance among players[11] (e.g. offensive numerical superiority) and that such situations may have different demands from those with numerical equality[12,13], researching SSG reliability with numerical superiority can provide subsides for coaches regarding training prescription. In addition, the reliability of tactical demand in SSG has not been investigated, limiting the understanding of the variability of these responses during SSG.

Therefore, the aim of this study was to investigate the reliability of physical, physiological and tactical demands in soccer SSG with numerical equality (3x3) and numerical superiority (4x3).

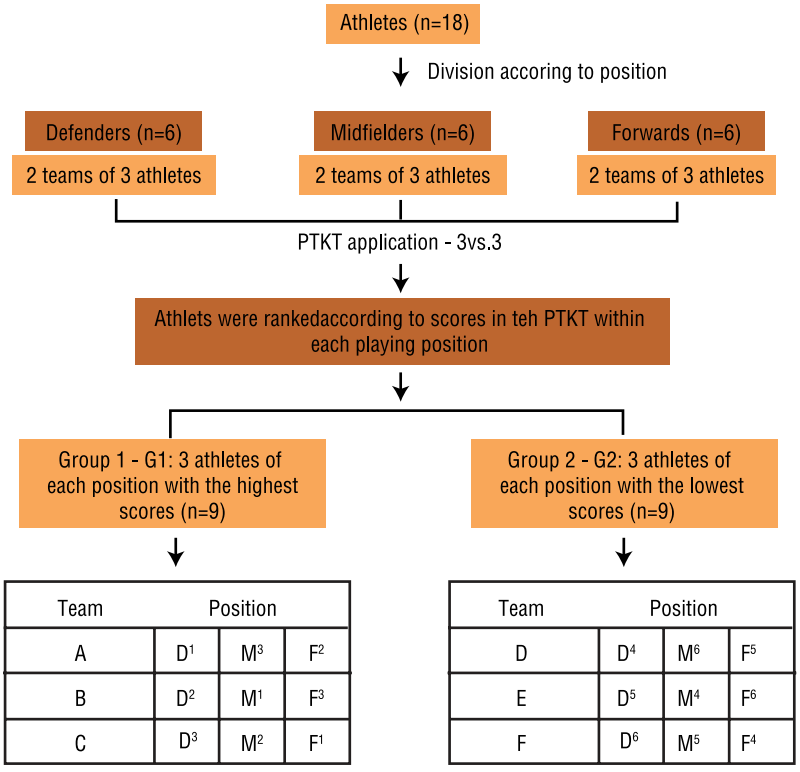
METHODOLOGICAL PROCEDURES

Sample

Eighteen U-17 male players were selected from a professional soccer club (age: 16.4 ± 0.4 years, weight: 68.4 ± 8.0 kg). All participated in competitions at national/international level and performed, on average, seven weekly training sessions. Players and their legal guardians signed the informed consent form with information about the research. The study was approved by the Ethics Research Committee of the Federal University of Minas Gerais (CAAE: 29215814.8.0000.5149).

Procedures

Each team was composed of a defender, a midfielder and a forward with similar levels of procedural tactical knowledge, as shown in Figure 1.



Team	Position		
A	D^{1}	M^{3}	F^{2}
B	D^{2}	M^{1}	F^{3}
C	D^{3}	M^{2}	F^{1}

Team	Position		
D	D^{4}	M^{6}	F^{5}
E	D^{5}	M^{4}	F^{6}
F	D^{6}	M^{5}	F^{4}

Figure 1. Procedures for the composition of teams
G1 and G2 = Athletes with higher and lower performance in PTKT, respectively; D = Defender; M = midfielder; F = Forward. Superscript number indicates the classification in the PTKT performance ranking in each positional category from 1st to 6th place.

To assess the procedural tactical knowledge of players in each position, the Procedural Tactical Knowledge Test (PTKT)[14] was applied to each group of six athletes from the same position (e.g., six defenders). In each of these groups, two teams of three athletes (randomly allocated) played a game that was filmed for later analysis of the procedural tactical knowledge. Based on the PTKT results, a performance ranking was established within each positional status (1^{st} to 6^{th} place). Then, the sample was divided into Group 1 (G1) and Group 2 (G2) composed of three players each positional status (total of 9 athletes each) with greater and lesser performance on the PTKT, respectively. Each group was divided into three teams (A, B and C and D, E and F) of three athletes, one defender, one midfielder and one forward. In order to make balanced teams, they could not have two athletes with the same classification in the PTKT performance ranking.

After the composition of teams, players performed 3x3 and 4x3 SSG in two familiarization sessions. The collection occurred every other day, always at the same time and after standardized preparatory activity. Teams from the same group randomly performed each type of SSG in all possible games (i.e. AXB, AXC, BXC, DXE, DXF and EXF). No games were played between G1 and G2 teams. For each game, two SSG (bouts) of each type were performed, totaling 12 games in each group (total of 24 games). Each SSG had total duration of four minutes with a four-minute rest be-

tween them[10]. To verify reliability, two SSG of the same type were carried out between the same teams (e.g., two 3x3 SSG between teams A and B).

Instruments

- **Small-sided games**

In both SSG, pitch size was 36x27 meters, with goals of 5x2 meters[15]. All the rules of formal soccer game were used, including offside. Auxiliary balls were at hand for a quick ball replacement. Two coaches provided external encouragement[3] to teams. In the 4x3 configuration, an additional floater player was included (midfielder of same tactical knowledge level of the team that was not playing - e.g., midfielder of team C in the AXB game in G1). After the loss of the ball by a team, the player was transferred to the other team and conducted the offensive actions for the new team. This player could perform all actions of the offensive process, except free kicks and ball replacement on sides and corners.

- **Physical demand**

GPS units brand GPSports Systems model SPIProX2 (15Hz) with coupled triaxial accelerometer (100Hz) were attached between athletes' shoulder blades. The validity and reliability of this equipment have been reported in previous studies[7]. Variables related to physical demand were total distance traveled, percentage of the total distance traveled in speed ranges from 0 to 7.2 km/h (% D0-7.2), 7.3 to 14.3 km/h (%D7.3-14.3), and 14.4 to 21.5 km/h (%D14.4-21.5)[16], peak speed, peak acceleration, number of accelerations greater than 2.0 m/s^2 and distance traveled in accelerations above 2.0 m/s.

- **Physiological demand**

HR was recorded using Polar®, FS1 transmitters (Finland), compatible with the GPS interface. Data relating to rest between bouts were excluded.

Mean heart rate (HR_{MEAN}) expresses the mean values recorded by the equipment during the four minutes of SSG. Peak heart rate (HR_{PEAK}) is the highest value recorded in the four minutes.

- **Tactical demand**

Games were analyzed using the Soccer Analyser® software. Two observers assessed the frequency of occurrence of individual tactical behavior of players using the System of Tactical Assessment in Soccer (FUT-SAT)[15], considering the location of actions on the playing field.

Intra- and inter-observer concordances were considered "perfect"[17], with Kappa coefficient values above 0.9 (standard error <0.006).

Statistical analysis

Reliability was calculated through the intraclass correlation coefficient 3,1 ($ICC_{3,1}$) and standard error of measurement (SEM) considering the individual values obtained in each bout of each type of SSG.

$ICC_{3,1}$ values[9] were accompanied by their respective 95% confidence

intervals and classified as weak (<0.4), moderate (0.4 to 0.59), good (0.6 to 0.74) and excellent (0.75-1)[18]. SEM[9] was relativized by the average values of variables, resulting in percentage SEM (%SEM)[9]. All analyses were performed using SPSS 20.0 software (Chicago, IL). The statistical significance level was 5%.

RESULTS

ICC, SEM, %SEM values and ICC classifications are shown in Tables 1 and 2. The number of accelerations and the distance traveled in accelerations above 2.0 m/s showed significant reliability values only in 3x3 SSG. For some variables, the absolute ICC values were higher in 4x3 SSG compared to 3x3 SSG.

Table 1. ICC, SEM, %SEM values and ICC classification for variables related to physical and physiological demands in 3x3 and 4x3 SSG.

	Small-sided games					
	3x3			4x3		
	ICC (95% CI)	ICC classification	SEM (%)	ICC (95% CI)	ICC classification	SEM (%)
HR_{MEAN}	0.72* (0.46 - 0.86)	Good	8.9 (5.4)	0.87* (0.74 - 0.93)	Excellent	6.7 (4.2)
HR_{PEAK}	0.51* (0.23 - 0.71)	Moderate	5.6 (3.0)	0.61* (0.32 - 0.79)	Good	6.0 (3.3)
Total distance	0.68* (0.21 - 0.86)	Good	22.6 (5.2)	0.71* (0.50 - 0.84)	Good	29.5 (7.2)
%D0-7.2	0.38* (0.07 - 0.63)	Weak	11.2 (6.6)	0.42* (0.12 - 0.65)	Moderate	13.2 (7.9)
%D7.3-14.3	0.56* (0.09 - 0.79)	Moderate	22.1 (11.2)	0.74* (0.55 - 0.86)	Good	24.0 (15.1)
%D14.4-21.5	0.54* (0.25 - 0.74)	Moderate	17.3 (30.0)	0.28* (-0.06 - 0.56)	Weak	21.3 (42.0)
Peak speed	0.08 (-0.24 - 0.39)	Fraco	2.3 (10.6)	0.09 (-0.26 - 0.40)	Weak	2.4 (10.8)
N. Accel. > 2.0 m/s²	0.66* (0.42 - 0.81)	Good	1.4 (17.3)	0.24 (-0.09 - 0.53)	Weak	2.1 (30.5)
% Dist. Accel. > 2.0 m/s²	0.51* (0.23 - 0.72)	Moderate	21.3 (27.1)	0.27 (-0.07 - 0.55)	Weak	22.5 (34.4)
Peak acceleration	-0.29 (-0.58 - 0.05)	Weak	0.4 (12.5)	0.24 (-0.09 - 0.53)	Weak	0.4 (12.0)

* = statistical significance for the ICC values. HR_{MEAN} and HR_{PEAK} = mean heart rate and peak heart rate; %0-7.2, %7.3-14.3, %14.4-21.5 = percentage of the total distance in speed ranges from 0 to 7.2 km/h, 7.3 to 14.3 km/h and 14.4 to 21.5 km/h, respectively; N. Accel.> 2.0 m/s² and % Dist. Accel.> 2.0 m/s ² = number of accelerations above 2.0 m/s² and percentage of the total distance traveled in accelerations above 2.0 m/s², respectively.

Table 2 indicates that 3x3 and 4x3 SSG show two and three variables, respectively, with significant ICC values which were classified as moderate. These variables are different in 3x3 and 4x3 SSG.

It is observed in Tables 1 and 2 that among variables with significant ICC in both SSG, %SEM values of variables related to physical and physiological demands ranged from 3.0 to 42.0% while those for variables related to tactical demand ranged from 31.6 to 75.0%.

Table 2. ICC, SEM, %SEM values and ICC classification for variables related to tactical demand in 3x3 and 4x3 SSG.

	Small-sided games					
	3x3			4x3		
	ICC (95% CI)	ICC classification	SEM (%)	ICC (95% CI)	ICC classification	SEM (%)
Penetration	0.07 (-0.27 - 0.39)	Weak	1.9 (40.6)	0.14 (-0.20 - 0.45)	Weak	1.9 (50.1)
Offensive coverage	0.40* (0.08 -0.64)	Moderate	2.0 (55.1)	0.16 (-0.18 - 0.47)	Weak	2.8 (72.1)
Width and length (without ball)	0.06 (-0.28- 0.39)	Weak	3.3 (45.9)	0.43* (0.14 - 0.66)	Moderate	2.9 (37.6)
Width and length (with ball)	0.17 (-0.17-0.47)	Weak	1.1 (82.0)	0.21 (-0.14 - 0.50)	Weak	1.0 (87.0)
Depth Mobility	0.35* (0.02- 0.61)	Weak	1.4 (71.5)	0.40* (0.08 - 0.65)	Moderate	2.1 (75.0)
Offensive unit	0.40* (0.08 - 0.64)	Moderate	3.5 (38.0)	0.23 (-0.11 - 0.52)	Weak	5.1 (43.7)
Delay	0.01 (-0.33 - 0.33)	Weak	2.1 (41.1)	-0.13 (-0.45 - 0.21)	Weak	2.6 (53.2)
Defensive coverage	0.36* (0.04 - 0.61)	Weak	2.2 (47.8)	0.19 (-0.15 - 0.49)	Weak	3.1 (53.8)
Defensive balance	0.02 (-0.32 - 0.34)	Weak	3.3 (60.4)	0.01 (-0.32 - 0.34)	Weak	3.0 (55.6)
Recovery balance	0.35* (0.02 - 0.61)	Weak	1.4 (70.9)	0.17 (-0.13 - 0.46)	Weak	1.9 (80.7)
Concentration	0.078 (-0.25 - 0.39)	Weak	1.8 (76.6)	0.07 (-0.27 - 0.39)	Weak	2.1 (78.0)
Defensive unit	0.22 (-0.12 - 0.51)	Weak	3.7 (30.9)	0.20 (-0.09 - 0.47)	Weak	4.0 (30.0)
(A) MC. OF.	0.38* (0.05 - 0.63)	Weak	4.4 (41.4)	0.69* (0.47 - 0.83)	Moderate	3.7 (31.6)
(A) MC. DEF.	0.36* (0.04 - 0.61)	Weak	6.4 (31.3)	0.23 (-0.11 - 0.51)	Weak	7.7 (35.5)
(D) MC. OF.	0.16 (-0.18 - 0.46)	Weak	6.5 (49.5)	0.34* (0.01 - 0.60)	Weak	5.2 (36.6)
(D) MC. DEF.	0.07 (-0.27 - 0.39)	Weak	5.7 (31.1)	0.27 (-0.05 - 0.55)	Weak	5.1 (26.5)

* = statistical significance for ICC values; (A) MC. OF. = Tactical attack actions carried out in the offensive midfield; (A) MC. DEF. = Tactical attack actions carried out in the defensive midfield; (D) MC. OF. = Tactical defense actions carried out in the offensive midfield; (D) MC. DEF. = Tactical defense actions carried out in the defensive midfield.

DISCUSSION

The ICC value reflects the magnitude of the variability between subjects and the consistency of this variability in various measures of the same test[9]. Low ICC values indicate that the differences between subjects are not maintained between repeated conditions of a test. The SEM value reflects the degree of fluctuation of the scores of an individual in a test/condition, indicating the expected natural variability (random error) for the response of a given variable[9]. Higher SEM values indicate higher ranges of expected scores for a certain variable, which makes it difficult to perceive significant changes in the scores of an individual following a systematic intervention (e.g., training).

Considering both SSG in the present study, several variables related to physical and physiological demands showed moderate or good ICC values and one variable showed excellent ICC, suggesting that individuals who had higher scores in the first bout continued to have higher scores in the second bout. In relation to HR, other studies with SSG corroborate the good consistency of this variable[3,4], and Hill-Haas et al.[5] showed a percentage typical error from 2 to 4% for HR in 4x4 SSG with athletes aged 17 years. In this study, %SEM (equivalent to percentage typical error) showed similar values from 4.2 to 5.4 and 3.0 to 3.3 for mean HR and peak HR, respectively. In addition, Ngo et al.[10] presented ICC of 0.95 and 0.96 for mean HR in 3x3 SSG with soccer players of the same age.

Physical demands showed moderate to good ICC values. For the total distance traveled, %SEM values between 5 and 7% corroborate the results of Ade et al.[4], who showed coefficients of variation from 6 to 8% for this variable in 1x1 and 2x2 SSG. For the distance traveled between 14.4 and 21.5 km/h, higher %SEM values were found (30.0 to 42.0%), but also close to those found by Ade et al.[4] (40-60%) in a similar speed range (14.5-19.8 km/h). In fact, studies have shown a decrease in reliability for higher speeds in SSG using 1Hz, 5Hz, and 10Hz GPS[7,8,19]. This may be related to the low sampling frequency of GPS devices, which limits the capture of short movements at high speeds[20].

Comparing SSG, only 3x3 configuration showed significant reliability for the number of accelerations and the distance traveled in accelerations above 2.0 m/s^2. Considering that these variables represent the most intense actions during SSG, greater reproducibility of these actions might be related to the increased need for intense confrontations among players in game with numerical equality. The other variables showed equal or greater reliability in the 4x3 configuration, suggesting that numerical superiority may show greater reproducibility in less intense demands, which are facilitated by the presence of the additional player. However, to prove the existence of statistical differences between absolute ICC values of the different variables in each SSG, an inferential analysis would be necessary and, consequently, a different experimental design.

For tactical variables with significant and moderate ICC values, %SEM valuesranged from 31.6 to 75.0%, considering both SSG. These data indicate a high fluctuation of measures and low consistency of differences between subjects in bouts 1 and 2 of each SSG. These results may be related to inherent characteristics of the game, such as unpredictability and complexity, requiring players to adapt their actions to tactical situational demands[21].

Moreover, it is possible that the frequency of occurrence of certain tactical behavior does not reflect the actual response of each tactical behavior of U-17 category athletes in the investigated conditions. For example, one of the athletes from team C had 9 penetration actions in the first SSG and only 2 in the second. Another athlete had seven defensive coverage actions in the first SSG and 17 in the second. Such data impact both the consistency of tactical behaviors as well as its variability and may have been influenced by the game duration[22]. In this study, the duration of 4 minutes

was determined considering previous data suggesting that 4 minutes are sufficient for the manifestation of different tactical principles[15]. However, if four minutes are sufficient for such events to occur with a frequency capable of representing the expected variability for each principle remains an issue to be investigated.

Another important result indicates that variables with significant ICC in 3x3 SSG were not the same that presented significant ICC in 4x3 SSG. Therefore, the reproducibility of the tactical demand seems to be influenced by SSG configuration. For example, the offensive unit may have had greater reproducibility in 3x3 SSG due to greater participation of players behind the line of the ball in attack due to the difficulty to progress with the ball in game with numerical equality. The presence of the additional player in 4x3 SSG may have allowed the three athletes of the team to be free to move between the ball line and the line of the last defender, providing moderate reliability in width and length (without the ball) principle. In 3x3 SSG, only two athletes would be able to perform this movement. These examples allow us considering that the ICC values of variables related to tactical demands may be associated to the frequency of a certain behavior, allowing it to present a "representative" variability for the investigated conditions.

The number of participants in this study may be a limitation to the generalization of results. In addition, considering that the level of tactical knowledge can be different between athletes of different ages[23], different patterns of tactical behavior in different categories are expected, thus limiting the conclusions of this study to the U-17 category.

CONCLUSION

The results indicate moderate to excellent reliability for several variables related to physical and physiological demands in soccer SSG, while most variables related to tactical demand have low reliability. These results suggest that coaches should be aware that 3x3 and 4x3 SSG as a means of training in soccer generate physical and physiological demands with variability around 3-42% and variability of up to 75% for tactical responses of athletes.

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