Original article (full paper)

Preliminary results on organization on the court, physical and technical performance of Brazilian professional futsal players: comparison between friendly pre-season and official match

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Abstract—The main aim of this study was to verify possible differences between a friendly pre-season match (FM) and an official in-season match (OM) regarding physical, technical, and organizational performances of a professional Brazilian futsal team. Ten professional futsal athletes participated in this study. The matches were monitored with video cameras (30 Hz) and athlete trajectories obtained with automatic tracking. The values obtained for distance covered per minute, percentage of distance covered at moderate intensity, team coverage area, spread, passes, possessions, ball touches and successful passes per minute were greater for the OM than FM. On the contrary, percentage of distance covered, standing and walking was greater for the FM than OM. We concluded that physical, technical, and tactical performances are different between a FM and an OM in futsal and also these parameters mutually influenced each other distinctly. Future studies should verify whether pre-season tournaments reproduce similar demands to a regular season official match.

Keywords: futsal, activity profile, technique, automatic tracking

Introduction

Analysis of match performance based on video recordings in futsal represents an extensive area of investigation (Moore, Bullough, Goldsmith, & Edmondson, 2014), with emphasis on variables related to physical and tactical performances (Bueno *et al*., 2014; Caetano *et al*., 2015; Castagna, D'Ottavio, Granda Vera, & Barbero Alvarez, 2009; Corrêa, Alegre, Freudenheim, Dos Santos, & Tani, 2012; Dogramaci, Watsford, & Murphy, 2015; Lapresa, Alvarez, Arana, Garzón, & Caballero, 2013; Makaje, Ruangthai, Arkarapanthu, & Yoopat, 2012; Travassos, Araújo, Vilar, & McGarry, 2011; Vieira *et al*., 2015; Vilar *et al*., 2014) and a smaller number of publications related to technical performance (Dogramaci *et al*., 2015; Gómez, Moral, & Lago-Peñas, 2015; Sarmento *et al*., 2016). Futsal vigorously taxes both the aerobic and anaerobic metabolism

signaling pathways (Castagna *et al*., 2009) as seen by athlete displacements above 18 km/h in 22.5% of total distance covered during a game (Barbero-Alvarez, Soto, Barbero-Alvarez & Granda-Vera, 2008). This represents an average effort of 86.4% of maximum heart rate (Rodrigues *et al*., 2011) along with 80–85% of exhaustion values based on blood-lactate concentration (Castagna *et al*., 2009). Furthermore, previous studies suggest that futsal athletes should have well developed aerobic capacity with a maximal oxygen uptake ($VO2_{MAX}$) of approximately 60 ml/kg/min (Baroni & Leal Junior, 2010; Castagna *et al*., 2009), which illustrates the high intensity nature of this team sport.

Although the literature now exhibits an increasing number of studies on athlete displacement patterns in futsal, studies involving in-game demands are still scarce when compared with soccer (Bueno *et al*., 2014). Greater physical demands during games have been previously reported when considering higher levels of competition, such as comparisons between professional and amateur athletes (Makaje *et al*., 2012) and those who play for national teams versus state team athletes (Dogramaci, Watsford & Murphy, 2011). Another factor contributing to differences in the physical demands during competitions is the nationality of the players, in other words, in futsal different leagues present specific physical requirements (Bueno *et al*., 2014).

Currently, studies examining tactical dynamics (or coordination dynamics) look at only fragmented sequences in futsal games. For example, when the goalkeeper of the attacking team is substituted with an extra field player (Travassos *et al*., 2011), when shots on goal occur (Moura *et al*., 2011; Lapresa *et al*., 2013; Vilar, Araújo, Davids, Correia, & Esteves, 2013), when tackles are performed (Moura *et al*., 2011), passing (Corrêa, Vilar, Davids, & Renshaw, 2014) and plays ending in goals (Vilar *et al*., 2014). Thus, a lack of studies exist evaluating the tactical features of futsal teams (i.e. organization on the court) (Moura *et al*., 2011), mainly during the whole match, considering each instant of time, using team coverage area and spread variables. This information would be useful to those involved with futsal tactics.

Previous studies have reported a total distance covered between of 3,133 to 6,535 m covered during a futsal game (Barbero-Alvarez *et al*., 2008; Bueno *et al*., 2014; Castagna *et al*., 2009; Makaje *et al*., 2012; Moreno, 2001). When these results were normalized by playing time, the values observed were 110.6 to 121 m/min (Barbero-Alvarez *et al*., 2008; Bueno *et al*., 2014; Castagna *et al*., 2009; Dogramaci *et al*., 2015). Nonetheless, it is not clear how to interpret these results since most studies are based on simulated matches (Castagna *et al*., 2009; Makaje, Ruangthai, Arkarapanthu & Yoopat, 2012; Milioni, 2014; Vieira, 2014), with few studies investigating official matches (OM) (Barbero-Alvarez *et al*., 2008; Bueno *et al*., 2014). The differences in the type of game situation (official versus simulated or friendly), likely, would contribute to the ample variance in the reported results.

This outcome has been previously reported during soccer matches. Although engaging in FM's during pre-season is a common strategy adopted by many sport teams as a preparatory period (i.e. pre-season period) (Folgado, Duarte, Fernandes & Sampaio, 2014), a previous study in soccer suggests that soccer FM's underestimate physical (i.e. time-motion characteristics, specially distance covered at very high intensity [> 19.8 km/h]) and tactical behavior demands (i.e. intra-team movement synchronization), depending on the opponent's level (see for instance Folgado *et al*., 2014). However, Bradley and Noakes (2013) reported that the importance given to the matches did not influence displacement performance in an English FA Premier League soccer team during two consecutive seasons.

There is a scarcity of studies examining the potential similarities between FM and OM's in futsal. Bueno *et al*. (2014) recently highlighted that kinematic studies about the patterns of displacement of Brazilian futsal athletes have not been sufficiently explored. Moreover, although knowledge exists regarding physiological aspects, psychological demands and game tactics of futsal based on video recordings, there are few studies that explore such topics and the results are difficult to compare (e.g. studies analyzing OM or analyzing FM) due to different methodologies employed for movement analysis (Moore *et al*., 2014). In addition, Beato, Coratella, and Schena (2014) in a recent review, also highlighted that future studies should examine physical demands during futsal matches in detail, as well as seasonal variations. In the same study, the need for further information from evaluations of friendly versus competitive matches was reported (Beato *et al*., 2014). This issue is important due to the fact that investigations into athlete performance during games is considered an important tool for designing and refining training methods (Barros *et al*., 2007; Carling, Bloomfield, Nelsen, & Reilly, 2008; Dogramaci, Watsford, & Murphy, 2011; Makaje *et al*., 2012). In addtion to which, it is necessary to establish if the results obtained in FM represent actual performance during competition for both scientific and coaching communities.

To our knowledge, no previous work has investigated the performance of Brazilian professional futsal teams regarding physical demands, technical performance and organization on the court simultaneously, in both types of games (i.e. FM and OM). While analyzing the first half, second half and whole match. Therefore, this study was performed to identify whether previously established high demands of futsal game (Bueno *et al*., 2014; Castagna *et al*., 2009; Rodrigues *et al*., 2011) cause or not impairment from the first to the second half in both types of games while also considering global performance. Additionally, characterization of game performance during the first half, second half and whole match allows for a more accurate comparison of the potential differences or similarities between an FM and OM.

Therefore, the aim of the current study was (i) to compare a friendly pre-season match and an official in-season match regarding physical, technical, and organizational performances of a professional futsal team, and (ii) to identify possible differences in global performance (i.e., physical, technical and organizational performances) between the first and second half in each match.

Methods

Participants and experimental design

A total of 10 Brazilian fulltime well-trained professional futsal athletes with no self-reported history of chronic musculoskeletal injuries and with more than five years of competitive experience, participated in this study (age = 23.2±2.25 years, weight = 73.60±8.28 kg, height = 173.1±6.17 cm, $VO2_{MAX}$: 50.15±2.46 ml/kg/min, body fat percentage = 18.37±2.64%). All athletes were from the city of Bauru, São Paulo, Brazil, belonging to the local team, which competes in the elite state league (reached the quarter-finals of the São Paulo State League 2013) and is affiliated to the Brazilian Futsal Confederation

Two matches were fully monitored for this study. The first match occurred at the end of the pre-season (i.e., FM) in February 2013 against an elite national team (first place in the Brazilian First Division League in 2013). The second match occurred in November 2013 at the middle-end of the regular season (i.e., OM) in the final round of matches before the São Paulo State League playoffs against another elite national team (reached the quarter-finals of the São Paulo State League 2013). The monitored team had to win the game to qualify for the playoffs. Both matches were home games, played on and official court (40 x 20 m; FIFA standard). The duration of the matches (i.e. the total time played) was similar (approximately 60 minutes), and the time playing on the court did not differ (see Table 1). The difference in daily average temperature between match days was 2^0C (climate record of Institute of Meteorological Research – IPMet – Bauru – SP - Brazil). The time frame between the FM and OM was approximately 8 months and these matches were purposely chosen to fully characterize a distinct situation (i.e., a friendly game at the beginning of the season and an important match in the middle-end of the season). During this period, athletes were engaged in 6-8 practice sessions per week and played a total of 27 matches. All coaching staff (coach, assistant coach, trainer, and medical staff) remained unaltered throughout the study.

All procedures were approved (protocol 5069/2012) by the University's Institutional Review Board for Human Subjects (Human Research Ethics Committee) and were conducted according to the Declaration of Helsinki.

Image sequences acquisition

Both games were fully monitored with three digital video cameras (SONY™ DCR-SR21) operating at an acquisition frequency of 30 Hz (720 x 480 pixel and 24-bit of color resolution). The cameras were placed in high places of the gymnasium where the games occurred (Figure 1). Following the acquisition, the sequences of images were transferred to a personal computer (8-core Intel Xeon® CPUX5650) for the computational tracking.

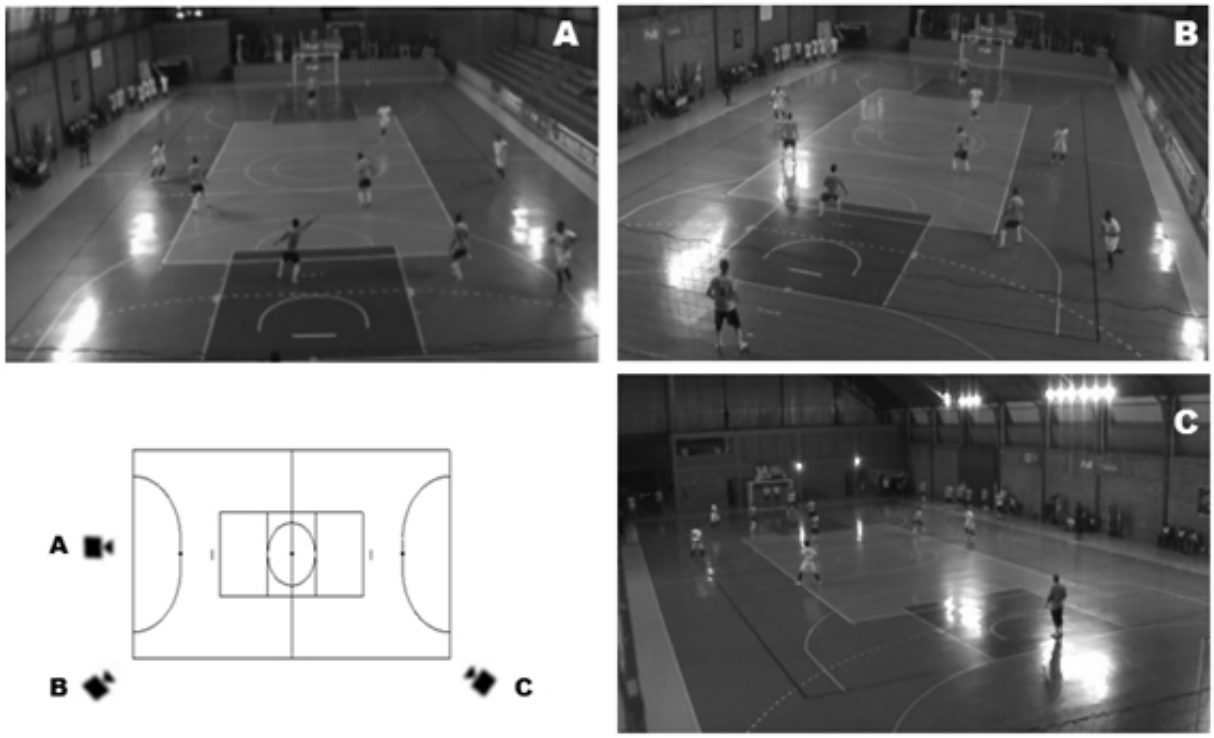

Figure 1. Position of cameras at the highest points in relation to the game court surface for the recording of the events in both games.

Table 1. Values of physical performance during the official match (OM) and pre-season friendly match (FM). Results are presented in medians (interquartile interval).

Variables	Level	First half	Second Half	Whole game
TD (m)	FM	1318.57 (781.96)	1661.61 (873.14)	2654.48 (1854.13)
	OM	1733.94 (1115.84)	1917.64 (769.43)	3191.13 (1455.50)
t (min)	FM	13.65 (8.26)	17.58 (11.46)	29.82 (21.50)
	OM	14.40 (12.59)	20.05 (12.32)	29.66 (20.56)
NS/t ratio (a.u.)	FM	0.64 (0.18)	0.75 (0.26)	0.73 (0.27)
	OM	0.75 (1.14)	0.83 (1.10)	0.92 (0.64)
V_{MAX} (km/h)	FM	26.04 (4.39)	24.46 (4.91)	27.67 (5.50)
	OM	28.16 (3.36)	25.07 (3.90)	28.16 (3.36)
D_{MIN} (m/min)	FM	95.35 (6.42)	91.18 (12.87)	94.79 (10.14)
	OM	105.91 (19.61)[# a]	104.18 (20.62)	103.53 (19.68)[# a]

TD: total distance covered; t: time on the court; NS: number of sprints; V_{MAX}: maximum velocity attained in the match; D_{MIN}: distance covered per minute; a.u.: arbitrary units.
[#] significant different values between official and friendly matches.
[a] large effect size when compared with FM.

Automatic tracking and data treatment

The software DVideo™ (Barros *et al*., 2011; Barros *et al*., 2007; Bueno *et al*., 2014; Figueroa, Leite, & Barros, 2006a; Vieira *et al*., 2015) was used for the automatic tracking analysis. Images were synchronized based on common events that occurred in overlapped areas of camera view, such as an instance where an athlete takes the first ball kick in the match or when the ball hits the floor (Bueno *et al*., 2014; Moura *et al*., 2013). The segmentation process was then executed based on a specific algorithm (Barros *et al*., 2011) that consists of morphological filtering (Figueroa, Leite, & Barros, 2006a) to separate the elements of interest (i.e. each athlete) from the other elements in the image (Figure 2).

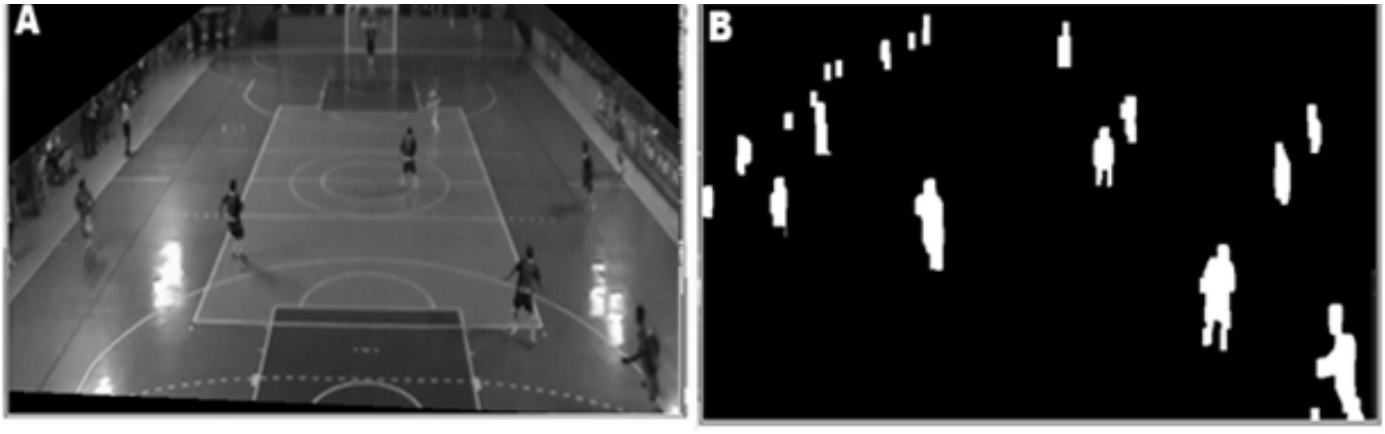

Figure 2. Example of one frame during the image segmentation process based on morphological filtering in DVideo™ environment.
A = actual frame. B = binary image.

Two-dimensional (2D) calibration was performed based on 21 points on the game court surface with actual known distances previously measured with a tape measure with respect to the origin of the court coordinate system defined. Frame marking was performed in a specific DVideo interface by only one experienced examiner, considering the player's position as a projection on the game plan (Misuta, 2004) and situations that were not automatically solved (e.g. mutual occlusions) and manually corrected frame-by-frame (Barros *et al*., 2007). This procedure allowed an automatic tracking rate of approximately 50% of the processed frames in the present study. Following frame marking, data matrices with all the two-dimensional position information of each athlete with respect to time (i.e. x(t), y(t)) were obtained via reconstruction using the DLT (Direct Linear Transformation) method (Abdel-Aziz & Karara, 1971), since the basic equations of the method were adequate for 2D reconstruction (Misuta, 2004).

During the data treatment phase, these matrices were exported to the Matlab environment (MathWorks Inc., USA). The 2D data were smoothed using a ButterWorth third-order low pass digital filter with a selected cut-off frequency of 0.4 Hz (Bueno *et al*., 2014; Vieira *et al*., 2015). In order to determine the experimental error using the automatic tracking model and filter parameters for data treatment, an experimental protocol

was executed where one of the participants was instructed to run for a known distance on the game court (Misuta, 2004; Moura *et al*., 2013).

In the present study, the average experimental error for the determination of distances covered was 0.93%. These values are similar to those previously reported (0.8%) for the determination of distances covered with the automatic tracking method via the software DVideo™ in a futsal context (Bueno *et al*. 2014).

Physical performance

The variables selected for this study were: total distance covered (m), time on the court (min), maximum velocity (km/h) and distance covered per minute (m/min). The percentage of distance covered in different efforts was also calculated. Five velocity bands were pre-determined based on the studies of Castagna *et al*. (2009) and Bueno *et al*. (2014): $0.0 \leq$ **V1** ≤ 6.0 km/h (standing and walking); $6.1 <$ **V2** ≤ 12.0 km/h (low-intensity running); $12.1 <$ **V3** ≤ 15.4 km/h (medium-intensity running); $15.5 <$ **V4** ≤ 18.3 km/h (high-intensity running) and; **V5** > 18.4 km/h (sprinting). Thus, frequency of sprints, defined as frequency of V5 runs, was measured and divided by the time on the court (NS/t) (Caetano *et al*., 2015) in arbitrary units (a.u.).

Quantification of team organization on the court

Two variables were used for the quantification of organization on the court; team coverage area and spread (Moura, Martins, Anido, Barros, & Cunha, 2012; Moura *et al*., 2013). Team coverage area was calculated by considering a convex polygon with a collection of finite S points in one plane, with each point representing the 2-D position of an athlete of the same team at each instant of time (Figure 3). The smaller convex polygon containing S is calculated and its vertices are a subgroup of S (Preparata & Shamos, 1985) by means of the Quickhull technique (Barber, Dobkin, & Huhdanpaa, 1996), available in the Matlab® software. This calculation was performed for each instant of time (i.e. each frame of image analyzed), considering the 2-D positional matrices of four field athletes present on the court. For the calculation of the total team coverage area, we divided the convex polygon obtained into triangles, and the total area represents the sum of areas of the triangles contained within the convex polygon.

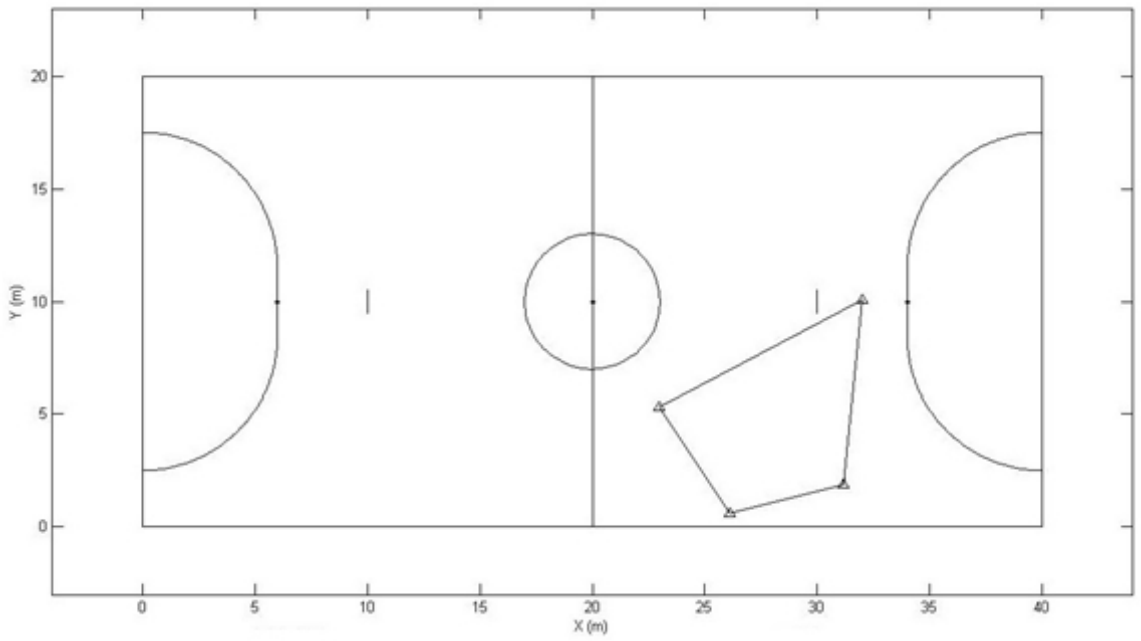

Figure 3. Example of one frame with its corresponding convex polygon created with the quartet of athletes present on the court.

Spread was measured by calculating the Euclidian distance (d) between each athlete and all the other players on their team (Figure 4). We then obtained the symmetrical matrix D(t) of 4th order (i.e., four players on the court) at each instant in time. The lower triangular matrix (labelled $||L\ (t)||_F$) from D was considered for the subsequent calculation, as D is a symmetrical matrix, and therefore d_{ij} equals d_{ji}, in other words, the element d_{p1p2} is equal to d_{p2p1}, and represents the Euclidian distance between player 1 and player 2, with the principal diagonal exhibiting values of 0 (zero) in all cases (Moura *et al*., 2012; Moura *et al*., 2013). The Frobenius norm (Golub & Van Loan, 2012) was calculated at each instant of time in order to represent the spread (Equation 1):

$$\|L(t)\|_F = \sqrt{\sum_{i=1}^{n}\sum_{j=1}^{n}|l_{ij}|^2}$$

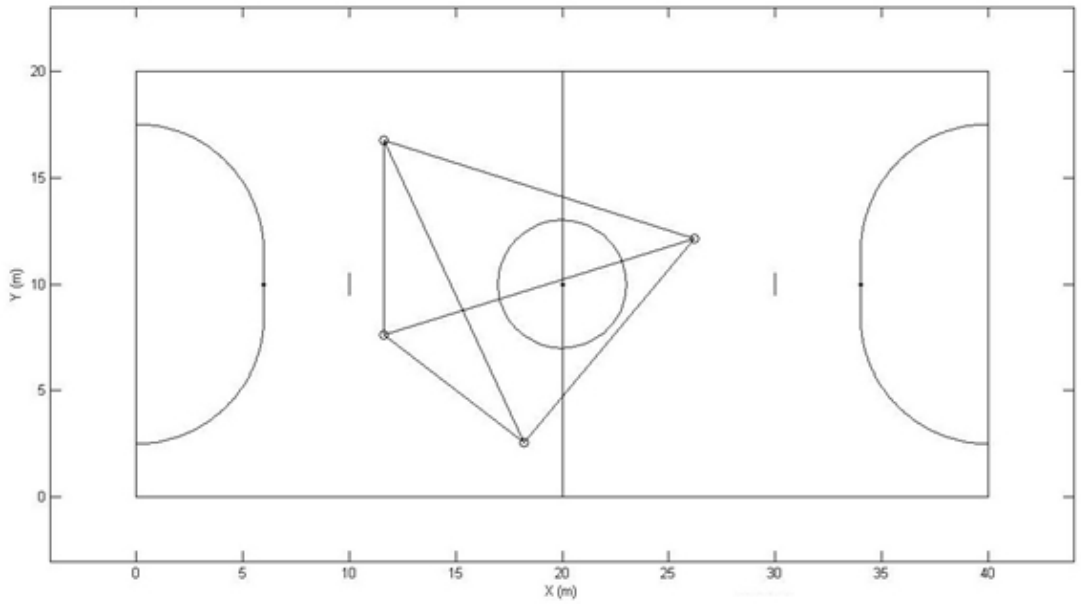

Figure 4. Example of one frame with the 2-D positions of the quartet of athletes on the court and the Euclidian distance of each athlete with respect to the all team his mate.

Greater values of the Frobenius norm represent a greater spread of the athletes on the court, whereas lower scores suggest that the athletes are closer to each other (Moura *et al*., 2012).

Technical performance

Technical performance was obtained in the DVideo environment (see for instance Moura *et al*., 2013) through the video recordings via scout (i.e., notational analysis) by the same rater. A total of 2,938 technical actions were recorded in both games. The total number (frequency) of passes, individual possessions, ball touches, duels, kicks and corrected passes, kicks on target (i.e., successful kicks) and duels won were recorded for each athlete (Carling & Dupont, 2011) for the first and second halves of the match and the whole match. Only one researcher performed the analysis in order to maximize reliability and decrease potential inter-rater variability of the assessed variables (Dogramaci *et al*., 2015). To verify the reliability of the measurements, we selected a window of 17 minutes in one of the matches and the scout assessment was re-performed after 6 weeks based on previous studies in futsal literature (Ré, Cattuzzo, Santos, & Monteiro, 2014). The intraclass correlation coefficient (ICC) was 1 for total kicks and kicks on target, 0.997 for total passes, 0.999 for number of ball possessions and ball touches, 0.996 for number of successful passes, 0.912 for duels won and 0.8 for total duels ($p < 0.01$). A previous futsal study reported ICC values between 0.72–0.93 when analyzing passes, dribbles and successful kicks along with disarms and interceptions (Ré *et al*., 2014).

Statistical analysis

Technical performance and organization on the court are displayed as mean ± standard deviation, while physical performance variables are presented as medians (interquartile interval) (Bueno *et al*., 2014). Data normality was initially verified with the Shapiro-Wilk test suggesting the use of non-parametric tests. The Mann-Whitney U test was used to compare the FM and OM and also the scores obtained from the first and the second halves of each of the matches. The 95% confidence intervals (95% CI) of all differences found and effect size (ES) calculations were used to determine the magnitude of the differences (Cohen, 1988; Dogramaci *et al*., 2015). The statistical significance level (α) was set at 95% ($p < 0.05$) and all analyzes were performed using the software Statistical Package for Social Sciences (SPSS, version 17).

Results

Table 1 presents the results (median ± interquartile interval) of displacement variables during the first and second halves and the whole match for both the FM and OM. When compared with the FM, distance covered per minute was significantly higher in the OM during the first half ($p< 0.01$ [95% CI: 0.36 – 22.93]) and whole match ($p= 0.03$ [95% CI: 2.22 – 17.99]).

Table 2 exhibits the results (median ± interquartile interval) of the percentage of distance covered in different intensity bands for both matches. It was verified that, compared with the OM, the percentage of distance covered in standing and walking in the first half ($p= 0.02$ [95% CI: -9.72 – -0.19]) and whole match ($p= 0.03$ [95% CI: -7.36 – -1.72]) was significantly greater during the FM. On the other hand, the percentage of distance covered in medium-intensity running in the first half ($p= 0.01$ [95% CI: -0.73 – 9.63]), second half ($p< 0.01$ [95% CI: 1.56 – 4.58]), and whole match ($p< 0.01$ [95% CI: 0.95 – 5.36]) was greater for the OM when compared with the FM.

Compared with the FM, the OM exhibited greater team coverage area when considering the first half ($p< 0.01$ [95%

CI: -5.55 – 48.33]) and whole match (p< 0.01 [95% CI: 9.54 – 45.79]), and greater spread in the first half (p< 0.01 [95% CI: 0.46 – 9.67]) and whole match (p= 0.03 [95% CI: 2.26 – 9.86]) (Table 3).

Tables 4 and 5 display the results of technical performance. Compared with the OM first half, significant decreases in the total number of passes (p< 0.01 [95% CI: 0.36 – 1.24]), possessions (p< 0.01 [95% CI: 0.24 – 1.25]), and ball touches (p= 0.04 [95% CI: 0.19 – 3.81]) per minute were observed in the second half. It was also observed that, when compared with the FM, the OM displayed greater scores in the first half in total number of passes (p< 0.01 [95% CI: 0.41 – 1.70]), possessions (p< 0.01 [95% CI: 0.37 – 1.55]), and ball touches (p< 0.01 [95% CI: 1.27 – 4.38]) per minute. Similar results were observed when comparing the scores obtained for the whole match, where the OM exhibited a significantly greater number

Table 2. Percentage of distance covered (%) within each of the pre-determined velocity bands for official match (OM) and pre-season friendly match (FM). Results are presented in medians (interquartile interval).

Velocity bands	Level	First Half	Second Half	Whole game
V1 (%)	FM	34.96 (5.14)	36.25 (37.62)	35.67 (6.10)
	OM	27.78 (10.15)[# a]	29.30 (9.20)	30.38 (8.24)[# a]
V2 (%)	FM	40.24 (5.36)	37.62 (5.74)	39.49 (3.07)
	OM	40.65 (6.65)	40.52 (2.41)	41.27 (3.36)
V3 (%)	FM	12.03 (1.33)	13.19 (1.88)	12.99 (1.50)
	OM	16.80 (3.68)[# a]	17.09 (1.88)[#]	16.41 (2.21)[# a]
V4 (%)	FM	5.45 (1.62)	7.03 (3.51)	6.13 (1.48)
	OM	7.56 (3.26)	8.43 (1.51)	7.51 (1.72)
V5 (%)	FM	5.96 (3.00)	5.21 (3.48)	6.15 (3.55)
	OM	5.56 (4.07)	5.31 (6.84)	5.27 (5.46)

0.0 ≤ V1 ≤ 6.0 km/h (standing and walking); 6.1 < V2 ≤ 12.0 km/h (low-intensity running); 12.1 < V3 ≤ 15.4 km/h (medium-intensity running); 15.5 < V4 ≤ 18.3 km/h (high-intensity running); V5 > 18.4 km/h (sprinting).
[#] significant different values between official and friendly matches.
[a] large effect size when compared with FM.

Table 3. Values of organization on the court variables during the official match (OM) and pre-season friendly match (FM). Results are presented in mean ± standard deviation.

	Team coverage area (m²)		Spread (m)	
	FM	OM	FM	OM
First Half	53.17 ± 13.05	80.45 ± 16.14[# a]	21.91 ± 2.8	28.01 ± 2.54[# a]
Second Half	59.8 ± 17.68	73.19 ± 35.3	23.9 ± 3.42	26.68 ± 7.55
Whole game	58.51 ± 26.45	75.53 ± 30.33[# b]	24.27 ± 5.33	27.11 ± 6.35[# b]

[#] significant different values between official and friendly matches.
[a] large effect size when compared with FM.
[b] medium effect size when compared with FM.

Table 4. Frequency of the execution of scout variables of technical skills during the official match (OM) and pre-season friendly match (FM), normalized by time on the court. Results are presented in mean ± standard deviation.

Skill	Level	First Half	Second Half	Whole game
Passes per minute	FM	0.9±0.29	0.95±0.39	0.9±0.29
	OM	1.9±0.38*[# a b]	1.1±0.35	1.45±0.3[# b]
Possessions per minute	FM	0.97±0.25	1.06±0.26	1±0.15
	OM	1.9±0.33*[# a b]	1.16±0.46	1.48±0.32[# b]
Ball touches per minute	FM	2.29±0.9	2.38±0.84	2.31±0.63
	OM	5±1.43*[# a b]	3.01±1.28	3.85±0.94[# b]
Duels per minute	FM	0.45±0.17 [# c]	0.28±0.14	0.34±0.14
	OM	0.24±0.12	0.35±0.21	0.29±0.11
Kicks per minute	FM	0.07±0.06	0.07±0.07	0.08±0.06
	OM	0.1±0.09	0.12±0.10	0.11±0.06

* significant different values between first and second halves.
[#] significant different values between official and friendly matches.
[a] large effect size when compared with second half.
[b] large effect size when compared with FM.
[c] large effect size when compared with OM.

Table 5. Frequency of successful execution of the scout variables of technical skills during the official match (OM) and pre-season friendly match (FM), normalized by time on the court. Results are presented in mean ± standard deviation.

Skill	Level	First Half	Second Half	Whole game
Corrected passes per minute	FM	0.74±0.33	0.85±0.33	0.79±0.24
	OM	1.75±0.43*[# a b]	0.95±0.39	1.31±0.31[# b]
Duels won per minute	FM	0.29±0.17*[a]	0.14±0.12	0.19±0.12
	OM	0.12±0.11[# b]	0.25±0.12	0.19±0.09
Successfull kicks per minute	FM	0.04±0.05	0.03±0.04	0.04±0.04
	OM	0.03±0.04	0.08±0.10	0.05±0.03

* significant different values between first and second halves.
[#] significant different values between official and friendly matches.
[a] large effect size when compared with second half.
[b] large effect size when compared with friendly match.

of passes (p< 0.01 [95% CI: 0.19 – 1.04]), possessions (p= 0.01 [95% CI: 0.09 – 0.83]) and ball touches (p= 0.01 [95% CI: 0.62 – 2.66]) per minute than the FM. On the other hand, the only FM variable with a score higher than the OM was the number of duels per minute in the first half of the match (p= 0.02 [95% CI: -0.25 – 0.07]).

During the OM, the frequency of successful passes decreased significantly (p= 0.01 [95% CI: 0.28 – 1.32]) when comparing the first and second halves of the match. Compared with the FM, a significantly greater number of successful passes per minute was observed in the OM in the first half (p< 0.01 [95% CI: 0.39 – 1.73]) and whole match (p< 0.01 [95% CI: 0.18 – 1]). However, the number of duels won per minute was greater during the FM first half than the OM first half (p= 0.04 [95% CI: -0.25 – 0.12]). Also, this variable (number of duels won per minute) was the only performance variable that significantly decreased from the first to the second half during FM (p= 0.045 [95% CI: -0.08 – 0.3]).

Discussion

The aim of the current study was to compare a friendly pre-season match and an official in-season match regarding physical, technical, and organizational performances of a professional futsal team, and to identify possible differences in global performance (i.e. physical, technical and organizational performances) between the first and second half, in each match. Significant differences were detected between friendly pre-season (FM) and official (OM) matches with large effect sizes found regarding intensity of displacement on the court (distance covered per minute, percentage of distance covered in standing and walking, percentage of distance covered in moderate intensity running), organization on the court (team coverage area and spread), and technical performance (passes per minute, possession per minute, ball touches per minute, successful passes per minute). In addition, differences between halves during the OM were found only for the technical performance (i.e. total passes, possessions and ball touches, duels won and correct passes).

Mohr *et al*. (2003) highlighted that total distance covered and distance covered in moderate velocity are greater towards the end of the soccer season. In addition, a previous study with professional futsal athletes indicated increased physical performance in field tests including aerobic capacity (Yo-Yo IR1) and repeated sprint ability (6 bouts x 40 m), when a comparison was made between in-season and middle-end of the regular session after 17 matches (two friendly and 15 official matches) (Oliveira, Leicht, Bishop, Barbero-Alvarez, & Nakamura, 2013). Accordingly, profiles of athlete displacement during OMs at the middle-end of the regular season was greater than that observed in the FM in the present study (distance covered per minute and percentage of distance covered in V3). This may partially explain the differences found in physical performance between the two matches. However this should be viewed with caution due to no significant relationship between match running performance and physiological variables (i.e., derived from aerobic fitness test) in professional well-trained futsal players (Castagna *et al*., 2009, Milioni, 2014).

Previous studies suggest that athletes undergo greater psycho-physiologic stress during an official match (Haneishi *et al*., 2007; Moreira, McGuigan, Arruda, Freitas, & Aoki, 2012). Organization on the court, technical and physical performances were also significantly different between the FM and OM. A key factor driving the differences between matches, concerning the analyzed team was the requirement to win to advance to playoffs. Thus, tactical functions seemed to be reduced during the FM, with the athletes exhibiting closer distances between them and displaying lesser team coverage area. Simultaneously, distance covered per minute, percentage of the distance covered in medium-intensity running, ball involvement and success in passing were also decreased. These findings suggest interference between team tactical, technical and physical performances in a futsal context. Serrano, Shahidian, Sampaio, & Leite (2013) have already indicated that technical qualities, tactical knowledge and physical capacities are related and conditioned by each other in the context of futsal. Literature has previously reported the likely dependence of team tactics on technical task execution (Bradley *et al*., 2011; Rampinini, Impellizzeri, Castagna, Coutts, & Wisloff, 2009; Williams & Reilly, 2000), physical performance directly interfering in team tactical performance (Moura *et al*., 2013), and physical performance associated with skill-related performance (Carling & Dupont, 2011) of soccer teams. However, future studies involving correlation analyzes are needed to understand the relationship between these variables in a futsal context more accurately.

After a long period of training and competitions, the team exhibited enhanced tactical and technical performances, along with enhanced physical performance. Among these variables, technical performance displayed a greater increase. Observed through ball touches (40%), passes per minute (37.97%), successful passes per minute (39.69%) and correct kicks per minute (20%), while physical performance displayed a maximum improvement of 20.84% (increased time in V3) with team coverage area and spread displaying an increase of 22.53% and 9.74%, respectively. The pronounced technical performance enhancement observed was likely due to the common practice of coaches allocating a great portion of practice time to individual skill training such as passing, kicking and dribbling (Ford, Yates, & Williams, 2010; Ré *et al*., 2014).

When considering OM, technical performance decreased from the first to the second half of the match. Specifically, a decreased number of total passes per minute, possession per minute, and ball touches per minute, along with successful passes per minute. These findings are in agreement with Rampinini *et al*. (2008), who reported decreased numbers of successful short passes, ball involvement and total successful passes during the second half of Italian Series A league soccer matches. Despite our study not investigating futsal match-related fatigue, it is possible to assume that a decrease in skill performance may be related to the establishment of the fatigue process (both, metabolic and neuromuscular) that is well documented in the literature (Castagna *et al*., 2009; Milioni, 2014; Pupo, Detanico, & Santos, 2014). However, except ball touches, Dogramaci *et al*. (2015) reported no significant changes in technical performance match-by-match during a sequence of six consecutive futsal matches. These authors concluded that incremental fatigue did not affect ball skill in futsal. However, the results were not reported between the first and second halves of the matches. The authors also alluded to the necessity of new studies verifying the acute effects on technical performance (Dogramaci *et al*., 2015). Which were addressed by the results presented in the current study by comparing the first and second halves.

It is known that knee joint torque production decreases after a futsal simulation (Pupo, Detanico, & Santos, 2014), suggesting that fatigue could be a factor affecting performance during a futsal match. Furthermore, Milioni *et al*. (2013) reported decreased lower extremity force production along with impairment in electromyography activity of the vastus lateralis muscle after a futsal simulation. Considering that the ability to maintain vigorous muscle contractions during a futsal match is likely associated with performance of technical actions during the game (Gorostiaga *et al*., 2009), the previously reported reduction in rate of force production during futsal practice would be related to a reduction in technical performance.

On the other hand, reduction in physical performance was not observed during the OM in previous studies. Relative distance covered did not change between halves, which is not in agreement with the results observed by Bueno *et al*. (2014) (97.9 and 90.3 m/min) or Barbero-Alvarez *et al*. (2008) (118.4 and 110.5 m/min) in first and second halves, respectively. Castagna *et al*. (2009) also reported that distance covered per minute decreases during the third and fourth quarters of a 4 x 10 minute futsal simulation. Our results related to the maintenance of the percentage of distance covered within the pre-determined velocity bands are also in contrast with previous studies. Distance covered within the "high" velocity band is known to decrease together with an increase in distance covered in the "low" velocity band (Barbero-Alvarez *et al*., 2008; Bueno *et al*., 2014). Nonetheless, our results concerning the kinematic variables of displacement during OM, considering the whole game, are very similar to the findings of Bueno *et al*. (2014). Such as total distance covered (total: 3133.2 m; first half: 1710.6 m; second half: 1635.9 m), and distribution of the percentage of distance covered within the pre-determined velocity bands (V1: 28 and 30.8%; V2: 39 and 38.7%; V3: 16.4 and 15.4%; V4: 8 and 7.5%; V5: 7.6 and 7.2%), for the first and second halves, respectively, who analyzed five official futsal matches of professional Brazilian teams (see Tables 1 and 2).

However, we would like to emphasize that the victory obtained in the OM led to the team's classification to the tournament playoffs (i.e., lead to the quarter-final round). Clemente, Couceiro, Martins, Ivanova, Mendes (2013) showed that in high level soccer competitions, displacement indices (such as total distance covered) are greater in teams that advanced to the playoffs compared with teams that did not advance. Interestingly, another study revealed that over a game, the stability of player and team behavior tends to occur comparing the first and second halves (Duarte *et al*., 2013). Future studies should explore these data during official futsal competitions. When considering the FM, we believe that the reduced game demands (i.e., low intensity) could have influenced the unchanged results between the first and second halves.

Organization on the court, measured by team coverage area and spread, was different between matches but no significant differences were observed between halves. It has been previously reported that the median frequency of the spectral analysis of team coverage area and spread of First Division Brazilian soccer teams are known to decrease (Moura *et al*., 2013). However, futsal displays smaller game team coverage area than soccer (Gorostiaga *et al*., 2009) with unlimited substitutions (Barbero-Alvarez *et al*., 2008; Bueno *et al*., 2014; Castagna *et al*., 2009; Dogramaci *et al*., 2015) and several events that can stop the game clock (Barbero-Alvarez *et al*., 2008; Bueno *et al*., 2014; Gorostiaga *et al*., 2009). Thus, these factors may have contributed to the stability of tactical (i.e. distribution of the athletes on the court) and physical performances observed between halves, mainly the rotation of players observed in the OM (i.e., total of 25 substitutions, 18 during second half), which is a factor suggested to prevent performance drop (Bueno *et al*., 2014; Dogramaci *et al*., 2015).

Future studies should systematically verify whether different numbers of athletes on the court, game score or coaching verbal instructions affect tactical, technical, and physical performances of a team during official and friendly pre-season matches. Also, future studies could focus on correlating variables obtained during pre-season with success during official competitions. In the present study, results of physical, technical, and tactical performances during a futsal friendly pre-season match were reported, variables which have not been previously presented.

Moreover, if future studies report lower performance in FM than OM, as seen in our study, futsal coaches should opt to engage in pre-season tournaments as a way to approximate the pre-season preparatory training to similar competition match demands and the indices obtained in the pre-season cannot be used for the prescription of training sessions. However, the efficacy of such a proposed strategy (i.e. pre-season tournaments) requires further investigation in futsal.

We chose to use a videogrammetry method based on the DVideo automatic tracking system due to its (i) previous use to obtain the trajectories of professional futsal players (Caetano *et al*., 2015; Bueno *et al*., 2014; Milioni, 2014; Moura *et al*., 2011; Vieira *et al*., 2015); (ii) low average error (i.e., uncertainties) related to determination of distances covered in a futsal context (0.8 – 0.93%) verified in our study and others (Bueno *et al*. 2014, Vieira *et al*., 2015) or even in soccer (0.3 – 1.4%) (Barros *et al*., 2007; Misuta, 2009; Moura *et al*., 2012; Moura *et al*., 2013) and (iii) GPS (Global Positioning System) and LPM (Local Position Measurement), alternative approaches which are capable of quickly obtaining and processing the data of players, i.e., physical performance (Buchheit, Allen, Poon, Modonutti, Gregson, & Di Salvo, 2014; Carling *et al*., 2008) to obtain almost the same information. However, there are some limitations in capturing displacements in indoor soccer (i.e. futsal) during competition due to the rules restrictions related to attachment of devices to the body of players and physical characteristics in the environment (e.g. roofs), which promotes interference in signal transmission (Caetano *et al*., 2015).

However, a limitation related to the methodology employed is the lower rate of automatic tracking in futsal scenarios (~50 – 56% of all processed frames) found in both the present and another study (Moura *et al*., 2011), than in soccer (86.1 – 95%) (Barros *et al*., 2007; Figueroa, Leite, & Barros, 2006b; Misuta, 2009; Moura *et al*., 2012; Moura *et al*., 2013). This leads to an increase in processing time due to the substantial amount of manual work performed by the examiner. Similar colors patterns of uniforms, luminosity variations in the environment, higher numbers of mutual occlusions situations and shadows of the players formed on the court surface, are some factors associated with a reduced automatic tracking percentage (for more details, see Misuta, 2009). Many situations of mutual occlusions were verified in both games analyzed (OM and FM).

Conclusions

Based on our results we concluded that the official competition match exhibited characteristics of higher intensity, technical involvement during the game, and tactic exertion when compared with the friendly pre-season match. Thus, the indices obtained in the pre-season cannot be used for the prescription of training sessions. The player's rotation (i.e. large number of substitutions) promotes stability in physical and tactical performances during professional futsal matches near the end of the regular season and playoffs; however, technical performance was likely affected by the high demands of the game. Therefore, the importance given to a match seems to directly influence team performance in a futsal context. Also, physical, technical, and tactical performances are likely to be mutually influenced in this sport. In addition, the use of friendly or simulated matches should be viewed with caution in future research, due to likely underestimate of global performance in this type of events. Furthermore, the conditions related to achieving high automatic tracking percentages need to be evaluated before opting for computational tracing analysis to obtain performance indicators, mainly during FM. Since, a long time is spent analyzing the data which can result in the preseason having already finished.

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