Sports Science

Muscular and cardiorespiratory parameters of Brazilian professional futsal players: comparison between top national and regional level athletes

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Abstract - Aim: To compare muscular and cardiorespiratory parameters between Brazilian professional futsal athletes from different competitive levels (national versus regional). A secondary aim was to explore the correlation of physical fitness variables between both competitive levels. **Methods:** Twenty-two futsal players (24.7 ± 3.7 years), 11 from a regional team and 11 from a national team, were evaluated with countermovement jump test (lower limbs muscle power), square test (the speed with change direction), RSSA (anaerobic power), and YOYOIR1 (aerobic power). Tests were performed in the middle of the season for both teams. **Results:** The speed with change direction ($p = 0.001$) and mean anaerobic power ($p = 0.04$) were higher for national than the regional players. Sprint performance decreased similarly for national and regional level players ($p < 0.001$), but the latter had poorer performance ($p = 0.044$). From the fourth sprint on, sprints for the national level players were slower than the first three, while for the regional level players, each sprint speed was slower than the subsequent. A significant correlation was found between anaerobic power with jump height ($r = -0.50$; $p = 0.01$), speed with change direction ($r=0.65$; $p = 0.001$) and distance covered in the YOYOIR1 ($r = -0.54$; $p = 0.01$). **Conclusion:** National-level athletes were more agile and presented a higher mean anaerobic power than regional ones. Moreover, national-level athletes presented better performance along with repeated sprint tests, maintaining this performance for a longer time during the test.

Keywords: team sport, performance, physiology.

Introduction

Futsal is a team sport characterized by intermittent high-intensity efforts and frequent direction changes, interspersed with recovery periods during the match[1,2]. Studies demonstrated that around 25% of the distance covered by players during official matches is performed > 15.5 km/h[2-4] and remain with values above 85% of the maximal heart rate in 83% of the match time[1]. For this reason, the capacity to perform high-intensity intermittent exercises is crucial for futsal performance[5].

From a physiological perspective, the athlete's performance depends on variables related to metabolic and neuromuscular fitness[5,6]. Thus, understanding the physiological demands of the sport is important to plan the workload and develop specific training for the athletes[7]. During a simulated match (i.e., a performed to represent an official match as to physical and physiological demands, following the sport's official rules), futsal players achieve between 59 and 92% of maximum oxygen consumption (VO_{2max}) and between 84 and 96% of maximum heart rate[8], showing the importance of aerobic power during the match. In addition, during official matches, most sprints happen every 15 to 30 s and last for 3 s[9]. Thus, variables such as the speed with change direction and repeated sprint's ability are essential. Moreover, the lower limbs muscle power may be a key factor for performing displacements in short distances and at high speed[10,11].

In this scenario, studies compared futsal players from different competitive levels[7,12,13]. Makaje et al.[7] compared Thai futsal professional and university players. They found significant differences in distance covered, aerobic power, and repeated sprint tests between groups, with superior results for the professional players. Naser and Ali[12] compared futsal players from three competitive levels (elite, sub-elite, and amateurs) and found differences in 10 and 20 m sprint time (elite versus amateurs), 5 m sprint time, and distance covered in the aerobic power test (elite versus sub-elite versus amateurs). However, they did not observe differences between groups for results in

the countermovement jump. Moreover, Ramos-Campo et al.[13] studied female futsal players of two competitive levels (elite versus sub-elite) and observed differences in speed with change direction, while repeated sprints, countermovement jump, and squat jump presented similar responses between groups.

It should be highlighted that the Brazilian futsal teams (selection and clubs) have an outstanding performance in worldwide championships. Thus, considering the inconsistency among results in the literature and the lack of data from Brazilian futsal players, a gap was found regarding important variables associated with the match performance for these athletes. In addition, to the best of the authors' knowledge, the maintenance of the repeated sprint tests performance has not been investigated in futsal players yet. It is essential to investigate the ability to perform repeated sprints, given the demands of official matches of the sport. Moreover, the studies have usually compared professional versus non-professional players, but not professionals playing at different levels (e.g., regional versus national level). Therefore, the present study aimed to compare muscular and cardiorespiratory parameters between Brazilian professional futsal players at different competitive levels (national versus regional teams). A secondary aim was to correlate physical fitness variables with competitive levels.

Methods

Study design

All players from two Brazilian futsal teams playing at different competitive levels (regional versus national) were compared regarding the physical fitness variables: aerobic power, anaerobic power, the speed with change direction, and lower limbs muscle power. Tests were performed in the middle of the season for both teams.

Participants

The sample comprised of twenty-two Brazilian futsal players (24.7 ± 3.7 years), 11 from a regional team, and 11 from a national team. The regional team played the state-level championship (the Rio Grande do Sul) and finished fourth. Twelve teams participated in the championship, which took place between April and December of 2015, and each team played between 22 and 28 matches. The national-level team played the National Futsal League from April to November 2015 and finished champion. Sixteen teams participated in the championship, and each team played between 30 to 36 matches. Since the team is from the Rio Grande do Sul state, it also played in the regional level championship and won the champion.

Goalkeepers and players who had been injured in the previous 14 days before the tests were excluded from the sample. The Ethics Research Committee from ESEF/UFPEL (43345315.4.0000.5313) approved the study. All participants were informed about the research procedures and signed an Informed Consent Form.

Procedures

Physical fitness was measured by anthropometric measures, lower limbs muscle power, the speed with change direction, anaerobic power, and aerobic power. All tests were performed in September, corresponding to the end of the first phase of the regional championship and half the national competition. Teams were measured within the same week.

In the beginning, body mass and height were measured using a digital scale (Filizola, São Paulo, Brazil) and a portable stadiometer (Sanny, São Paulo, Brazil). Further, all tests were performed on the same day. The order of tests was pre-determined, aiming to minimize fatigue in the following tests. The order of tests was countermovement jump, square test, repeated sprint ability, and Yoyo intermittent recovery level 1. There were rest intervals of at least 5 min after the first test, 5 min after the second test and, and 20 min after the third test. Before starting the tests, the athletes performed a standardized 10 min warm-up.

Countermovement Jump (CMJ). The CMJ was performed to estimate lower limbs muscle power. Each athlete stood up upon the contact platform with both hands in the waist and performed hip and knee flexion up to about 90 degrees at maximum speed, followed by a vertical jump as high as possible. Each participant made three attempts with rest intervals of 30 s. The highest score was considered for analyses. The contact platform (Hidrofit, Belo Horizonte, Brazil) was connected to a computer with software to control and store data (MultiSprintFull).

Square test. This test was used to measure the speed with change direction. The test consists of one square with 4 x 4 m, demarcated using cones. At the beep signal, the athlete should complete the following: 1) the diagonal displacement, 2) the straight-line until the next cone, 3) the diagonal displacement again, and 4) finally, the return in straight-line to the starting point[14]. The participant should move at the greatest speed possible during all courses, touching each cone before changing directions. Each athlete performed two attempts with 1 min rest interval. The shortest time was considered for analyses. A photocell (Hidrofit, Belo Horizonte, Brazil) controlled time positioned next to the cone corresponding to the starting and ending point, connected to a computer with software to control and store data (MultiSprintFull).

Repeated Shuttle Sprint Ability test (RSSA). The RSSA was used to measure the anaerobic power[15]. The test consists of six 40 m sprints (20 + 20m sprints with 180° turns), with a rest interval of 20 s between them. The lowest time ($RSSA_{best}$), the average time of six sprints ($RSSA_{mean}$), and the decrement index ([$RSSA_{mean}$/

[$RSSA_{best}$]×100 - 100) were used for analyses. A photocell (Hidrofit, Belo Horizonte, Brazil) controlled time positioned next to the cone corresponding to the starting and ending point, connected to a computer with software to control and store data (MultiSprintFull).

Yo-yo intermittent recovery level I (YOYOIR1). The YOYOIR1 was used to measure aerobic power. Each participant ran successive 40 m course (20 + 20 m sprints with 180° turns), with controlled speed by a beeping device and with 10 s of rest between each 40 m course[16]. The test was interrupted when the athlete did not complete the 20 m course at the proposed intensity (i.e., twice consecutive beeps at the same stage). The total distance covered was considered for analyses.

Statistics analyses

Data were presented as mean ± standard deviation (SD). Shapiro-Wilk and Levene tests were used to verify data normality and variances. Student's t-test for independent samples was used to compare variables between competitive levels. The effect size was calculated using Cohen's *d*. Values between 0.20-0.30 were considered small, between 0.40-0.70 as a medium, and higher than 0.80 as a large effect size. Two-way ANOVA for repeated measures (sprint as a within-group factor; competitive level as a between-group factor) was used to compare the six sprints performed along with the RSSA test and competitive levels teams with the Bonferroni post hoc test. In addition, values of partial eta squared (η_p^2) were used to identify the effect size for the main factors and interactions. Pearson correlation was used to verify the association between physical fitness variables using the pooled competitive levels. The adopted significance level was $\alpha = 0.05$, and all analyses were processed using SPSS 20.0[17].

Results

Considering the anthropometric measurements, body mass did not present significant difference ($p = 0.38$; $d = 0.56$) between athletes from national (75.1 ± 4.7 kg) and regional (72.5 ± 8.7 kg) level. The same pattern ($p = 0.46$; $d = 0.32$) was shown for height, with values of 174.7 ± 7.2 cm and 177.0 ± 7.2 cm for athletes of national and regional levels, respectively.

Variables of physical performance and comparisons between athletes from the investigated teams are described in Table 1. Superior performances in speed with change direction and anaerobic power were observed in athletes from the national team. On the other hand, no significant differences were verified between competitive levels in CMJ, final distance covered during YOYOIR1, peak anaerobic power, and fatigue index in the RSSA.

Data on the RSSA results are presented in Figure 1. Differences between sprints ($F = 18.68$; $p < 0.001$; $\eta_p^2 = 0.50$) and between competitive levels ($F = 3.33$; $p = 0.044$; $\eta_p^2 = 0.15$) were observed, with significant interaction ($F = 4.67$; $p = 0.017$; $\eta_p^2 = 0.20$). The fifth and the sixth sprints showed an increase in time compared to the second sprint. From the fourth sprint on, sprints for the national level players were slower than the first three, while for the regional level players, each sprint speed was slower than the subsequent.

Table 1 - Physical performance description and comparison between national and regional level futsal athletes (n = 22).

	National (n = 11)	Regional (n = 11)	*d*	p
CMJ (cm)	40.1 ± 3.7	37.9 ± 3.4	0.59	0.16
Speed with change direction (s)	4.9 ± 0.1	5.3 ± 0.2*	3.16	0.001
Distance covered YOYOIR1 (m)	1145.5 ± 288.6	1007.3 ± 347.2	0.48	0.32
$RSSA_{mean}$ (s)	7.21 ± 0.20	7.41 ± 0.20*	1.00	0.04
$RSSA_{peak}$ (s)	6.96 ± 0.23	7.09 ± 0.15	0.57	0.15
$RSSA_{decrement}$ (%)	3.7 ± 1.1	4.5 ± 1.6	0.76	0.18

CMJ: countermovement jump; YOYOIR1: Yo-yo intermittent recovery level 1; RSSA: Repeated Shuttle Sprint Ability; *d*: Effect size Cohen coefficient. *Significant difference from national team $p < 0.05$.

Regarding the correlation coefficient between variables for the pooled analyses (n players = 22), significant relationships were found for mean anaerobic power and final distance covered in YOYOIR1 (Figure 2A), the speed with change direction (Figure 2B), and CMJ (Figure 2C). On the other hand, the CMJ did not present significant correlations with speed with change direction (Figure 2F) and final distance covered in YOYOIR1 (Figure 2D), while the speed with change direction did not

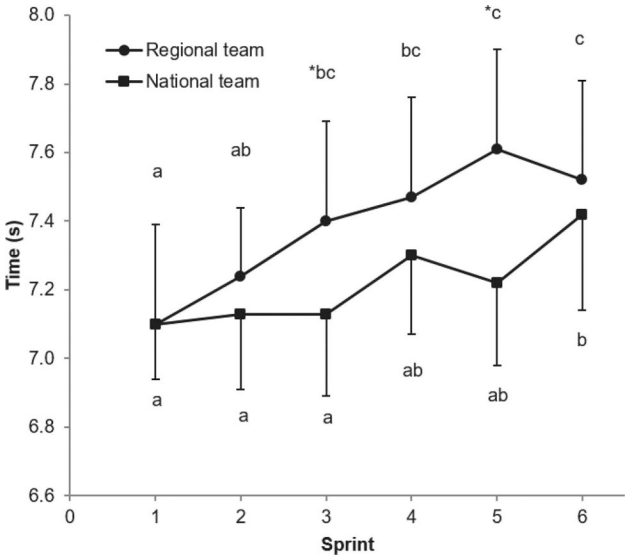

Figure 1 - Comparison of performance at each sprint performed during Repeated Shuttle Sprint Ability test. *Significant difference between teams $p < 0.05$. Letters different indicate significant difference $p < 0.05$.

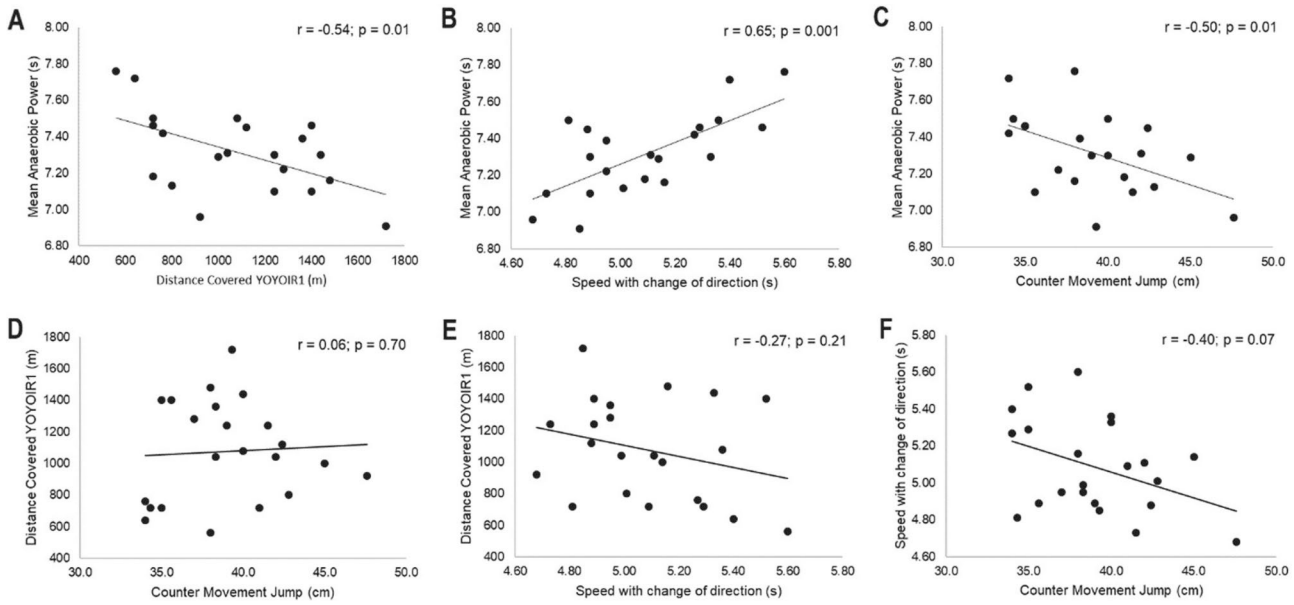

Figure 2 - The relationship between Mean Anaerobic Power ($RSSA_{mean}$) and distance covered in YOYOIR1 (A); $RSSA_{mean}$ and Speed with change direction (B); $RSSA_{mean}$ and Counter Movement Jump (C); distance covered in YOYOIR1 and Counter Movement Jump (D); distance covered in YOYOIR1 and Speed with change direction (E); and Speed with change direction and Counter Movement Jump (F). YOYOIR1: Yoyo Intermittent Recovery Test Level 1.

present a significant correlation with the final distance covered in YOYOIR1 (Figure 2E).

Discussion

The present study compared professional futsal players from different competitive levels on muscular and cardiorespiratory parameters. The main findings indicated greater speed with change direction and anaerobic power at the national than state-level players. The other parameters evaluated presented similar responses between players of both teams. Regarding the performance in the RSSA test, players from the national level team had a decreased performance from the fourth sprint on, while the performance from players of the state-level team deteriorated from sprint one onwards (i.e., an early impairment in the RSSA performance). In addition, significant relationships were found between mean anaerobic power with lower limbs muscle power, the speed with change direction, and aerobic power when considering all pooled athletes.

In the present study, lower limbs muscle power, measured by CMJ, was similar between futsal players from national (40 cm) and regional (38 cm) competitive levels. Similar results were found by Naser and Ali[12], who measured the CMJ height in elite, semi-elite, and amateur futsal players (52 cm, 50 cm, and 47 cm, respectively), and by Nakamura et al.[18], who compared CMJ height between professional and U-20 futsal athletes (39 versus 40 cm, respectively). Ramos-Campo et al.[13] evaluated the same jump test in female futsal players comparing elite and sub-elite players and did not find any difference between groups (27 versus 24 cm, respectively). The similarity in these results may be explained by the lack of specificity in the CMJ for the futsal sport since athletes practically do not perform jumps in matches. Thus, this test may present a low sensibility and do not discriminate the lower limbs muscle power performance in this group of athletes.

Regarding the aerobic power, measured using the YOYOIR1 test, differences between regional (1007 m) and national (1145 m) players were not statistically significant, in contrast with the literature. Naser and Ali[12] compared athletes from New Zealand at the same competitive level to those evaluated in the present study, including also amateur players, in a specific aerobic power test for the sport. The authors observed increased distances covered in the test for national team athletes compared to the others (national: 1378 m, regional: 1018 m, and amateur: 782 m). These differences found between Naser and Ali[12] and the present study may be related to the protocols used to determine aerobic power since a greater recovery time between courses was used in FIET (10 to 30 s) than YOYOIR1 (10 s). In addition, Makaje et al.[7] found significant differences between Thai high-level professional and university athletes for aerobic power (1558 m versus 1203 m, respectively). However, in contrast to the present study, the authors used the YOYOIR2 test, which starts at a higher intensity, with the athletes completing the test in a shorter time, which could underestimate VO_{2max} values. Using the same test of the present study (YOYOIR1), Nakamura et al.[18] compared adult and professional U-20

players and found better performance for the adults (1507 m versus 1264 m, respectively). It is possible that the difference between this result and the present one may be related to the period of evaluation because Nakamura et al.[18] evaluated athletes in pre-season, while the present in the middle of the competitive period. We believe that the similar YOYOIR1 performance between national and regional levels observed in the present study is related to the fact that aerobic power is a fundamental parameter for futsal players regardless of the competitive level[19].

Regarding anaerobic power, measured by the RSSA test, only the meantime had a significant difference between groups. These findings may have occurred because the players started at a similar point; nevertheless, throughout the sprints, the sprint time increase seems to be higher in the regional competitive level players (Figure 1), influencing this outcome (i.e., RSSA meantime). Our data partially corroborate the findings from Makaje et al.[7], which observed differences between professional and university athletes for all variables related to anaerobic power (mean power, peak power, and fatigue index). The competitive level of the athletes might explain the difference in the findings of the study. The demand level of the futsal sport is possibly shorter for university athletes, mainly linked to training load, since professional athletes have higher volume and intensity of training than amateurs; consequently, they present higher physical fitness levels. Ramos-Campo et al.[13] compared anaerobic power in female futsal athletes from the first and second national divisions of Spain and found similar values between them, contrasting with findings of the current study. Such divergences may be related to the fact that female futsal is still an ascending sport and did not achieve the same level of professionalism as male futsal athletes, not only for weekly frequency but also for training loads.

The present investigation is the pioneer to determine fatigue along with six sprints and between teams during RSSA. It was observed that the national team kept the level of performance for a longer time during the test (from first to the fourth sprint), while the regional team presented a performance drop in each sprint performed during the test (Figure 1). This response is probably attributed to the high competitive level elicited from national team players. Caetano et al.[9] evaluated professional players during five official futsal matches from the National Brazilian league and observed that most of the sprints performed during the matches occurred with intervals between 15 and 30 s, highlighting the importance of repeated sprint ability for these athletes.

The speed with change direction results, measured by the square test, revealed significant differences between teams (regional and national). These findings corroborate Ramos-Campo et al.[13] results, which found better results in the speed with change direction test for the elite than the second division female futsal athletes. Ré and Correa[20] compared U-17 athletes who participated in national and school competitions and did not find any significant difference in speed with the change direction test without the ball. Nevertheless, these authors found significant differences for the test performed with the ball, with better results for the U-17 athletes with higher competitive levels (i.e., national competitions). On the other hand, Nakamura et al.[18] evaluated this variable between adults and U-20 athletes using a speed test with the change of direction and observed better performance for the U-20 group. Such differences observed between outcomes studies may be attributed to age, since both adults and U-20 athletes have the same competitive level, while in the present study, age was similar between teams, which differed in the competitive level. Present results may be related to a higher number of matches played by the national team during the season and the adaptation induced by this exposure since athletes perform several high-speed direction changes during the matches[21]. However, the speed with the change of direction also may be determinant to the players reaching high-level futsal teams.

According to the correlation coefficient observed ($r = -0.54$), it may be inferred that higher anaerobic fitness was associated with higher aerobic power (i.e. shorter sprint time and longer distance covered). These results corroborate with Dupont et al.[22], who observed a relationship between the better sum of time of 15 sprints ($r = 0.80$; $p = 0.001$) and better oxygen consumption (VO_2) kinetic, as well as better fatigue index was associated to better VO_2 kinetic ($r = 0.80$; $p = 0.001$) and higher VO_{2max} ($r = 0.71$; $p < 0.05$) in soccer players. Recently, this information was reinforced by Dupont et al.[23] study, which demonstrated association between fatigue index with VO_2 kinetic ($r = 0.85$; $p < 0.001$) and peak VO_2 ($r = -0.83$; $p < 0.001$) in amateur soccer players. Such similarities between findings from literature and the present study may be explained considering that a higher aerobic power may allow a better recovery between sprints, enabling athletes to repeat them with lower fatigue[24,25].

The mean anaerobic power also showed association with vertical jump, corroborating with the findings by Ribeiro et al.[26]. This study indicated a relationship between triple jumps performance and repeated sprint tests performance (composed by six sprints), specifically with the second ($r = -0.58$; $p = 0.01$), third ($r = -0.57$; $p = 0.01$), fifth ($r = -0.50$; $p = 0.04$), and sixth sprints ($r = -0.68$; $p = 0.001$), as well as the relative mean power ($r = 0.57$; $p = 0.01$). Probably these findings occur because both the parameters depend of the use of the elastic energy of the stretch-shortening cycle[27].

Some limitations of the current study must be taken into consideration when interpreting the findings. First, there was no control of training loads applied to the athletes throughout the season. Second, we evaluated both teams only once in the season. Multiple evaluations along

the season could indicate different results. Moreover, lean and fat mass was not measured, and they may influence the results. Additional evaluations were not allowed by the coaching staff due to a high number of professional commitments. However, as a strength of the study, both teams were evaluated in the same season period to minimize possible issues. In addition, the sample was composed of professional athletes with high performance in the respective competitive levels (i.e., regional-level in the fourth position; national-level in the first position).

Conclusion

National level athletes were faster to change direction and presented a higher mean anaerobic power than the regional ones. In addition, national-level athletes presented better performance during repeated sprint tests, maintaining this performance for a longer time during the test.

As practical applications, these findings suggest that anaerobic power and speed with the change of direction should be more focused at training sessions for professional futsal players in order to increase the ability since their role may be determinant to achieve high competitive levels.

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