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Total and regional body composition are related with aerobic fitness performance in elite futsal players

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ABSTRACT

Body composition (i.e., fat and lean mass profile) has been related to aerobic performance, an essential capacity for futsal athletes. The present study aimed to verify the relationship between total and regional body composition (percentage of fat and lean mass) with aerobic performance in elite futsal players. Male professional futsal athletes ($n = 44$) from two Brazilian National Futsal League teams and athletes representing the National team participated in this study. Body composition was evaluated using DXA (Dual-Energy X-ray Absorptiometry) and aerobic fitness by ergospirometry. There was a negative ($p < 0.05$) correlation between maximum oxygen uptake and maximal velocity reached with total body ($r = -0.53$; $r = -0.58$), trunk ($r = -0.52$; $r = -0.56$) and lower-limb ($r = -0.46$; $r = -0.55$) fat mass percentage. Lower-limb lean mass percentage had a positive ($p < 0.05$) correlation with maximum oxygen uptake ($r = 0.46$) and maximal velocity ($r = 0.55$). In conclusion, total and regional body composition present a relationship with aerobic performance in professional futsal players.

1. Introduction

Futsal involves high-intensity fast efforts as sprinting, high-intensity running, accelerations and changes of direction, interspersed with running at medium and low-intensity, which characterizes the sport as intermittent and stochastic (Spyrou et al., 2020; Taylor et al., 2017). During a match, each player performs sprints lasting 1–3 s, with some repeated-sprint sequences with an interval of <15 s (Caetano et al., 2015; Taylor et al., 2017). Additionally, most of the playing time is performed at a high intensity (~85% of maximum heart rate or ~80% of maximal oxygen uptake) (Barbero-Alvarez et al., 2008; Spyrou et al., 2020). This scenario requires the athletes to have a high aerobic fitness capacity (Castagna et al., 2009; Makaje et al., 2012; Mohr et al., 2003; Spyrou et al., 2020).

In sports like soccer and futsal, aerobic fitness is preferentially assessed by ergospirometry, providing maximum oxygen uptake, maximal velocity and ventilatory thresholds (Álvarez et al., 2009; Baroni and Leal Junior, 2010; Castagna et al., 2009; Pedro et al., 2013). Previous studies have shown that professional athletes have superior aerobic fitness than non-professional futsal players (Álvarez et al., 2009; Makaje et al., 2012; Pedro et al., 2013). Also, high aerobic fitness is negatively correlated with training sessions perceived exertion (Milanez et al., 2011). Strategies to improve aerobic performance are essential aims of team staff. Thus, it is vital to identify parameters (negatively and positively) associated with high-level physical capacities to optimize performance.

Body composition (i.e., percentage of fat and lean body mass) is usually related to aerobic and neuromuscular athletes' performance (Barbieri et al., 2017; Hamano et al., 2015; Högström et al., 2012; Nikolaidis et al., 2019; Sekulic et al., 2020, 2021). In intermittent and stochastic sports like futsal, excessive body fat mass is an extra non-productive mass, impacting the initiation of movements, accelerations, and speeds achieved. On the other hand, a greater amount of lean mass can be decisive for achieving greater muscle strength, velocity and power. Thus, it is important that this parameter is assessed with high-quality to provide relevant and accurate information to the coaching staff. A growing number of studies have used the Dual-Energy X-ray Absorptiometry method (DXA) to assess body composition profile in sports (Bilsborough et al., 2014; Hind et al., 2018; Munguia-Izquierdo et al., 2018; Sanfilippo et al., 2019), which is a valid technique when

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compared to magnetic resonance imaging (Borga et al., 2018). Assessments with DXA are especially advantageous due to the short time spent assessing total and regional (e.g., trunk and lower limbs) fat and lean mass.

Only one study verified the relationship between body composition with aerobic performance in futsal players. Nikolaidis et al. (2019) found no significant relationship between total body fat mass assessed by skinfolds and shuttle run test in professional futsal athletes. It has recently been demonstrated in professional soccer athletes that although fat mass by skinfolds and DXA are significantly correlated, the correlation's magnitude depends on the skinfold equations adopted (Suarez-Arrones et al., 2018). Nonetheless, the impact of the regional lower-limb fat and lean mass using a more accurate assessment on futsal performance has not been investigated. Evaluation of aerobic performance and body composition using more accurate methods will provide a better understanding of the impact of body composition on the performance of elite futsal athletes.

To the authors' knowledge, there are no studies assessing global and regional body composition parameters by using DXA in elite futsal players, as well as total and regional fat and lean mass relationship with aerobic fitness in this population. Additionally, it is essential to note that futsal players performance parameters in the literature are mainly obtained with young athletes (Álvarez et al., 2009; Baroni and Leal Junior, 2010; Castagna et al., 2009; Makaje et al., 2012; Milanez et al., 2011; Pedro et al., 2013), and they may not represent the current age and physical capacity of players in elite Leagues and National teams. The present study aimed to verify the relationship between total and regional fat and lean body mass assessed by DXA with aerobic fitness performance in elite futsal players.

2. Methods

2.1. Study design

Initially, a researcher contacted the technical staff involved with the professional athletes to present and explain the aims of the study. After participation acceptance by all of those involved (committee and athletes), the evaluations were scheduled. The local Institutional Ethics Committee approved all procedures performed in this study (approval number 2.903.811). Participants were informed of the objectives, risks and benefits of the study before signing an informed consent form. Assessments took place in just one day, starting with DXA followed by aerobic fitness performance, and were performed between January–February 2020. The sample size was determined by convenience as the present study is part of a larger project where we evaluate futsal players of different teams.

2.2. Participants

Forty-four male elite professional futsal players from three different groups participated in this study. Participants were professional athletes from two Brazilian National Futsal League teams and athletes representing a National team. The National team sample was composed of athletes who were playing in seven teams from 3 different countries (Brazil, Spain, Portugal) at the time of the study conduction. Most of the players were in the pre-season period, while nine athletes were in the mid-season period (European calendar). The participants were free of musculoskeletal injuries. Brazilian National Futsal League teams traveled from their home cities to the laboratory (90–105 min by bus to Porto Alegre city) on the evaluation days. The athletes of the national team arrived in Porto Alegre from Europe and other Brazilian states the day before the evaluations.

2.3. Body composition

Body composition was evaluated using DXA (software enCORE version 14.1, Prodigy Primo, GE Healthcare, USA). The equipment was calibrated before evaluations according to the manufacturers' specifications. According to previous recommendations, the same analysis pattern was followed for all participants (Machado et al., 2022; Nana et al., 2015). Participants wore training uniforms and removed metal accessories. The participants were placed in a prone position, aligned and centered on the examination table with hips and shoulders extended and hands in a neutral position to start scanning. Fat mass percentage of total body mass and trunk were evaluated. For lower-limbs, absolute and percentage values of fat and lean mass were accessed. Parameters are presented without considering bone tissue. The same experienced evaluator conducted the assessments.

2.4. Aerobic fitness performance

Maximum oxygen uptake (VO_2max) and maximum heart rate (HRmax) were determined through an incremental running test on a treadmill (Inbramed, REAB 01). The warm-up consisted of 5 min at 8 km h^{-1}. The slope was kept constant at 1% until the end of the test. Stage 1 started at the same warm-up velocity for 1 min; then, the velocity was increased by 1 km h^{-1} every minute until volitional exhaustion (Álvarez et al., 2009; Castagna et al., 2009). The pulmonary gas exchange was measured continuously, breath-by-breath, using an open-circuit spirometry system (Quark CPET, Cosmed Italy) previously calibrated according to the manufacturer's instructions. Heart rate was recorded every 15-s using a short-range telemetry system (RS800, Polar Electro Oy, Finland). In order to be considered a maximum effort test, players must have attained at least two of the following criteria: (1) age-predicted HRmax (220-age); (2) respiratory exchange ratio (RER) $\geq$1.1; (3) VO_2 plateau despite increasing treadmill velocity (<150 mL/min increased between last two levels); (3) clear muscle fatigue signals, as motor coordination loss. HRmax was considered the highest value in the last stage of the test, and VO_2max was identified as the highest VO_2 value in a tendency line plotted against the time (Howley et al., 1995). Finally, ventilatory thresholds (VT1 and VT2) were also assessed (Wasserman et al., 1973). The same experienced evaluator conducted the assessments.

2.5. Statistical analysis

Data normality was assessed using the Shapiro-Wilk test, and descriptive values are shown as mean ± SD and range (minimum-maximum). The correlations between body composition and aerobic fitness capacity parameters were verified with Pearson (r) and Spearman (r_s) tests, according to the distribution of the outcomes. For correlation value classification, we adopted trivial ($r = \leq 0.1$), small ($r = 0.1 < r \leq 0.3$), moderate ($r = 0.3 < r \leq 0.5$), large ($r = 0.5 < r \leq 0.7$), very large ($r = 0.7 < r \leq 0.9$), nearly perfect ($r = > 0.9$) and perfect ($r = 1$) (Cohen, 1998). The level of significance (α) was set at <0.05. All statistical procedures were performed using the Statistical Package for Social Science (SPSS) version 23.0 (IBM SPSS Inc., Chicago, IL, USA).

3. Results

All players, outfield players and specific positions athletes' characteristics are presented in Table 1. One athlete reported discomfort in the posterior thigh (hamstring muscle) and, for precaution, interrupted the aerobic fitness test at 20 km h^{-1}, with maximal performance at this speed adopted for the analyses. Secondary aerobic fitness characteristics (e.g., heart rate) are presented in a supplementary file (Table S1). Body composition and aerobic fitness quartiles are shown in a supplementary file (Table S2).

Table 2 presents the results of the correlation analysis. Total body mass, body mass index, fat mass percentage of the total mass, trunk and lower-limb, as well as the lower-limb fat and lean mass amount tissue showed a significant negative correlation with maximum oxygen uptake

Table 1
General and specific futsal players' characteristics and aerobic fitness performance (n = 44; Mean ± SD; minimum to maximum).

	All players (n = 44)	Outfield players (n = 36)	Goalkeeper (n = 8)	Defender (n = 8)	Winger (n = 20)	Pivot (n = 8)
Age (years)	29.2 ± 5.8	29.1 ± 5.7	29.2 ± 6.7 (18–36)	31.1 ± 7.0 (20–40)	28.4 ± 5.4 (20–40)	29.0 ± 5.5 (20–37)
Height (cm)	176.8 ± 4.8	177.0 ± 4.8	176.1 ± 4.9 (168–182)	181.0 ± 4.4 (174–186)	174.5 ± 3.3 (165–178)	179.2 ± 4.9 (171–186)
Body mass (kg)	76.5 ± 8.4	75.8 ± 7.6	79.8 ± 11.1 (58.0–90.7)	80.8 ± 5.6 (73.0–88.8)	71.7 ± 6.4 (58.8–83.0)	81.2 ± 6.3 (71.8–88.3)
Body mass index (kg/m^2)	24.4 ± 2.1	24.2 ± 1.9	25.6 ± 2.5 (20.5–28.3)	24.7 ± 2.1 (21.1–26.5)	23.5 ± 1.7 (19.4–26.2)	25.3 ± 1.6 (23.2–28.2)
Total body fat mass (%)	17.7 ± 3.9	17.2 ± 3.7	19.9 ± 3.9 (13.9–25.0)	18.3 ± 4.7 (12.9–24.9)	16.5 ± 3.1 (11.7–21.3)	18.0 ± 4.4 (10.2–23.7)
Trunk fat mass (%)	17.8 ± 5.1	17.3 ± 4.9	20.5 ± 5.2 (14.5–30.5)	18.8 ± 6.1 (12.0–28.0)	16.4 ± 4.1 (9.5–24.8)	18.0 ± 5.7 (8.6–24.6)
Lower-limb fat mass (%)	17.5 ± 3.8	17.0 ± 3.5	19.7 ± 4.7 (12.1–28.7)	17.9 ± 4.1 (13.1–23.7)	16.3 ± 2.9 (11.1–21.4)	17.8 ± 4.3 (9.7–23.4)
Lower-limb lean mass (%)	82.5 ± 3.8	83.0 ± 3.5	80.3 ± 4.7 (71.2–87.9)	82.1 ± 4.1 (76.3–86.9)	83.7 ± 2.9 (78.6–88.9)	82.2 ± 4.3 (76.6–90.3)
Lower-limb fat mass (kg)	4.6 ± 1.4	4.4 ± 1.2	5.5 ± 1.8 (3.5–9.0)	4.9 ± 1.2 (6.4–3.3)	3.9 ± 0.9 (2.2–5.6)	5.0 ± 1.5 (2.7–7.3)
Lower-limb lean mass (kg)	21.4 ± 2.4	21.2 ± 2.2	22.3 ± 3.1 (16.4–25.3)	22.2 ± 1.2 (21.0–23.8)	20.1 ± 1.8 (17.1–24.1)	23.0 ± 2.4 (19.9–26.6)
VO_2max (ml.kg.min-^{1})	58.2 ± 6.2	59.2 ± 6.2	53.8 ± 4.7 (46.3–60.2)	55.1 ± 6.8 (45.2–68.2)	60.6 ± 5.4 (51.2–74.7)	59.7 ± 6.4 (47.6–66.9)
Maximal speed (km.h-^{1})	17.9 ± 1.4	18.2 ± 1.4	16.7 ± 0.9 (15.0–18.0)	17.2 ± 1.0 (16–19)	18.7 ± 1.1 (16–20)	18.0 ± 1.7 (15–21)

VO_2max.:maximal oxygen uptake; %: percentage values.

Table 2
Correlations values between body composition with aerobic fitness (n = 44).

	VO2max (ml.kg.min-^{1}); r	Maximal speed (km.h-^{1}); r_s
Age (years)	−0.27	−0.27
Body mass (kg)	−0.47**	−0.41**
Body mass index (kg/m^2)	−0.47**	−0.45**
Total body fat mass (%)	−0.53**	−0.58**
Trunk fat mass (%)	−0.52**	−0.56**
Lower-limb fat mass (%)	−0.46**	−0.55**
Lower-limb lean mass (%)	0.46**	0.55**
Lower-limb fat mass amount (kg)	−0.54**	−0.56**
Lower-limb lean mass amount (kg)	−0.32*	−0.30*

VO_2max.: maximal oxygen uptake; %: percentage values; *$p < 0.05$; **$p < 0.01$. Pearson (r) was used to correlate VO2max with body composition and Spearman (ρ) was used to correlate maximal speed with body composition.

(r = −0.32 to −0.54), maximal velocity (r = −0.30 to −0.58) and second ventilatory threshold (r = −0.39 to −0.49). Lower-limb lean mass percentage showed significant positive correlations with maximum oxygen uptake, maximal velocity reached and second ventilatory threshold (r = 0.49 to 0.56). The relationship data between body composition parameters with maximum oxygen uptake and maximal speed are shown in Figs. 1 and 2, respectively. The results of secondary correlation analyses are presented in a supplementary file (Table S3).

4. Discussion

The main findings of the present study were that aerobic fitness performance was a) negatively correlated to the total body, trunk, and lower-limb fat mass percentage, and b) in contrast, positively correlated with the lower-limb lean mass percentage. Based on the present results, it can be inferred that the global and regional body composition profile is related to the aerobic performance in elite futsal athletes.

High aerobic fitness has been demonstrated to be an essential condition for elite futsal players. Previous studies have shown that athletes of higher competitive levels have greater maximum oxygen uptake and maximal aerobic speed than players from lower categories (Álvarez et al., 2009; Makaje et al., 2012; Pedro et al., 2013). Additionally, high aerobic fitness can provide support to the high-intensity activities during a match (Barbero-Alvarez et al., 2008) and is associated with a lower magnitude of perceived exertion during futsal training sessions (Milanez et al., 2011).

Similar to our findings, previous studies have shown a relationship between body composition with aerobic performance in athletes of different modalities (Barbieri et al., 2017; Hamano et al., 2015; Högström et al., 2012). Contrary to our results, Nikolaidis et al. (2019) found no significant relationship between total body fat mass and aerobic performance in futsal athletes. The discrepancy between Nikolaidis et al. (2019) and the current results might be attributed to different methods of assessment used (skinfolds and 20 m shuttle run test vs. DXA and ergospirometry). DXA is a two-dimensional indirect technique used to evaluate bone, fat and lean tissues by dual-energy X-ray emission, while fat mass % by skinfold is an equation-dependent double-indirect measure. Also, ergospirometry is considered the gold-standard method for aerobic fitness assessments. Nevertheless, it is important to note that DXA and ergospirometry are more precise and expensive assessment methods than skinfolds and field aerobic fitness tests, which are less expensive. Additionally, Suarez-Arrones et al. (2018) recently demonstrated in professional soccer athletes that, although the fat mass by skinfolds and DXA were significantly correlated, the magnitude of the correlation is dependent on the skinfold equation adopted. We speculate that the same might occur with professional futsal athletes, thus it is possible that the lack of relationship reported previously by Nikolaidis et al. (2019) is due to the equation used.

To our knowledge, the present study is the first to demonstrate the relationship between body composition profile assessed by DXA and aerobic performance assessed by the gold standard method in elite futsal athletes (i.e., ergospirometry). It is important to note that previous studies with aerobic performance in futsal athletes involved younger samples aging between 22.8 ± 1.5 and 24.2 ± 5.0 years old (Álvarez et al., 2009; Baroni and Leal Junior, 2010; Castagna et al., 2009; Makaje et al., 2012; Milanez et al., 2011; Pedro et al., 2013). This age condition may not reflect the characteristics of elite futsal teams as our three groups aged between 27.5 ± 7.6 years and 28.7 ± 5.9 years old in the Brazilian National Futsal League teams, and 29.3 ± 4.2 years old in the National team. Thus, the current participants' data characteristics may also be helpful as a comparative reference for coaching staff and teams composed of older athletes. Importantly, although investigating more advanced ages, our results for maximal oxygen consumption (all: 58.2 ± 6.2; outfield: 59.2 ± 6.2; goalkeeper: 53.8 ± 4.7) are similar to the

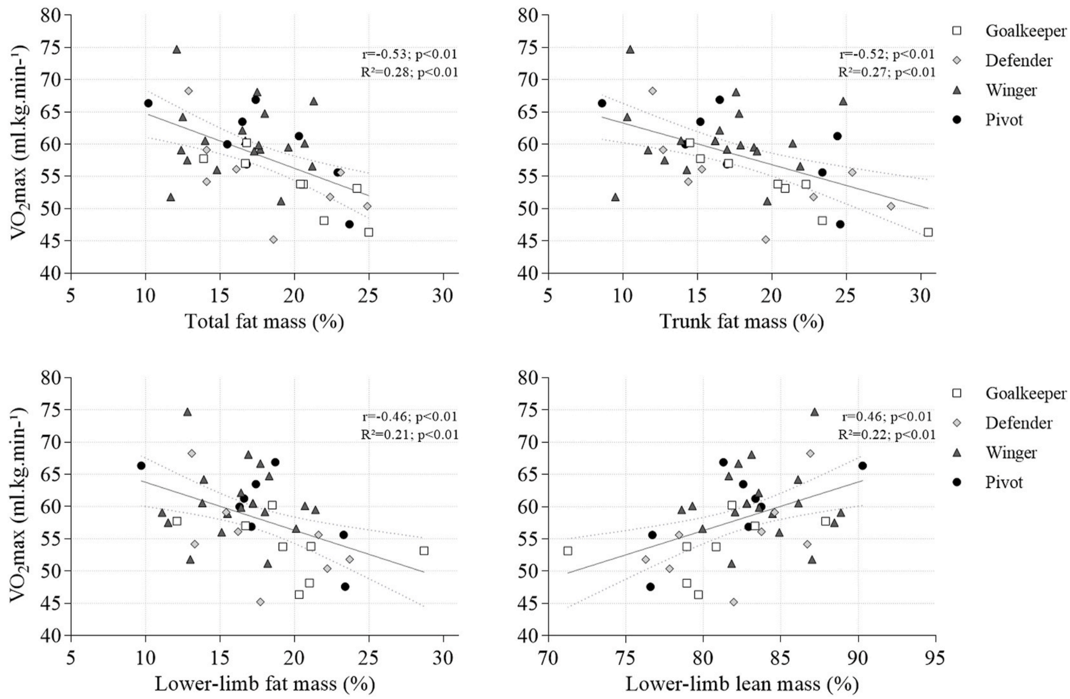

Fig. 1. Relationship between total body, trunk and lower-limb fat mass (%) and lower-limb lean mass (%) with maximum oxygen uptake (VO_2max).

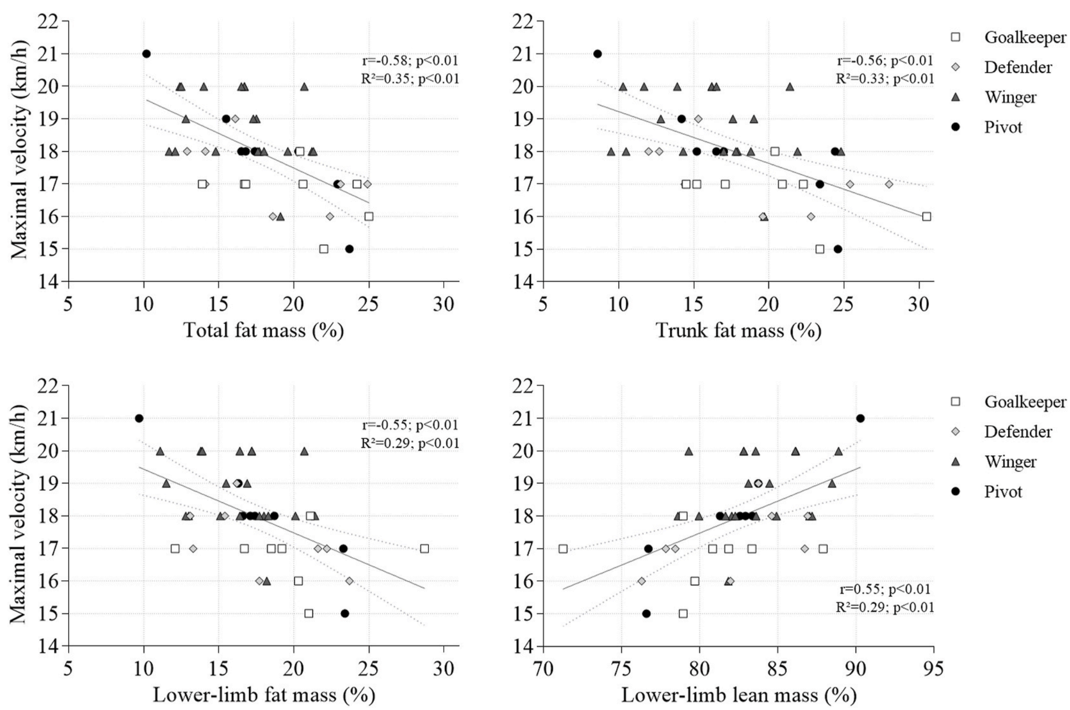

Fig. 2. Relationship total body, trunk and lower-limb fat mass (%) and lower-limb lean mass (%) with maximal velocity reached at aerobic fitness test.

findings of Baroni and Leal Junior (2010) (outfield: 58.0 ± 6.4; goalkeeper: 50.6 ± 6.4; 5.2), Makaje et al. (2012) (outfield: 60.4 ± 5.1; goalkeeper: 54.6 ± 5.7) and Milanez et al. (2011) (59.6 ± 2.5) using younger professional futsal players.

We emphasize that the number of players evaluated and the reduced number of tests conducted may be relevant limitations of the present study. Due to the COVID-19 pandemic in Brazil, we had limitations to recruit more players and perform further assessments. We believe that the investigation of athletes' functional performance using parameters such as sprints, jumping, maximum muscle strength and rate of torque development could help to understand the impact of body composition profile on neuromuscular performance. Nonetheless, our study is the first to demonstrate the relationship between global and regional body composition with aerobic performance in elite professional athletes.

5. Practical application

The present study reinforces the need for interventions to improve body composition profile (i.e., higher lean mass and low-fat mass percentages) in professional futsal athletes. Body composition can be decisive for weight-bearing sports like futsal since an athlete constantly needs to perform actions against the inertia caused by the total body mass. Excessive fat mass can be understood as an extra non-productive mass, while lean mass as a productive tissue. Thus, besides the possibility of not contributing to performance, an excess of fat tissue makes athletes' actions more difficult. Considering the intermittent and stochastic nature of futsal, the quantity of fat mass impacts each frequent action during the game, such as accelerations, changes of direction, high-intensity running and sprints. Meanwhile, a greater proportion of muscle tissue can be fundamental as it means less fat mass and more tissue that contributes to the generation of muscle strength, velocity and muscle power, as well as oxygen uptake capacity.

6. Conclusion

We observed that the body composition profile accessed by DXA is related to aerobic fitness performance verified by ergospirometry in elite futsal athletes. Total body, trunk, and lower-limb fat mass have a negative relationship with the aerobic performance parameters, while lower-limb lean mass percentage a positive correlation with aerobic fitness.

CRediT authorship contribution statement

Carlos Leonardo Figueiredo Machado: Methodology, Data curation, Formal analysis, Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Fábio Yuzo Nakamura:** Conceptualization, Writing – review and editing. **Marcos Xavier de Andrade:** Data curation, Investigation, Writing – review & editing. **Gabriela Cristina dos Santos:** Data curation, Investigation, Writing – review & editing. **Rodrigo Carlet:** Data curation, Investigation, Writing – review & editing. **Clarissa Muller Brusco:** Data curation, Investigation, Writing – review & editing. **Rogério da Cunha Voser:** Methodology, Project administration, Writing – review & editing. **Ronei Silveira Pinto:** Methodology, Conceptualization, Project administration, Writing – review & editing.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbmt.2023.04.030.

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