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The relationship between lower-limb body composition with isokinetic performance in futsal players: Body composition and performance in futsal players

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HIGHLIGHTS

- Absolute lean and fat mass (kg) are related to knee extension-flexion strength.
- Relative lean and fat mass (%) present no relationship with knee extension-flexion strength.

ABBREVIATIONS

DXA	Dual-Energy X-ray Absorptiometry
H:Q	hamstrings-to-quadriceps ratios
KE	Knee extension
KF	Knee flexion
Kg	Total amount (absolute)
PT	Peak torque
%	Percentage (relative)

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BACKGROUND: Optimal neuromuscular performance is essential for futsal athletes and it has been linked to body composition.
AIM: The present study aimed to verify the relationship between absolute (total amount; kg) and relative (percentage; %) lower-limb and thigh lean and fat mass with isometric and dynamic maximal strength in professional futsal players.
METHOD: Sixteen male elite futsal athletes participated in this study. Unilateral lower-limb and thigh lean and fat mass were evaluated using DXA (Dual-Energy X-ray Absorptiometry) and strength performance using unilateral isokinetic concentric-eccentric knee extension (KE) and flexion (KF) peak torque (PT), KE and KF isometric PT at 30° and 70°, and hamstrings-to-quadriceps ratios (H:Q).
RESULTS: Unilateral lower-limb lean mass amount showed a significant positive correlation with concentric and isometric KE PT (60°/s: r=0.58; 30°: r=0.55; 70°: r=0.65), and with concentric (60°/s: r=0.61), eccentric (60°/s: r=0.67) and isometric (30°: r=0.79; 70°: r=0.70) KF PT. No significant relationship between lower-limb lean and fat mass percentage with isokinetic performance was verified. Thigh lean mass amount had a significant positive correlation with concentric and isometric KE PT (60°/s: r=0.52; 30°: r=0.51; 70°: r=0.84) and also with concentric (60°/s: r=0.75) and eccentric KF PT (60°/s: r=0.54), while thigh fat mass amount was only associated with eccentric KF PT (r=0.54). No significant correlation between lower-limb and thigh body composition with H:Q ratios was observed.
CONCLUSION: In conclusion, contrary to the relative (%) values, absolute (kg) lower-limb and thigh fat and lean mass present a significant correlation with dynamic and isometric KE and KF performance in futsal players.

KEYWORDS: Indoor soccer | Indoor football | Team sports | Muscle strength | Peak torque | Muscle imbalance

INTRODUCTION

Futsal involves high-intensity explosive efforts such as sprinting, accelerations, and change of direction [1,2]. These characteristics have been identified to contribute to the injuries in intermittent sports. During the pre-season, futsal athletes are especially affected by lower-limb injuries (92%), and 39% of these injuries occur in the thigh and knee regions [3]. Therefore, the assessment of injury risk factors for the lower-limb has been part of the futsal teams' routine during the pre-season period.

During high-speed running, the quadriceps muscle acts concentrically to extend the knee during the late swing phase of the gait cycle, while the hamstring works eccentrically to decelerate the knee extension (KE) and promote joint stability. Thus, a good relationship between the performance of the knee flexors (KF) and KE (i.e., hamstrings-to-quadriceps ratio [H:Q]) has been proposed as a protective factor against injuries as anterior cruciate ligament [4,5]. Additionally, high levels of eccentric muscle strength are essential for tolerating large stretching loads in sports demands and protecting against hamstring strain injury [6].

Isokinetic assessment has been used to identify possible injury risk factors for the lower-limb in athletes. This method allows assessing maximum isometric, concentric and eccentric capacities of KF ad KE, as well as conventional (concentric/concentric) and functional (eccentric/concentric) H:Q ratios profile [4,7]. These parameters can guide specific interventions to increase performance and injury prevention programs. Thus, it is also important to know the underlying factors (negative and positive) to these results.

Body composition seems to be related to neuromuscular performance. Previous studies have observed a negative correlation between total body fat mass with jump and sprint performance in futsal players [8–10]. The proportion of fat and lean mass can impact muscle performance as it is expected that individuals with greater lean mass will have better muscle strength performance than those with lower lean mass or greater proportion of fat mass. However, how the regional body composition profile (i.e., lower-limb and thigh lean and fat mass) impacts maximal KE and KF performance in futsal athletes remains unknown. Also, although previous researchers have investigated concentric and eccentric peak torque (PT) and H:Q ratios profiles in futsal players [11,12], they did not investigate the impact of body composition in these parameters.

The knowledge regarding the association between fat and lean mass with parameters of muscle performance in futsal players can help to understand the importance of body composition parameters to optimize performance. The present study aimed to verify the relationship between absolute (total amount; kg) and relative (percentage; %) lower-limb and thigh fat and lean mass assessed by DXA with maximum concentric and eccentric KF and KE PT and H:Q ratios in elite futsal players.

METHODS

Participants

Sixteen male professional futsal players participated in this study. Participants were professional athletes from one Brazilian National Futsal League team and were free of musculoskeletal injuries. Evaluations were conducted in one visit during the pre-season period (February 2020). The local Institutional Ethics Committee (UFRGS Research Ethics Committee) approved all procedures performed in this study. Participants were informed of the studys' objectives, risks, and benefits, and a signed consent form was given by all participants. Body composition assessment occurs firstly, followed by isokinetic measurements.

Body Composition

Athletes' body composition was assessed using Dual-Energy X-ray Absorptiometry (DXA) (software enCORE version 14.1, Prodigy Primo, GE Healthcare. Chicago, Illinois, EUA) (Figure 1). The total body fat mass percentage was used to characterize the participants'. Individual lower-limbs (left [n=16] + right [n=16]) fat and lean mass values (absolute [kg] and relative [%]) were assessed and used for correlations with individual right (n=16) and left (n=16) isokinetic performance. Participants' right thigh images (n=16) were analyzed using manual boxes and related to right (n=16) isokinetic performance. The right thigh was determined considering the most lateral and superior point of the femurs' head to the superior and lateral tíbias' edge [13]. Lean and fat mass are presented without considering bone tissue amount (kg). The equipment was calibrated before evaluations according to the manufacturers' specifications. Evaluations were performed with the participants using training uniforms and metal accessories removed. Participants were laying in the prone position, aligned and centered on the examination table with hips and shoulders extended and hands in a neutral position to start scanning. The same experienced evaluator conducted the assessments.

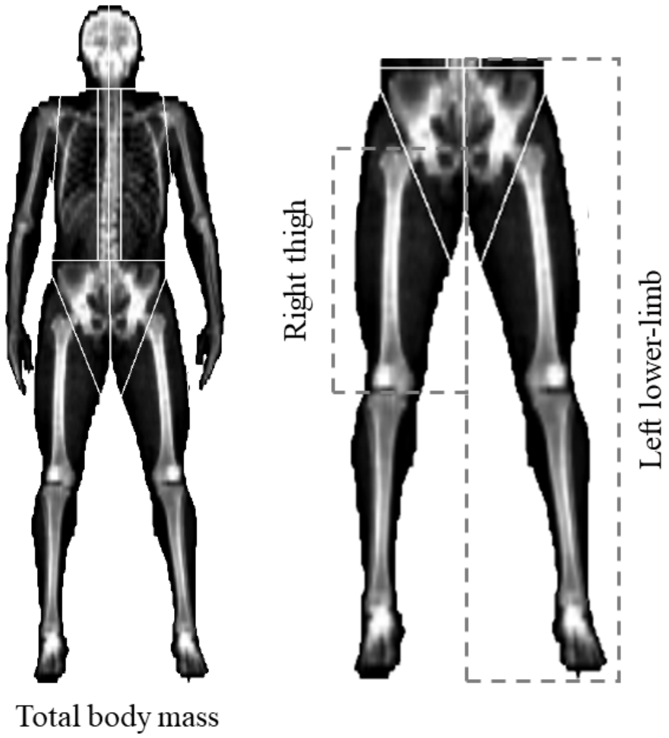

Figure 1. Athletes' lower-limb and thigh body composition assessments.

Knee flexors and extensors peak torques and H:Q ratios

Right (n-16) and left (n-16) KE concentric PT and KF concentric and eccentric PT were evaluated using an isokinetic dynamometer (Cybex Norm; Ronkonkoma, NY, USA). Initially, participants were seated in the equipment with the trunk flexed at 85° and the knee joint aligned with the rotation axis of the dynamometer. Also, the leg, thigh, torso, and pelvis were secured by straps to avoid compensatory movements. After a five-minute general warm-up on a cycle ergometer (Movement Technology, BM2700, São Paulo, Brazil) at a self-reported comfortable velocity, a specific warm-up consisting of ten submaximal dynamic contractions at 120°/s was performed. KE and KF PT were evaluated during five consecutive contractions performed using the concentric–concentric mode at 60°/s (range of motion: 0-90°). KF eccentric PT was assessed during five consecutive contractions performed at 60°/s. Contractions with the highest PT were used for analyses. Then, participants performed isometric flexion-extension contractions at 30° and 60°, respectively. Participants were instructed to perform all contractions with maximal effort (i.e., "as hard and fast as possible") [14]. For logistical reasons, the first participant started the test with the right limb, followed by the evaluation of the left limb, while participant 2 started the evaluation with the left side and later the right limb. This order of member assessments has been maintained successively to optimize the total time of the test battery. Verbal encouragement was given at all times. Also, visual feedback was provided in real-time on a screen placed in front of the participants. Right (n=16) and left (n=16) limbs were individually used for the lower-limb analyses, while only the right limb isokinetic performance (n=16) was used for the exploratory thigh analyses. The same experienced evaluator conducted the assessments.

Statistical analysis

Descriptive values are shown as mean ± SD. Data normality was assessed using the Shapiro-Wilk test, and the correlations 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 ($r = 1$) [15]. The level of significance (α) was set at <0.05. All statistical procedures were performed using the Statistical Package for the Social Science (SPSS version 23.0. Armonk, NY: IBM Corp.).

RESULTS

The athletes' characteristics are presented in Table 1. All athletes performed the body composition assessment and isokinetic evaluations. No adverse event was identified. Tables 2 and 3 present the correlation analysis between isokinetic performance with lower-limb and thigh fat and lean mass, respectively. Additional analyses involving the correlation between lower-limb and thigh total (lean + fat + bone tissues), lean mass, fat mass and bone amounts (kg) are present in the supplementary material (Table S1). Muscle quality (isokinetic performance/muscle measure) is present in the supplementary material (Table S2).

Table 1. Characteristics of futsal players (n=16).

	Mean ± SD
Age (years)	27.50 ± 7.62
Height (cm)	174.69 ± 5.61
Body mass (kg)	74.17 ± 9.32
Body mass index (kg/cm²)	24.25 ± 2.31
Total body fat mass percentage (%)	18.20 ± 3.82
Lower-limb body composition (right and left; n=32)	
Lower-limb fat mass amount (kg)	2.26 ± 0.72
Lower-limb fat mass percentage (%)	17.71 ± 3.54
Lower-limb lean mass amount (kg)	10.28 ± 1.33
Lower-limb lean mass percentage (%)	82.29 ± 3.54
Lower-limb fat/lean mass ratio (kg/kg)	0.22 ± 0.05
Lower-limb lean/fat mass ratio (kg/kg)	4.87 ± 1.17
Thigh body composition (n=16)	
Thigh fat mass amount (kg)	1.66 ± 0.60
Thigh fat mass percentage (%)	15.98 ± 4.20
Thigh lean mass amount (kg)	8.56 ± 0.99
Thigh lean mass percentage (%)	84.02 ± 4.20
Thigh fat/lean mass ratio (kg/kg)	0.19 ± 0.06
Thigh lean/fat mass ratio (kg/kg)	5.73 ± 1.98
Isokinetic strength performance (n=32)	
Concentric knee extension peak torque (N.m)	207.81 ± 36.63
Concentric knee flexion peak torque (N.m)	122.75 ± 22.90
Eccentric knee flexion peak torque (N.m)	157.19 ± 34.84
Conventional (concentric/concentric) H:Q ratio	0.59 ± 0.10
Functional (eccentric/concentric) H:Q ratio	0.76 ± 0.15
Isometric knee extension peak torque at 30° (N.m)	177.38 ± 34.25
Isometric knee extension peak torque at 70° (N.m)	224.81 ± 53.90
Isometric knee flexion peak torque 30° (N.m)	140.00 ± 31.54
Isometric knee flexion peak torque 70° (N.m)	112.19 ± 22.30

H:Q: hamstring-to-quadriceps ratio.

Lower-limb body composition correlations

A significant positive correlation was found between lower-limb lean and fat mass amount (kg) with concentric KE ($p<0.01$) and KF PT ($p<0.05$), as well as eccentric KF PT ($p<0.01$) (Table 2). Lower-limb lean mass amount (kg) had a positive relationship ($p<0.01$) with isometric KE and KF PT, while lower-limb fat mass amount showed only a significant correlation with isometric KF PT (Table 3). Relative (%) values of lower-limb fat and lean mass showed no association with dynamic or isometric KE and KF performance (Table 2). Conventional and functional H:Q ratio showed no significant association with lower-limb body composition (Table 2). Also, lower-limb lean/fat mass and fat/lean mass ratios present no significant correlation with isokinetic measures (Table 2). The correlations between lower-limb body composition with isokinetic parameters are shown in supplementary material (Figures 2-8).

Table 2. Correlations between lower-limb (right + left) body composition with knee extension and flexion peak torque and H:Q ratios (n=32).

	Concentric KE PT (N.m)	Concentric KF PT (N.m)	Eccentric KF PT (N.m)	Conventional H:Q ratio	Functional H:Q ratio	Isometric KE PT 30° (N.m)	Isometric KE PT 70° (N.m)	Isometric KF PT 30° (N.m)	Isometric KF PT 70° (N.m)
Lower-limb lean mass (kg)	0.58* (p<0.01)	0.61* (p<0.01)	0.67* (p<0.01)	0.04 (p=0.81)	0.21 (p=0.24)	0.55* (p<0.01)	0.65* (p<0.01)	0.79* (p<0.01)	0.70* (p<0.01)
Lower-limb lean mass (%)	-0.29 (p=0.10)	-0.21 (p=0.24)	-0.27 (p=0.13)	0.05 (p=0.76)	-0.08 (p=0.54)	-0.25 (p=0.17)	-0.05 (p=0.78)	-0.19 (p=0.29)	-0.19 (p=0.29)
Lower-limb fat mass (kg)	0.46* (p<0.01)	0.30 (p=0.09)	0.44* (p=0.01)	-0.06 (p=0.75)	0.12 (p=0.52)	0.34 (p=0.54)	0.30 (p=0.08)	0.39* (p=0.03)	0.46* (p<0.01)
Lower-limb fat mass (%)	0.29 (p=0.11)	0.21 (p=0.24)	0.27 (p=0.13)	-0.05 (p=0.76)	0.08 (p=0.65)	0.25 (p=0.17)	0.51 (p=0.78)	0.19 (p=0.29)	0.19 (p=0.29)
Lower-limb fat/lean mass ratio (kg)	0.26 (p=0.14)	0.11 (p=0.54)	0.23 (p=0.21)	0.02 (p=0.93)	0.05 (p=0.77)	0.10 (p=0.60)	0.25 (p=0.16)	0.11 (p=0.53)	0.24 (p=0.18)
Lower-limb lean/fat mass ratio (kg)	-0.25 (p=0.16)	-0.12 (p=0.50)	-0.21 (p=0.24)	0.13 (p=0.47)	-0.04 (p=0.82)	-0.03 (p=0.87)	-0.25 (p=0.16)	-0.17 (p=0.39)	-0.16 (p=0.39)

Dynamic isokinetic protocol performed at 60°/s. KE: knee extension; KF: knee flexion; PT: peak torque; H:Q: hamstring-to-quadriceps conventional (concentric/concentric) and functional (eccentric/concentric) ratios.

Table 3. Correlations between right thigh body composition with knee extension and flexion peak torque and H:Q ratios (n=16).

	Concentric KE PT (N.m)	Concentric KF PT (N.m)	Eccentric KF PT (N.m)	Conventional H:Q ratio	Functional H:Q ratio	Isometric KE PT 30° (N.m)	Isometric KE PT 70° (N.m)	Isometric KF PT 30° (N.m)	Isometric KF PT 70° (N.m)
Thigh lean mass (kg)	0.52* (p=0.04)	0.75* (p<0.01)	0.77* (p<0.01)	0.32 (p=0.22)	0.44 (p=0.09)	0.51* (p=0.04)	0.84* (p<0.01)	0.86* (p<0.01)	0.89* (p<0.01)
Thigh lean mass (%)	-0.32 (p=0.22)	-0.05 (p=0.85)	-0.32 (p=0.23)	0.22 (p=0.40)	-0.10 (p=0.70)	-0.16 (p=0.56)	-0.16 (p=0.56)	-0.24 (p=0.36)	-0.11 (p=0.67)
Thigh fat mass (kg)	0.46* (p<0.01)	0.30 (p=0.09)	0.44* (p=0.01)	-0.06 (p=0.75)	0.12 (p=0.52)	0.34 (p=0.54)	0.30 (p=0.08)	0.39* (p=0.03)	0.46* (p<0.01)
Thigh fat mass (%)	0.29 (p=0.11)	0.21 (p=0.24)	0.27 (p=0.13)	-0.05 (p=0.76)	0.08 (p=0.65)	0.25 (p=0.17)	0.51 (p=0.78)	0.19 (p=0.29)	0.19 (p=0.29)
Thigh fat/lean mass ratio (kg)	0.26 (p=0.14)	0.11 (p=0.54)	0.23 (p=0.21)	0.02 (p=0.93)	0.05 (p=0.77)	0.10 (p=0.60)	0.25 (p=0.16)	0.11 (p=0.53)	0.24 (p=0.18)
Thigh lean/fat mass ratio (kg)	-0.25 (p=0.16)	-0.12 (p=0.50)	-0.21 (p=0.24)	0.13 (p=0.47)	-0.04 (p=0.82)	-0.03 (p=0.87)	-0.25 (p=0.16)	-0.17 (p=0.39)	-0.16 (p=0.39)

Dynamic isokinetic protocol performed at 60°/s. KE: knee extension; KF: knee flexion; PT: peak torque; H:Q: hamstring-to-quadriceps conventional (concentric/concentric) and functional (eccentric/concentric) ratios.

Right thigh body composition correlations

The amount (kg) of thigh lean mass showed a significant ($p<0.05$) positive correlation with KE and KF concentric PT. Eccentric KF PT showed a significant positive correlation with the amount of thigh lean ($p<0.01$) and fat mass ($p=0.03$) (Table 3). Contrary to thigh fat mass, thigh lean mass amount had a significant ($p<0.01$) positive correlation with isometric performance. Thigh fat and lean mass relative values (%) showed no association with dynamic or isometric performance (Table 2). Conventional and functional H:Q ratio showed no significant relationship with thigh body composition (Table 3). Also, thigh lean/fat mass and fat/lean mass ratios present no significant correlation with isokinetic measures (Table 2). The correlations between thigh body composition with isokinetic parameters are shown in supplementary material (Figures 9-15).

DISCUSSION

The main findings of the present study were that a) the lower-limb and thigh lean and fat mass amount (kg) had a significant positive correlation with dynamic and isometric KF and KF performance; b) relative (%) fat and lean mass were not related to muscle strength and c) H:Q ratios showed no significant association with body composition. In summary, our study verified that the relationship between body composition and isokinetic performance depends on the use of absolute (kg) or relative (%) values.

Isokinetic performance has been previously investigated in futsal players [11,12,16]. The results found in the present study for concentric KE PT (207.8 ± 36.6 N.m) and KF PT (122.7 ± 22.9 N.m) are similar to those reported by de Lira et al. (2017) [12] (223.9 ± 33.4 N.m and 128.6 ± 27.6 N.m, respectively) and Nunes et al. (2018)11 (214.7 ± 49.6 N.m and 136.6 ± 31.7 N.m, respectively). Regarding to H:Q ratios, it is important to highlight that the present results are outside the commonly considered safe for conventional (present study: 0.59 vs. > 0.60 to 0.90) and functional (present study: 0.76 vs. > 0.90 to 1.20) H:Q ratios [7]. Still, we found similarities between our findings and the conventional H:Q ratio reported by previous studies (H:Q ratio of 0.59 vs. 0.57, 0.64 and 0.51) [11,12,16]. Unfortunately, none of these previous works have evaluated the eccentric force of hamstrings at 60°/s, which impairs the comparison of the eccentric KF PT and functional H:Q ratio (eccentric/concentric) values observed in the present study. Finally, these studies did not verify the relationship between lean and fat mass with isokinetic parameters.

Total body fat mass percentage is related to futsal players' jumping and sprint performance [8–10]. To our knowledge, our study is the first to demonstrate the relationship between body composition evaluated by DXA and isokinetic performance in futsal athletes. We observed a significant correlation between lean and fat mass amount (kg) with KF and KF PT (Table 2 and 3). This positive relationship may be due especially to the muscles mass. In additional analyses (Table S1), we verified a positive relationship between the total lower-limb tissue amount (lean [kg] + fat [kg] + bone [kg] tissues) with the lower-limb absolute (kg) lean ($r= 0.96$; $p<0.01$) and fat mass ($r= 0.83$; $p<0.01$). Furthermore, we verified a positive correlation ($r= 0.64$; $p<0.01$) between the lower-limb fat mass amount (kg) with lean mass amount (kg). The PT observed comes from the amount of muscle mass involved, which explains the positive relationship between lean mass amount and performance (Tables 2 and 3). Based on this, individuals with greater amounts of lean mass also tend to have greater amounts of fat mass (Table S1), which may explain the positive relationship between fat mass and performance. Previous studies have observed that obese (i.e., superior fat mass %) individuals may have greater lean mass compared to non-obese counterparts [17–21]. Also, a positive relationship between body mass index, fat and lean mass amount with KE performance was previously demonstrated [18,22–24]. However, even with a positive relationship between fat mass amount with performance, we do not recommend that athletes seeking superior muscle strength capacity increase their amount of fat mass since a negative relationship between fat mass with the jumping and sprint performance of futsal players [8–10]. We believe these findings reinforce the use of alternative assessments in futsal athletes, such as muscle quality, which involves the relativization of muscle strength by the amount of mass involved with this performance. Thus, the current muscle quality values (KE and KF performance/muscle mass) were also presented (Table S2).

In contrast to our expectations, the lean and fat mass percentage values were not significantly correlated with isokinetic performance. As a greater amount of muscle mass represents a superior quantity of potential tissue for force generation, it is common to expect a positive relationship between muscle mass and performance. On the other hand, a greater amount of fat mass means extra non-productive tissue, which can negatively impact performance. We observed a positive correlation between the lean and fat mass amount with muscle strength. Even so, within a group of athletes, it is natural that individuals will present different proportions of lean and fat tissue due to the variable physical characteristics. Thus, identifying fat and lean mass percentage values is a strategy that considers these differences. Unexpectedly, we found that lean and fat mass percentages were not related with muscle strength. This may be due to the nature of the performance measures (i.e., isokinetic assessment) adopted in the present study. The impact of the lean and fat mass may be more evident in weight-bearing tasks (e.g., sprints and jumps) since an athlete needs to perform actions against the inertia caused by the total body mass. This may explain previous findings where the percentage of fat mass was related to sprint and jump performance in futsal players [8–10]. Also, body composition by DXA does not isolate the muscle groups involved in KE and KF, impacting the current results. Previously, Masuda et al. (2003) [25] verified a positive relationship between KE and KF isokinetic performance with lean mass assessed by the cross-sectional area of quadriceps and hamstrings muscles verified by magnetic resonance images.

Additionally, we believe that this lack of relationship may also be due to the timing of the assessments. Previous studies demonstrated that body composition and performance change in athletes throughout the season and after off-season periods due to the athletes' training status [26–28]. As mentioned before, a greater proportion of muscle tissue reflects a greater amount of tissue with potential to exercise performance. However, as the evaluations were performed at the beginning of the pre-season, the athletes' performance was not optimized or in maximum condition. This imbalance can influence the relationships between body composition and performance. Finally, neuromuscular performance is influenced by neural and morphological aspects, and parameters as electrical muscle activation and motor unit discharge rate also influence performance [29] but unfortunately were not assessed in the present study.

One of the possible limitations of the present study are that we investigated only one professional futsal team. Also, we believe that the investigation of weight-bearing tasks such as sprints and jumps could help understand the impact of lower-limb body composition profile on athletes' performance. Moreover, the lower-limb and thigh body composition assessment by DXA does not isolate the muscle groups involved in KE and KF. Finally, isokinetic assessments do not represent the specific demands of the futsal game; however, it is a well-established measure of performance and has been used to estimate injury risk and readiness to return to sport [30–33]. Nonetheless, our study is the first to assess the relationship between regional body composition by DXA with KE and KF dynamic and isometric muscle strength and H:Q ratios in elite professional athletes.

CONCLUSION

We observed that the absolute (kg) lower-limb and thigh lean and fat mass assessed by DXA positively correlate with dynamic and isometric KE and KF PT. In contrast, relative (%) lower-limb and thigh values were not related to PT performance. Finally, no correlation between body composition with conventional or functional H:Q ratios was observed.

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