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Short Communication

Associations Between Fat and Lean Mass Indexes and Physical Performance in Prefrail and Frail Older Women

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Abstract

Age-related changes in body composition have been associated with reduced physical performance. However, the relationship of fat and lean mass indexes with physical performance in the setting of frailty is yet to be clearly established. We investigated the association between fat and lean mass indexes and physical performance in prefrail and frail older women. Fifty-one community-dwelling women 65 years and older (mean age 76 years) were classified as prefrail or frail according to a modified frailty phenotype. Body composition was estimated by dual-energy X-ray absorptiometry, while physical performance was assessed via the following tests: Berg balance scale, timed-stands, timed up-and-go test, 6-minute walk test, and the short performance physical battery. Correlation coefficients were determined to assess the association between body composition and physical performance parameters. Associations between continuous variables with a p-value <0.05 were included in a linear regression analysis. All fat mass indexes predicted a reduced performance in at least one functional test. Among the lean mass indexes, only leg lean mass adjusted by body fat mass was directly associated with better physical performance. Our findings indicate that fat mass indexes may have a greater impact on physical performance than lean mass in frail and prefrail older women.

Keywords: Aging, Body composition, Frailty, Functional performance, Physical function

Frailty is a complex age-related condition characterized by an increased risk of mobility impairment and other negative health outcomes[1]. Although multiple operational definitions of frailty are available, most of them, including the frailty phenotype[2], enlist physical inactivity as a key element. Lack of adequate physical activity increases the risk for detrimental changes in body composition, such as muscle loss and increasing adiposity[3]. Deteriorations in body composition, in turn, have important implications, including insulin resistance, low-grade chronic inflammation, and decreased physical function[4].

Previous investigations have shown that adiposity is negatively associated with physical performance in older adults, with a greater impact than lean mass indexes[5,6]. Nevertheless, the impact of adiposity on physical function in the setting of frailty is still debated, which prevents from providing solid recommendations for interventions. Few studies have specifically examined the association of body composition indexes with physical performance in frail or prefrail individuals regardless obesity status[7-9].

The paucity of research in this field is understandable given that frailty is generally associated with sarcopenia, while its link to adiposity is controversial[10]. To increase the knowledge on the subject, the present study aimed at investigating the association of fat and lean mass indexes with physical performance in prefrail and frail older women.

The authors have no conflict of interest.

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Parameters	All (n=51)	Prefrail (n=34)	Frail (n=17)
Age (years)†	76.3±7.1	75.2 ± 6.5	78.4 ± 7.8
BMI (kg/m²)†	27.4±4.8	27 ± 4	27.9 ± 6.3
MMSE score†	25.9±2.9	26.2 ± 2.9	25.02 ± 3
SPPB score‡	9.5±2.5	9.9 ± 2.6	7.8 ± 3.5*
TUG (s)‡	9.5±3	9 ± 2.9	10.8 ± 3.2
TS (n)‡	13±3.1	13.4 ± 3.1	12.1 ± 3
BBS (n)‡	51.5±6.8	52.7 ± 5.5	49.2 ± 8.6*
6-MWT (m)‡	428±104	450 ± 94	375 ± 114*
FM (kg)†	28.6±7.8	28.1 ± 6.3	28.9 ± 10
%FM†	44.3±5.6	44.2 ± 4.5	44.3 ± 7.1
%TFM†	44±5.7	43.9 ± 5	44.1±7.2
VAT (g)†	791±295	784±260	806±362
WHR†	0.854±0.062	0.840 ± 0.06	0.882±0.05*
ALM (kg)†	13.9±2	13.9 ± 1.9	13.7 ± 2.2
LLM (kg)†	10.7±1.6	10.7 ± 1.5	10.6 ± 1.8
ALM/height²†	5.88±0.74	5.85 ± 0.67	5.86 ± 0.9
ALM/BMI†	0.514±0.075	0.518 ±0.07	0.507±0.08
LLM/BMI†	0.397±0.058	0.399 ± 0.05	0.393±0.06
LLM/FM†	0.399±0.105	0.393±0.07	0.409 ± 0.14

*Data are shown as mean ± standard deviation. † = Student t test; ‡ = Mann-Whitney test; Abbreviations: BBS = Berg balance scale; TS = timed-stands; TUG = timed up-and-go (TUG); 6-MWT = 6-minute walk; SPPB = Short Performance Physical Battery Test; BMI = Body mass index; MMSE = Minimental state examination; WHR = waist-hip ratio; ALM = appendicular lean mass; LLM = leg lean mass (LLM); FM = absolute fat mass; %FM = body fat percentage; %TFM = trunk fat percentage; VAT = visceral adipose tissue; ALM/height² = muscle mass index). * Significantly different (p<0.05) between prefrail and frail participants.*

Table 1. Characteristics of study participants.

In this cross-sectional study, community-dwelling older women were recruited in community centers located in the metropolitan area of Campinas, Brazil, between August and November 2022. Candidates were considered eligible if they were ≥65 year-old and were prefrail or frail according to a modified version of the frailty phenotype. Those with self- or proxy-reported cognitive impairment or any cardiovascular, neurological, or musculoskeletal problem that could interfere with physical function tests (e.g. ability to stand up and walk independently) were excluded. All participants signed an informed consent prior to inclusion.

Candidate participants received a structured assessment including determination of frailty status, collection of medical history, measurement of anthropometric parameters, and the mini-mental state examination[11]. Prefrail and frail women with no impediment to participate were then evaluated for physical performance and body composition.

Participants were classified as prefrail when they presented one or two criteria based on the Fried's frailty phenotype[2] and frail when presented three or more. The frailty phenotype criteria are: a)unintentional weight loss; b)low handgrip strength; c)self-reported exhaustion[12]; d) slowness; and e)low physical activity levels[13]. Details on frailty criteria are provided in the supplementary material.

For the evaluation of physical function, participants were requested to perform the following tests: Berg balance scale (BBS), timed-stands (TS), timed up-and-go (TUG) test, 6-minute walk test (6-MWT), and the short performance physical battery (SPPB). Procedures for all tests are fully described elsewhere[14-18]. SPPB scores were categorized as low[1-3], intermediate[4-9], and high[10-12]. For all tests, a familiarization session was completed at least 48 hours prior to the actual testing.

Body mass was measured using an analogue scale (Filizola, São Paulo, Brazil) with a resolution of 0.1 kg. Height was measured using a stadiometer (resolution of 1 cm). Waist

Parameters	FM	%FM	%FTM	VAT	WHR	ALM	LLM	ALM/ BMI	ALM/ Height^2	LLM/ BMI	LLM/FM
TUG	0.443**	0.350*	0.271	0.262	0.116	0.259	0.248	-0.244	0.291	-0.252	-0.380**
TS	-0.443**	-0.275	-0.271	-0.256	-0.125	-0.325*	-0.332*	0.113	-0.275	0.110	0.284
BBS	-0.283	-0.241	-0.204	-0.259	-0.217	-0.168	-0.159	-0.153	-0.157	0.183	0.298*
6-MWT	-0.525***	-0.458**	-0.391**	-0.340*	-0.154	-0.297*	-0.316*	0.281	-0.306*	0.266	0.456**
SPPB score	-0.231	-0.170	-0.198	-0.292*	-0.322*	-0.165	-0.151	0.129	-0.204	0.151	0.195
SPPB levels	-0.350*	-0.290*	-0.265	-0.289*	-0.159	-0.234	-0.249	0.231	-0.265	0.224	0.293*

**p < 0.05, ** p < 0.01, *** p < 0.001; Coefficient's interpretation: 0-0.19 = no or negligible relationship; 0.20-0.29 = weak relationship; 0.30-0.39 = moderate relationship; 0.40-0.69 = strong relationship; ALM = Appendicular lean mass; LLM = leg lean mass; FM = absolute fat mass; %FM = relative fat mass; %TFM = trunk fat percentage; VAT = visceral adipose tissue; ALM/height^2 = muscle mass index; ALM/BMI = appendicular muscle mass/body mass index; LLM/FM = leg lean mass/fat mass; LLM/BMI = leg lean mass/body index mass; WHR = waist-hip ratio; BBS = Berg balance scale; TS = timed-stands; TUG = timed up-and-go; 6-MWT = 6-minute walk test; SPPB = Short Performance Physical Battery Test.*

Table 2. Correlation analysis among functional and body composition indexes.

circumference was taken at the midpoint between the last rib and the iliac crest with an inelastic tape with a resolution of 0.1 cm, while hip circumference was measured at the most salient point of the gluteus. Body mass index (BMI) was calculated as the ratio between body mass (in kg) and height squared (m^2). Body composition was assessed using a dual-energy X-ray absorptiometry (DXA) equipment (Hologic, MA, USA). Recorded parameters included appendicular (ALM) and leg lean mass (LLM), fat mass (FM), fat percentage (%FM), trunk fat percentage (%TFM), and visceral adipose tissue (VAT). Muscle mass index (ALM/height^2), ALM/BMI, LLM/FM, and LLM/BMI were calculated.

Variables are expressed as the mean ± standard deviation. Normal distribution of variables was assessed by Shapiro-Wilk. Prefrail and frail characteristics were compared with Student's *t*-test or the Mann-Whitney, as appropriate. Spearman's coefficients were determined to assess the association between body composition and physical performance parameters. Significant associations were included in a linear regression analysis. The final model was adjusted for age. For all tests, statistical significance was set at $p<0.05$. All analyses were performed using Jamovi (version 2.3.21.0).

Fifty-one older women were eligible to participate (age range: 66-93 years). The characteristics of participants are reported in Table 1. Significant differences between prefrail and frail participants were only observed for waist-hip ratio (WHR), BBS, 6-MWT, and SPPB score. Body composition data and SPPB performance were collected from all participants. Five participants did not perform TS, TUG, and 6-MWT (four for scheduling reasons and one for a health problem not related to the study), while three did not perform the BBS (two for scheduling reasons and one for a health problem not related to the study).

Spearman's correlation coefficients (Table 2) were adopted since data from all physical performance variables presented a non-normal distribution with robust outliers. Poor performance in TUG, TS, 6-MWT, and SPPB scores was significantly associated with two (FM and %FM), three (FM, ALM, and LLM), 7 (FM, %FM, %FTM, VAT, ALM, LLM, and ALM/height2), and two (WHR and VAT) composition indexes, respectively. When SPPB scores were categorized, lower physical performance was associated with higher FM, %FM, and VAT. On the other hand, only LLM/FM was significantly associated with better physical performance (TUG, BBS, 6-MWT, and SPPB levels). Regression analysis (Table 3) also indicated that all body composition parameters were better predictors of physical performance when adjusted for age except for %TFM (p=0.071).

In the present study, we found that several fat mass indexes were associated with reduced physical performance in prefrail and frail older women, while only one lean mass index (LLM/FM) was associated with better physical performance. These results corroborate previous studies demonstrating a greater impact of adiposity than lean mass on physical function in the general older population[6,7]. Additionally, the coexistence between obesity and sarcopenia, known as sarcopenic obesity, has been associated with poorer physical performance and frailty when compared to sarcopenia[5,19].

The various tests employed to assess physical performance rely on physical capabilities (e.g., muscle strength, balance, aerobic capacity) in different proportions[20]. Skeletal muscle morphology (i.e. volume and size) is not the only factor the contributes to functional capacity. Indeed, impaired muscle quality is a better predictor of low physical function than muscle mass and individuals living with obesity commonly have more muscle mass than normal-weight counterparts but poorer muscle quality[21]. This may

Parameters	FM		
	Unstandardized Coefficients	R^2	p-value
TUG	0.193	0.211	0.001
TS	-0.169	0.168	0.005
6-MWT	-8.02	0.306	<0.001
	%FM		
	Unstandardized Coefficients	R^2	p-value
TUG	0.215	0.125	0.016
6-MWT	-10.02	0.234	<0.001
	%TFM		
	Unstandardized Coefficients	R^2	p-value
TUG	0.157	0.072	0.071
6-MWT	-7.88	0.152	0.007
	VAT		
	Unstandardized Coefficients	R^2	p-value
6-MWT	-0.148	0.161	0.006
SPPB score	-0.002	0.098	0.025
	WHR		
	Unstandardized Coefficients	R^2	p-value
SPPB score	-11.9	0.085	0.039
	LLM/FM		
	Unstandardized Coefficients	R^2	p-value
TUG	-10.7	0.099	0.033
6-MWT	462	0.156	0.007
BBS	23.4	0.107	0.023

FM = absolute fat mass; %FM = relative fat mass; %TFM = trunk fat percentage; VAT = visceral adipose tissue; LLM/FM = leg lean mass/fat mass; WHR = waist-hip ratio; BBS = Berg balance scale; TS = timed-stands; TUG = timed up-and-go; 6-MWT = 6-minute walk test; SPPB = Short Performance Physical Battery Test. Adjusted by age.

Table 3. Predictive capacity of body composition indexes on physical performance.

explain why some lean mass indexes were associated with low physical performance in this investigation. Furthermore, excess adiposity negatively interferes with many physical capabilities[6].

Our findings support the notion that, in the setting of frailty, the management of adiposity may be more relevant to prevent functional losses than maintenance of lean body mass. Hence, adiposity indexes should be periodically monitored in older adults and therapeutic strategies, such as including an aerobic component in exercise programs and reducing calorie intake while increasing protein consumption[22], should be considered to manage excess body fat.

These findings also provide information for future investigations. First, our results allow for cross-sectional studies with larger samples to be carried out. Second, in a context in which there is still debate as to whether a higher or lower BMI is associated with frailty incidence[10], our results indirectly support the idea that a higher incidence of frailty may be associated with higher BMI. Longitudinal studies addressing this question are warranted. Along similar lines, cutoff values for adiposity indexes in frail or prefrail individuals need to be identified. In this regard, LLM/FM may have better practical implications than indexes usually employed in the setting of frailty and sarcopenia, such as ALM/height^2 or ALM/BMI. Future studies are necessary to identify the most informative index.

This study has limitations. First, we did not perform a formal sample size calculation, reinforcing the need for further studies. Furthemore, the study needs to be replicated in frail men, as fat mass may influence physical performance differently in women and men[9]. Finally, since most participants did not show poor physical performance, our findings may not be generalizable to very old individuals or institutionalized frail older adults.

In conclusion, our study indicates the fat mass may be more relevant than lean mass in predicting physical performance in prefrail and frail older women. These results support the notion that reduction of excess adiposity should be one main target in the clinical management of frailty. Furthermore, our findings provide important information to design future studies with larger samples.

Ethical Approval

The study was approved by the Ethics and Research Committee of the University of Campinas (number process:28864820.0.0000.5404).

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Supplementary Material

Frailty assessment description

Participants were classified as prefrail and frail when they presented, respectively, one or two and three of the following criteria based on the Fried's frailty phenotype[2]:

a) Self-reported unintentional weight loss ≥4.55 kg or >5% of body weight (by direct measurements of weight) in the last 12 months. If yes, then frail for weight loss criterion.

b) Low handgrip strength (<17 kg for BMI <23 kg/m^2, <7.3 kg for BMI 23.1–26 kg/m2, <18 kg for BMI 26.1–29 kg/m^2, and <21 kg for BMI >29 kg/m^2). Handgrip strength was assessed using an isometric dynamometer (Jaymar, Bolingbrook, IL, USA) in the dominant hand. During the test, participants were sat with their shoulders adducted, elbows flexed at 90 degrees, and forearms in a neutral position. Three trials were performed and a familiarization session was conducted at least 48 hours prior to definitive testing. The mean and maximum values for each attempt were recorded, and the mean values were used to determine frailty. Verbal encouragement was provided and testing sessions were conducted by an experienced researcher.

c) Self-reported exhaustion, assessed by two items from the Brazilian version of the Center for Epidemiologic Studies Depression Scale (CES-D)[12];

d) Slowness, operationalized as a time ≥7 s when height was ≤1.59 m or ≥6 s when height was ≥1.60 m to walk 4.6 m at usual pace, not considering the initial 2 m;

e) Low level of activity, operationalized as a weekly energy expenditure <270 kcal determined using a validated version of the Minnesota Leisure Time Activities Questionnaire for older adults[13].