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Body composition, muscle strength and quality of active elderly women according to the distance covered in the 6-minute walk test

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ABSTRACT | Background: Changes arising from the aging process, particularly changes in body composition, contribute to the functional decline of the elderly. **Objective:** To compare the body composition and muscle strength, mobility and quality in active elderly women according to the distance walked during the 6-minute walk test (6MWT). **Method:** The study included 77 active elderly women aged 65 to 80 years, who were divided into tertiles (A, B and C) according to the distance covered in the 6MWT. We performed anthropometric and clinical evaluations. Body composition was determined by dual energy X-ray absorptiometry (DXA). Handgrip strength (HGS) was measured with a portable dynamometer (Saehan), and knee extension strength (KES) was measured with the one repetition maximum test (1-RM). Functional mobility was assessed by the Timed Up and Go (TUG) test, and body balance was assessed by the Berg Balance Scale (BBS). Muscle quality was defined by the ratio between muscle strength (kgf) and muscle mass (kg). **Results:** The group that walked the shortest distance in the 6MWT had a higher BMI (A=30.8±7.0, B=27.2±4.2 and C=25.9±3.5 kg/m^2), greater amount of fat mass (A=31.3±10.7, B=25.9±6.7 and C=23.81±6.46 kg) lower HGS (A=21.8±5.1, B=22.1±3.5 and C=25.5±5.1 kgf), lower knee extension strength (A=30.6±10.9, B=40.4±12.5 and C=47.2±10.1 kgf), lower arm muscle quality (A=10.1±3.7, B=11.6±2 and C=12.7±2.2 kg) and lower leg muscle quality (A=1.78±1, B=2.84±0.98 and C=3.31±0.77 kg). There was no significant difference between muscle mass (p=0.25) and lean mass (p=0.26). **Conclusion:** Body fat has a negative influence on functional performance, even among active elderly women.

Keywords: body composition; muscle strength; six-minute walk test; muscle quality; elderly subjects; physical therapy.

HOW TO CITE THIS ARTICLE

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Introduction

The aging process is characterized by systemic changes that cause an individual to suffer a progressive inability to adapt to the environment in which he or she lives in. Consequently, this increases an individual's vulnerability to the onset of diseases[1]. With advancing age, muscle mass tends to decrease and adipose tissue tends to increase, following a typical pattern of greater visceral, subcutaneous and intramuscular distribution[2-4].

This change in body composition, mainly the infiltration of intramuscular fat, reduces muscle quality and performance and contributes to a reduction in strength and functional mobility[5].

According to Bouchard et al.[6], this increase in body fat may affect an individual's functional capacity. Obesity usually precedes functional decline and is associated with an increased risk of degenerative joint disease, especially in the knees, thus negatively affecting mobility. Obese individuals also present a proinflammatory state that may contribute to the reduction of muscle mass, thus affecting muscle strength and quality[3].

Sarcopenia, defined as a slow, progressive and apparently inevitable process of loss of muscle mass and strength, is one of the most important changes that occur with aging[2]. The condition has been associated with the atrophy of fast twitch (type II) muscle fibers and the substitution of functional tissues by adipose and fibrotic tissues that have reduced rates

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of protein synthesis, thus leading to reduced muscle strength, also known as dynapenia, and efficiency[7].

Other changes, such as reduced mineral bone density, visual deterioration, and vestibular and somatosensory changes, lead to immobility, muscle weakness and morbidity[8]. The reduction of muscle strength, especially in the lower limbs, is related to a decline in balance and to gait changes[5]. Carmeli et al.[9] demonstrated that in the elderly, there is a relationship between the strength of the knee extensor muscles and physical ability.

Some studies have reported that the loss of muscle quantity and quality contributes to a decline in the performance of daily tasks by causing a reduction of gait velocity[5,6,8]. Within this context, studies have suggested that a decline in gait velocity may be used to identify elderly subjects with reduced muscle strength and mass that have functional losses and risks of limitations of the lower limbs[5,6].

Tests based on physical performance are routinely used to quantitate functionality. In this respect, the six-minute walk test (6MWT) has been extensively used as a method for assessing physical fitness because it is easy to apply, is well tolerated by the volunteers, and reflects the activities of daily life[10]. Although this test is more frequently used to assess functional capacity in individuals with cardiorespiratory dysfunctions, it is also used in other populations[10,11].

Some studies have reported a positive correlation between physical activity, muscle strength and functional performance in the elderly, demonstrating the importance of regular physical activity for the maintenance of functional capacity[8,12]. However, studies elucidating the relationship between muscle performance and muscle quality in elderly women and their performance in walk tests are still lacking.

In view of the above considerations, the objective of the present study was to compare the body composition, mobility and muscle strength and quality of active elderly women according to their distances covered in the 6MWT.

Method

Study design

The study was an observational investigation with a cross-sectional design.

The study was approved by the Ethics Committee of the University Hospital, Faculty of Medicine of Ribeirão Preto, Universidade de São Paulo (HCFMRP, USP), Ribeirão Preto, SP, Brazil, HCRP protocol no. 12152/2007, and the volunteers gave written informed consent prior to participation.

Sample

The sample consisted of 77 female volunteers aged 65 to 80 years who were recruited by Programs of Community Integration of the city of Ribeirão Preto, SP, and by the Center of Physical Education, Sports and Recreation of USP, Ribeirão Preto Campus (CEFER- USP).

The exclusion criteria were women who were younger than 64 years, bedridden, dependent, amputated, and using ortheses or prostheses, with cognitive alterations in the Mini-Mental state Examination[13] that would prevent the understanding of the questionnaires and of the tests. Women with osteomyoarticular changes, localized loss of strength, decompensated acute or chronic disease requiring medical care, visual disorders with no appropriate clinical correction with corrective lenses at the time of the tests, and with uncompensated vestibular deficits were also excluded.

The sample was divided into three groups according to the tertiles of the 6MWT as follows: 1st tertile (Group A) $\leq$ 33.3% (n=23), 2nd tertile (Group B) >33.3% $\leq$ 66.3% (n=32) and 3rd tertile (Group C) > 66.3% (n=22).

Clinical evaluation

Clinical evaluations were performed by means of anamnesis, including a self-report of the presence or absence of diseases, such as heart conditions, arterial hypertension, diabetes mellitus, cancer, rheumatic disease, chronic pulmonary disease, and depression. The participants were questioned about their personal and family history, associated diseases, medications, daily life activities, habits, and physical activity.

The level of physical activity of the subjects was evaluated by applying the International Physical Activity Questionnaire (IPAQ) version 8, in the format of an interview containing questions about the frequency and duration of moderate or vigorous physical activities and walks in the last week. On the basis of this interview, the volunteers were classified into one of the four categories: very active, active, irregularly active, or sedentary[14].

Anthropometry and evaluation of body composition

Body weight was measured using a Filizola ID 500 scale with 0.1 kg graduations. The volunteer, wearing light clothing and barefoot, was instructed to position herself on the center of the scale. Height was measured using a stadiometer with an inextensible vertical bar graduated from 0.5 to 0.5 cm.

Body composition was determined by dual energy X-ray absorptiometry (DXA) using total body analysis (Hologic, QDR 4500W®, Bedford, MA, USA). The data obtained were processed with the latest program of the system, version 11.2:5. In this scanning technique, an X-ray generator emits pulses of double energy alternate radiation of 70 and 140 kilovolts (kv) by means of an X-ray beam bundle that is attenuated when passing through the body. The attenuation is measured for each point of the body surface in a linear array of 128 detectors. A complex set of measurements follows, permitting the evaluation of bone mineral density and of soft tissue density. This set is then divided into lean mass and fat mass due to their different characteristics of attenuation. The equipment was calibrated daily using a phantom for bone mass and a phantom for soft tissues.

Six-Minute Walk Test

The 6MWT was carried out according to the directives established by the American Thoracic Society[11] using the following equipment: a chronometer (Kadio Professional Quartz Timer, Model KD1069, Taiwan), a measuring tape, a heart rate monitor (Polar FS1, China), a sphygmomanometer (Bic, Itupeva, São Paulo, Brasil), and a double stethoscope (BIC, Itupeva, São Paulo, Brasil).

The tests were carried out in a 40 meter corridor of the University Hospital, Faculty of Medicine of Ribeirão Preto. The test area was marked on the floor with colored adhesive tape, and the distance was measured every 5 meters with an inextensible tape. The final distance achieved was recorded in meters, with a final precision of 1 m.

A volunteer's arterial pressure, heart rate and respiratory rate were determined before and after the test. The volunteers were asked to walk from one end of the corridor to the other at the highest possible speed for six minutes and were instructed to stop the test if they developed pain in the lower limbs, tachycardia or any symptoms of discomfort.

Handgrip strength (HGS)

A portable hydraulic dynamometer (Saehan Corporation, Masan Free Trade Zone, Korea) with a graduation scale in kilograms/force was used for the HGS test. The test was applied according to the recommendations of the American Society of Hand Therapists (ASHT)[15].

The volunteer was instructed to remain sitting comfortably with an arm adducted parallel to the trunk, the elbow flexed at 90°, the forearm in a neutral position and the wrist in 0° to 30° extension, with the mobile loop of the equipment remaining in position II. The volunteer was instructed and encouraged to pull the loop of the dynamometer, keep it pulled for six seconds and then relax. Three measurements were performed at one minute intervals, with the subject alternating between the dominant and non-dominant side. The highest value was recorded.

Knee Extension Strength (KES)

KES was measured using the 1 repetition maximum (1-RM) protocol adapted from Kraemer et al.[16].

Some strategies, based on the guidelines of Simão et al.[17], were adopted to reduce the margin of error in the 1-RM test. Standardized instructions were offered before the test so that the volunteers were aware of the technique for the execution of the exercise and the subjects performed some repetitions without a load in order to familiarize themselves with the movement. Correct positioning was monitored in order to avoid compensatory movements.

An extensor chair was used for the tests (Moviment, São Paulo, Brasil). The loads applied followed the overload of the instrument itself in the form of plates, and when necessary, weights of 1, 2, and 3 kg were added. The instrument was regulated according to the size of the segment of the lower limbs of the volunteers[18].

The exercise chosen was bilateral knee extension on the chair. The sitting position was first chosen, with the volunteer's arms along the body and holding the support of the instrument, with the trunk inclined at 70° and the knee flexed at 90°. The test started from the knee flexion position, followed by complete leg extension and the return of the legs to the initial position[17].

A series of warm-up movements, comprising 6 to 10 repetitions, was first started with approximately 50% of the load used in the first attempt of each test[19]. The evaluation was started two minutes after the warm-up period, and the volunteers were instructed to try to complete two repetitions of each movement. If two repetitions were completed in the first attempt or if no repetition was completed, a second attempt was performed after a recovery interval of three to five minutes with a greater or lower load than that used in the previous attempt. If the load referring to the single maximum repetition was not determined, a third attempt was made, and the procedure was repeated again. Thus, the load recorded as 1-RM was that for which the volunteer was able to complete only a single repetition of the movement[20,21]. All tests were carried out at the same time of day in a temperature-controlled room, and the volunteers were instructed not to practice physical exercises on the eve of the test in order to guarantee the quality of the results[20].

Muscle quality

The muscle quality of the upper limbs was calculated as the ratio between the HGS (kgf) and the lean mass of the dominant upper limb (kg).

The muscle quality of the lower limbs was calculated as the ratio between the bilateral KES (kgf) and the quantity of lean mass of the lower limbs (kg)[22].

Berg balance scale

The Berg Balance Scale consists of 14 tasks related to daily tasks. The maximum score is 56 points, and each item has an ordinal scale with 5 alternatives from 0 to 4, according to the quality of performance and the time spent to complete each task[23].

Before the test, the volunteers were instructed, and when necessary, the execution of the task was demonstrated. The equipment that was used included a chronometer (Kadio Professional Quartz Timer, Model KD1069, Taiwan*),* a ruler, two chairs with a distance of 43 cm from the seat to the floor, and a ladder with two steps.

Timed Up and Go Test (TUG)

A 43 cm high chair with an armrest and a chronometer (Kadio Professional Quartz Timer, Modelo: KD1069, Taiwan) were used to perform the TUG. After the command to start the test, the volunteer was observed as she rose from the chair, walked straight for three meters, and sat down again, while wearing her usual shoes. The time needed to complete the task was recorded in seconds.

Statistical analysis

The Kolmogorov-Smirnov test was used to determine the normality of the data. Descriptive statistics was then applied (mean, standard deviation, minimum and maximum value). A one-way analysis of variance (ANOVA) was used to determine the differences between groups, and the post hoc Tukey test was applied, when necessary. The level of significance was set at 5%.

Results

Group A, corresponding to the 1st tertile, consisted of 23 elderly women who walked on average 369.7±57.6 m (240-428 m). Group B, corresponding to the 2nd tertile, consisted of 32 elderly women who walked on average 450.2±12.3 m (433-470 m). Group C, corresponding to the 3rd tertile, consisted of 22 elderly women who walked on average 524±44.5 m (478-643 m).

Table 1 shows the most prevalent diseases of the subjects and the number of medications they used daily according to medical indication. In all the groups, systemic arterial hypertension (SAH) was the most prevalent disease, followed by dyslipidemia, diabetes mellitus (DM) and osteoarthritis.

Table 2 presents the values (mean±SD) of the variables and the comparison of the groups. Age, height, lean mass, total fat mass and limb mass did not differ between the groups. The remaining variables differed significantly, especially between groups A and C (Table 2).

Discussion

In the present study, the elderly women who covered a shorter distance in the 6MWT also had a higher body mass index (BMI), a greater quantity of fat mass and worse muscle performance, as defined by muscle strength and quality. Although some studies have investigated the relationship between changes in body composition and functional capacity in the elderly[2,6,9,12,24-26], thus far, no publications have described the performance of elderly subjects in the 6MWT and the muscle quality of active elderly women, especially in the Brazilian population.

According to the data reported in this study, a greater quantity of fat mass and fat percentage were determinants of worse functional performance of the sample studied. These results in agreement with data reported by Pires et al.[10], who observed

Table 1. Prevalence of comorbidities and number of medications.

Disease	Group A N=23	Group B N= 32	Group C N= 22
SAH (%)	86	68	45
Dyslipidemia (%)	34	40	22
DM (%)	8	21	18
Osteoarthritis (%)	34	18	18
Medications/day	4.9	4.1	2.5

SAH: systemic arterial hypertension, DM: diabetes mellitus, Osteoarthritis: spine, hip and knee.

Table 2. Anthropometric data, body composition, mobility and muscle quality of the subjects studied.

Variables	Group A N=23	Group B N=32	Group C N=22	P-Value
Demographic and anthropometric data				
Age (years)	70.26 (3.99)	69.96 (4.67)	68.59 (4.25)	0.38
Weight (kg)	72.94 (16.77)	65.18 (9.81)	63.45 (9.20)	0.02^{*}
Height (m)	1.53 (0.04)	1.54 (0.06)	1.56 (0.06)	0.25
BMI (kg/m^2)	30.88 (7.00)	27.27 (4.22)	25.93 (3.52)	$0.01^{\#*}$
Body composition				
FM (kg)	31.38 (10.75)	25.91 (6.79)	23.81 (6.46)	$0.01^{\#*}$
% fat	42.27 (5.84)	39.37 (5.39)	37.22 (5.76)	0.01^{*}
MM (kg)	39.43 (6.56)	37.30 (3.96)	37.58 (3.96)	0.25
LM (kg)	41.12 (6.75)	38.95 (4.10)	39.23 (4.14)	0.26
RAMM (kg)	2.08 (0.55)	1.85 (0.25)	1.93 (0.32)	0.09
LMM (kg)	13.12 (2.33)	12.30 (1.72)	12.50 (1.41)	0.26
Functional capacity and muscle strength				
6minWT (m)	369.74 (57.62)	450.25 (12.32)	524.05 (44.49)	$0.01^{\#*+}$
HGS (Kgf)	21.82 (5.19)	22.07 (3.51)	25.59 (5.17)	0.01^{*+}
KES (Kgf)	30.65 (10.90)	40.43 (12.55)	47.27 (10.08)	$0.01^{\#*}$
TUG (seg)	10.72 (2.60)	9.00 (1.09)	7.70 (0.99)	$0.01^{\#*+}$
BBS (0-56)	51.78 (3.56)	55.03 (0.99)	55.40 (1.05)	$0.01^{\#*}$
Muscle quality				
AMQ	10.17 (3.77)	11.59 (2.01)	12.77 (2.26)	0.01^{*}
LMQ	1.78 (0.99)	2.84 (0.98)	3.31 (0.77)	$0.01^{\#*}$

P<0.05 (AB#) (AC*) (BC+); BMI: Body mass index; HGS: Hand grip strength; KES: Knee extension strength; TUG: Timed Up and Go Test; BBS: Berg Balance Scale; FM: Fat mass; MM: Muscle mass; LM: Lean mass; RAMM: Right arm muscle mass; LMM: Leg muscle mass; AMQ: Arm muscle quality; LMG: Leg muscle quality.

that individuals with a BMI of more than 35 kg/m^2 walked a shorter distance compared to individuals with a BMI of less than 25 kg/m^2, indicating that fat had a negative influence on the performance of the sample population. In another study, Sallinen et al.[24] also reported a strong association between percentage of body fat and maximum walking velocity among elderly people aged 60 to 79 years. In particular, they found that obese elderly individuals had a higher prevalence of dependence and greater impairment of functionality.

The reduced muscle performance observed in the group that walked a shorter distance agrees with the results obtained by Visser et al.[25], who reported a significant correlation between lower limb strength and gait velocity. This finding demonstrates that the loss of muscle strength in the elderly is a factor that contributes to the functional decline of this population.

Regarding the Berg Balance Scale and the TUG test data, the results showed the same pattern, i.e., the elderly women who covered a greater distance in the 6MWT also had a better performance on the BBS and the TUG. In a similar study, Barbosa et al.[1] assessed the association of the nutritional status of elderly individuals with tests of motor performance and observed a significant association between BMI with balance among women aged 60 to 79 years. Their results suggested that during the execution of functional balance tests, appropriate support of body mass is necessary, and therefore, the indirect effects of excess body fat may negatively interfere with body balance.

Additionally, the present results demonstrate that in terms of body composition, excess body fat can increase body overload and limit movement due to the stress between joints and muscles, thus increasing the risk of disabilities[27]. In a study of 156 elderly subjects conducted by Villareal et al.[26], obesity was found to be an important cause of physical dysfunction among the elderly, with almost all the obese subjects who were studied showing evidence of physical frailty. These results are in agreement with the results presented herein and support the notion that obesity can worsen the age-related decline in physical function for these individuals.

With regard to muscle quality, Group C showed better results. Strength was the determinant factor for better muscle quality since muscle mass was constant among the groups. Muscle quality has been previously described to demonstrate muscle strength in a more functional manner in relation to the quantity of muscle mass[28].

Although the aging process involves a decline of muscle quality, the present study suggests that the increase of fat mass may also be associated with this decline, as elderly women with a larger amount of fat performed more poorly on tests of muscle strength and functional capacity.

Changes in body composition such as sarcopenic obesity, reduced lean mass and increased fat percentage negatively affect the health of elderly individuals, leading to an increased risk of disease and mortality. Although research on changes in body composition in the elderly began only recently, its association with other health-related variables, such as strength, muscle function and indices of quality of life, is important in order to identify frailty among older people[29].

The 6MWT is a simple, low-cost and safe technique that is representative of daily activities. This test has been validated in various populations and is now extensively used to assess functional capacity in the elderly[30]. The scarcity of reference values for the 6MWT in healthy subjects limits the interpretation of its results. However, according to Pires et al.[10], the variability of the test results among healthy elderly subjects can be explained by age, gender, height and weight.

In the present study, the level of physical activity was evaluated with the IPAQ, which showed that the elderly volunteers performed regular physical activity, suggesting that subjects' practice of physical activity may account for, at least in part, the results regarding body balance and functional mobility. HGS was normalized according to the BMI (HGS/BMI), but the normalized values were not added to the table because they did not differ between the groups.

The muscle strength of the upper limbs was measured by the HGS test, a common measurement used in geriatric evaluation that is also used as a predictor of invalidity in the elderly[31]. According to Giampaoli et al.[32], the HGS test is reflective of global muscle strength and is used as an indicator of strength in the elderly. The strength of the lower limbs was measured by assessing bilateral knee extension strength (KES) using the 1-RM test. This practical and low-cost method is commonly used in large studies to determine muscle strength[17]. In the present study, the elderly subjects who performed better on the KES test also performed better on the 6MWT, which requires good muscle performance of the legs. This result demonstrates that the observed variations in walking velocity can be explained by changes in muscle strength.

The combination of increased fat mass and reduced muscle mass leads to an accelerated decline of physical performance in the elderly. In addition, many other factors are related to the decline of independence of the elderly, such as comorbidities, the use of medications, life habits and level of physical activity. These factors should all be considered in evaluating the functional capacity of these individuals[6,24,25].

A limitation of the present study was the restriction of the sample to the female gender, which limited the generalization of the results. In addition, due to the cross-sectional design of the study an association between body composition and physical function can be identified, but a cause-effect relationship cannot be determined. Thus, the present findings suggest that changes in body composition, especially an increase in fat mass, are an important cause of functional decline in the elderly. The increased prevalence of obesity among the elderly may not affect the mortality rate for elderly subjects but may lead to a substantial increase in the number of elderly subjects with compromised physical function.

Despite the strong evidence of a relationship between increased body fat and problems related to physical performance, whether this association varies with age remains unknown. As such, studies analyzing the association between body fat and physical performance in study populations of different age ranges are needed to identify elderly groups that are more susceptible to functional decline in order to apply better intervention measures.

Thus, the clinical implications of the present study are related to the importance of preventing the functional and muscular decline that occurs as a result of aging and developing interventions aimed at reducing weight and optimizing muscle strength and potency training in order to preserve the functionality and muscle quality of the elderly.

Conclusion

The group of elderly women who covered the shortest distance in the 6MWT had a higher BMI, a greater amount of fat mass and worse physical performance, suggesting that a high percentage of body fat has a negative influence on functional performance, even in active elderly women.

The present results also suggest that muscle quality is the best parameter of functionality since the high muscle mass in the group of elderly women with high body fat was not sufficient to maintain good strength and performance in the functional tests.

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