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Association between strength, flexibility, anthropometric measurements and muscle mass estimates in active elderly women

Associação entre força, flexibilidade, medidas antropométricas e estimativas de massa muscular em idosas ativas

Asociación entre fuerza, flexibilidad, medidas antropométricas y estimaciones de masa muscular en ancianas activas

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Abstract
Objective: to characterize physically active elderly women and correlate the variables muscle strength and flexibility with anthropometric parameters, Body Mass Index, Waist-Hip Index, Estimated Muscle Mass, and Muscle Mass Index. **Methods:** cross-sectional study with a quantitative approach, developed in a program entitled "*Universidade Aberta à Terceira Idade*" (Open University for the Elderly) of a public higher education institution, in 2016. Muscle strength was assessed by Handgrip Strength, flexibility by the Sit and Reach test, and anthropometric variables by tape measure. The Estimated Muscle Mass and Muscle Mass Index were calculated from the circumferences of the calf, thigh, and arm. Sociodemographic data were assessed through anamnesis. The Shapiro-Wilk test and Pearson's correlation test were used with a significance level of 5%. **Results:** 25 elderly women participated, with a mean age of 66.6 (±6 years), medication users, and a Body Mass Index of 30.77 (±5.85). Significant positive correlations were found between Body Mass Index and Waist-Hip Index (r=0.43, p=0.032); Estimated Muscle Mass and Body Mass Index (r=0.77, p=0.00); Muscle Mass Index and Body Mass Index (r=0.83; p=0.00); Muscle Mass Index and Estimated Muscle Mass (r=0.92, p=0.00); Handgrip Strength and Estimated Muscle Mass (r=0.40, p=0.047). And, a negative correlation between flexibility and Body Mass Index (r=-0.42, p=0.036). **Conclusion**: excess weight limits the flexibility of elderly people and although muscle mass is associated with strength, other physiological adaptations influence the degree of muscle strength.
Keywords: Aged; Muscle strength; Anthropometry; Functional status.

Resumo:
Objetivo: caracterizar idosas fisicamente ativas e correlacionar as variáveis força e flexibilidade muscular com parâmetros antropométricos, Índice de Massa Corporal, Índice Cintura Quadril, Estimativa da Massa Muscular e Índice de Massa Muscular. **Método:** estudo transversal, de abordagem quantitativa, desenvolvido num programa intitulado "Universidade Aberta à Terceira Idade" de uma instituição de ensino superior pública, em 2016. A força muscular foi avaliada pela Força de Preensão Palmar, flexibilidade pelo teste *Sit and Reach* e variáveis antropométricas por fita métrica. Das circunferências da panturrilha, coxa e braço foi calculada a Estimativa da Massa Muscular e Índice de Massa Muscular. Os dados sociodemográficos foram avaliados por meio da anamnese. Utilizou-se o teste de Shapiro Wilk e o teste de correlação de Pearson com significância de 5%. **Resultados:** participaram 25 idosas, com média de idade de 66,6 (±6 anos) anos, usuárias de medicamentos, com Índice de Massa Corporal de 30,77(±5,85). Verificou-se correlações significativas positivas entre Índice de Massa Corporal e Índice Cintura Quadril (r=0,43, p=0,032); Estimativa da Massa Muscular e Índice de Massa Corporal (r=0,77, p=0,00); Índice de Massa Muscular e Índice de Massa Corporal (r=0,83; p=0,00); Índice de Massa Muscular e Estimativa da Massa Muscular (r=0,92, p=0,00); Força de Preensão Palmar e Estimativa da Massa Muscular (r=0,40, p=0,047). E, uma correlação negativa entre flexibilidade e Índice de Massa Corporal (r=-0,42, p=0,036). **Conclusão:** o excesso de peso limita a flexibilidade da pessoa idosa e apesar da massa muscular apresentar associação com a força, outras adaptações fisiológicas influenciaram no grau de força muscular.
Palavras-chave: Idoso; Força muscular; Antropometria; Estado funcional.

Resumen
Objective: to characterize physically active elderly women and correlate the variables muscle strength and flexibility with anthropometric parameters, Body Mass Index, Waist-Hip Index, Estimated Muscle Mass, and Muscle Mass Index. **Methods:** cross-sectional study with a quantitative approach, developed in a program entitled "*Universidade Aberta à Terceira Idade*" (Open University for the Elderly) of a public higher education institution, in 2016. Muscle strength was assessed by Handgrip Strength, flexibility by the Sit and Reach test, and anthropometric variables by tape measure. The Estimated Muscle Mass and Muscle Mass Index were calculated from the circumferences of the calf, thigh, and arm. Sociodemographic data were assessed through anamnesis. The Shapiro-Wilk test and Pearson's correlation test were used with a significance level of 5%. **Results:** 25 elderly women participated, with a mean age of 66.6 (±6 years), medication users, and a Body Mass Index of 30.77 (±5.85). Significant positive correlations were found between Body Mass Index and Waist-Hip Index (r=0.43, p=0.032); Estimated Muscle Mass and Body Mass Index (r=0.77, p=0.00); Muscle Mass Index and Body Mass Index (r=0.83; p=0.00); Muscle Mass Index and Estimated Muscle Mass (r=0.92, p=0.00); Handgrip Strength and Estimated Muscle Mass (r=0.40, p=0.047). And, a negative correlation between flexibility and Body Mass Index (r=-0.42, p=0.036). **Conclusion**: excess weight limits the flexibility of elderly people and although muscle mass is associated with strength, other physiological adaptations influence the degree of muscle strength.
Palabras clave: Anciano; Fuerza muscular; Antropometría; Estado functional.

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INTRODUCTION

Population aging is a reality in Brazil, resulting from demographic, social and economic changes in the country. The life expectancy of Brazilians in 2023 is 77.4 years, and it is expected to reach 81.04 years in 2060[1]. Aging is a natural process, with physiological changes that vary from person to person. Among the changes that occur during this period of life are reduction of muscle mass and increase in body fat percentage, which interferes with anthropometric measurements[2].

Changes in the body composition of the elderly, in addition to contributing to the development of comorbidities, are associated with the reduction of muscle strength, flexibility and physical capacity[3]. The decline in physical function is an important indicator of frailty, which increases the risk of functional dependence, falls and hospitalization[4].

However, regular physical exercise plays a fundamental role in reducing functional declines resulting from the aging process. Active elderly individuals have better functional mobility and handgrip strength than sedentary individuals. For elderly women, muscle strength is a predictor of functional performance compared to body composition[5-6].

Therefore, in addition to functional performance, level of physical activity, flexibility and muscle strength, there is a need to include anthropometric variables in the assessment of elderly individuals. Anthropometric measurements such as the Waist-Hip Index (WHI), calf and arm circumferences and Body Mass Index (BMI) are highly effective in estimating the volume, fat and muscle distribution of an individual and are considered a practical and low-cost method applicable in clinical practice. Calf circumference is also a measurement closely linked to data on muscle mass and sarcopenia[7-8].

Few studies have correlated muscle mass measurements with anthropometric variables of physically active elderly individuals. Thus, this study aims to characterize physically active elderly women and correlate the variables of muscle strength and flexibility with anthropometric parameters, Body Mass Index, Waist-Hip Index, Estimated Muscle Mass and Muscle Mass Index.

METHODS

This is a cross-sectional study with a quantitative approach, developed between August and November 2016, in the "*Universidade Aberta à Terceira Idade - UATI*" (Open University for the Elderly) program of a federal public educational institution.

The UATI extension program develops several workshops aimed at the elderly, such as Memory, Use of WhatsApp™, Health and Well-Being, Rights of the Elderly, among others. The study included elderly women regularly enrolled in the UATI, over 60 years of age and classified as active or very active by the International Physical Activity Questionnaire (IPAQ) – short version. The criteria for exclusion from the study were: disabling diseases such as paralysis, stroke, cancer, hyperthyroidism, hypothyroidism, kidney or liver failure. Knowledge of the existence of these diseases was self-reported through a general health questionnaire[9-10].

Sociodemographic data such as age, medications in use, housing arrangement, educational level and general health questionnaire were assessed during the anamnesis. Physical and anthropometric variables, muscle strength, weight and height (to calculate BMI), waist and hip circumferences (to calculate WHI), calf, thigh and arm circumferences (to calculate MM) and flexibility were obtained by specific and qualified evaluators in order to standardize the assessment and avoid errors.

To assess Handgrip Strength (HGS), a JAMAR™ dynamometer with a unit of measurement in kilograms/force (kg/F) was used. During collection, the individuals were seated with the dominant upper limb positioned as follows: wrist and forearm in neutral position, elbow flexed at 90 degrees and arm adducted parallel to the trunk. The dynamometer was adjusted to position 2 for all women and three measurements were taken, with a minimum interval of one minute between repetitions[11].

The BMI was determined with a precision scale from the BALMAK brand with a maximum capacity of 300 kg and a maximum length of 2 meters. Based on these data, the BMI was calculated by the ratio between the weight (in kg) and the height squared[12].

The anthropometric variables were obtained using an inelastic tape measure, with a precision of 1 mm. The evaluators adopted centimeters as the reference unit of measurement. To assess the Waist-Hip Index (WHI), the waist was measured, with the tape positioned at the smallest curvature between the last ribs and the iliac crests. Then, the hip measurement was measured, with the tape positioned at the region of greatest volume in the hip area[13].

The values of height and circumferences of the calf (CP), thigh (CC) and arm (CB) were used to calculate the Estimated Muscle Mass (MM)[14]. Subsequently, the Muscle Mass Index (MMI) was obtained by dividing the MM by the height, in meters, squared.

To calculate the MME, the following were considered for men = 1 and women = 0; for race - Asians = 2.0; black = 1.1 and white = 0. The following formula was used[14]: *MM (kg) = height*^{2} x (0.00744 x arm circumference^2 + 0.00088 x thigh circumference^2 + 0.00441 x calf circumference)^2 + 2.4 x sex – 0.048 x age + race + 7.8.

The flexibility of the participants was assessed by the "Sit and Reach" test, using the Wells Bench. The elderly women sat on a mat, with their backs supported, lower limbs extended and positioned with their feet parallel to the support of the Wells Bench. At the evaluator's command, the participants flexed their torso and moved the marker measured in cm forward, flexing the torso, without flexing the knee or making any compensatory movements. The movement was performed three times and then, for analysis, the average of the three results was calculated[13].

The data regarding the characterization of the elderly women were described by means of descriptive statistics containing mean and standard deviation. The normality of the data of HGS, BMI, WHI, MM, MMI and flexibility was verified by the Shapiro Wilk test. All data followed a normal distribution, thus the correlation between variables was verified by the Pearson correlation test with a significance of 5%. A low correlation was considered r up to 0.25; a low correlation was considered r from 0.26 to 0.49; a fair correlation was considered r from 0.50 to 0.69; a high correlation was considered r from 0.70 to 0.89 and a very high correlation was considered r above 0.9015. Excel™ software was used to analyze the data and perform descriptive statistics. SPSS version 22 was used to perform the normality test and Pearson correlation.

The research was approved by the Research Ethics Committee of the Universidade Federal do Triângulo Mineiro under protocol number 853.59; and the research participants signed the Free and Informed Consent Form.

RESULTS

Twenty-five elderly women with a mean age of 66.6 (±6 years) were included in the study, of whom 23 required daily medication to control health parameters such as blood pressure, blood glucose and insomnia. Varied levels of education were observed, with the highest level corresponding to completion of the 3rd year of high school (Table 1).

Table 1. Characteristics of the elderly women. Uberaba/MG - Brazil, 2017.

Variables	Mean(SD)	%
Age (years)	66.6 (±5,3)	-
Take medication/Do not take medication	23/2	92/8
Work/Do not work	16/9	64/36
Lived with other people/Lived alone	24/1	96/4
Educational level: Primary/Secondary /Terciary	7/11/7	28/44/28

In the physical evaluation, the elderly women presented mean values of HGS: 24.90 (± 6.52) kg/f; WHI: 0.87 (± 0.07) cm; BMI: (30.77 ± 5.85); MM: 36.64 (± 7.54) kg; MMI: 15.80 (± 3.36) kg/m^2 and flexibility: (20.86 ± 9.8) cm (Table 2).

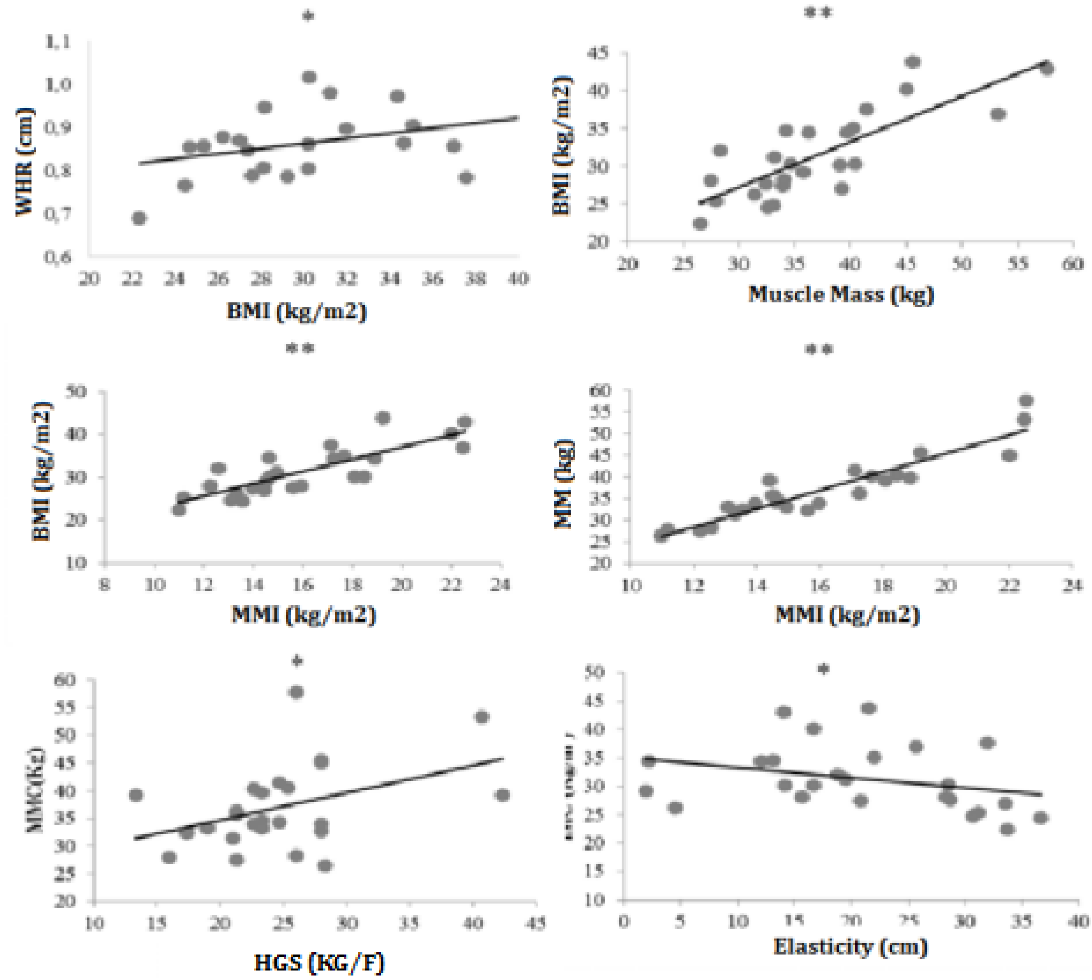
Table 2. Mean and SD of the studied variables. Uberaba/MG - Brazil, 2017.

Variable	Mean (SD)	CI
HGS	24.90 (±6.52)	22.21 - 27.60
WHI	0.87 (±0.07)	0.84 - 0.90
BMI	30.77 (±5.85)	28.37 - 33.21
MM	36.64 (±7.54)	33.55 - 39.77
MMI (Kgm^2)	15.80 (±3.36)	14.41 - 17.19
Flexibilidade	20.86 (±9.87)	16.78 - 24.94

HGS: handgrip strength (kg/force); **WHR:** waist-hip index (cm); **BMI:** body mass index (kg/m^2)**; MM:** muscle mass (kg); **MMI:** Muscle Mass Index (kg/m2)**. SD:** Standard deviation; **CI:** confidence interval.

Considering the interactions between the variables analyzed, significant positive correlations were found between BMI and WHI (r=0.43, p=0.032); MM and BMI (r=0.77, p=0.00); IMM and BMI (r=0.83; p=0.00); MMI and MM (r=0.92, p=0.00); HGS and MM (r=0.40, p=0.047); as well as a significant negative correlation between Flexibility and BMI (r=-0.42, p=0.036) (Figure 2).

Figure 2. Pearson correlation graphs between variables. Uberaba/MG - Brazil, 2017



HGS: handgrip strength (kg/force); WHR: waist-hip index (cm); BMI: body mass index; MM: muscle mass expressed in kg; MMI: Muscle Mass Index expressed in kg/m2. *p<0.05 **p<0.01

DISCUSSION

The HGS measurement is widely used in research and clinical practice and is associated with MM to assess sarcopenia. However, due to the scarcity of national studies investigating the normal values of this measurement, especially in the elderly population, Brazilian results are often compared to studies from other countries. In the present study, the HGS values were similar to the results of other studies[17-18].

The elderly women in this study obtained an average of 24.90 kg/f in HGS, being classified above the cut-off score of 20 kg/f, suggested by researchers who evaluated 154 elderly Brazilian women living in the community and followed the protocol proposed by the American Society of Hand Therapy (ASHT)[19]. In contrast, another study evaluated the functional performance of 37 elderly women participating in a program aimed at people aged 60 or over, and obtained an average of 27 kg/f in HGS[20]. Thus, an inverse association between age and HGS performance[21] is observed.

A significant positive correlation was found between HGS and the estimated MM of elderly women. Currently, it is recommended to measure muscle mass by means of Bioelectrical Impedance Analysis and Dual Energy X-ray Absorptiometry (DEXA)[8]. However, despite being accurate methods, they are too expensive to be used in clinical practice in Brazil, especially in primary and secondary care services. Therefore, studies suggest the evaluation of anthropometric measurements to estimate muscle mass in elderly people[22-24].

The results showed that variations in muscle mass indicators interfered with the HGS of active elderly women, which corroborates the results of a study that observed the interaction of HGS with the anthropometric measurements of 420 elderly people, which demonstrated a significant positive correlation between HGS and arm muscle area (r=0.29) and arm muscle circumference (r=0.30)[25]. In 2023, the muscle mass of 323 elderly people from the community was analyzed by DEXA and a positive correlation was identified between BMI and HGS (r=0.423)[26].

However, muscle mass alone is not capable of explaining muscle strength in elderly women, since even with a significant difference, the correlation was small. Linear regression analysis demonstrated that only 0.6% of muscle mass can explain HGS in this population. This demonstrates that other physiological adaptations, in addition to muscle mass, are related to the measurement of strength with age[27]. However, the findings of this study did not find any other correlation between HGS and the other variables analyzed.

A mean BMI value of 30.77 was found, classified as obesity, and a negative correlation of this parameter with flexibility. A similar result was found in a study[4] with elderly people from the community, in which it was identified that elderly women with obesity presented limited mobility and difficulty in performing tests that assess the range of joint movement. Increased adipose tissue and body size produce friction between joints, which reduces the capacity for myoarticular stretching[17]. However, other factors, such as reduced physical activity levels, can also influence test performance[20].

With aging, in addition to increased body fat, fat is also redistributed to the abdominal region. Thus, despite the logical correlation between BMI and WHI, increased abdominal circumference increases the risk of developing cardiometabolic diseases and mortality in elderly individuals with different BMI classifications[28].

Furthermore, significant positive correlations were found between BMI and the estimated MM and IMM. Similarly, an epidemiological study of elderly individuals in the community found a strong correlation between appendicular muscle mass and BMI. This relationship shows that changes in body composition that influence muscle mass also appear to be associated with a reduction or increase in adipose tissue[26].

CONCLUSION

It is possible to conclude that excess weight influences flexibility limitations in elderly individuals. BMI and WHI have a positive correlation and should be used in clinical practice as predictors of global and central obesity, respectively. Although muscle mass is associated with muscle strength, other physiological adaptations influence the degree of muscle strength in elderly individuals. Future studies with this population are necessary, with a view to finding a factor that best correlates with the strength level of active elderly individuals.

Therefore, in addition to assessing functional capacities, physical activity levels, flexibility and muscle strength, anthropometric variables should also be included in the assessment of elderly individuals, contributing to possible clinical interventions aimed at minimizing functional losses.

The limitations of the study include: the lack of a control group with sedentary elderly individuals to compare the results obtained; the convenience sample, resulting only in female elderly individuals, since they are the most frequent participants in the UATI; and the cross-sectional approach that does not allow establishing cause and effect relationships.

Despite this, this research brings, at a given moment and group, results that in themselves can be used in the context of other regions and groups, which point to the need for other works with other designs that can instrumentalize clinical practice with the elderly.

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