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Relationship between strength and muscle mass in middle-aged and elderly women: a cross-sectional study

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Abstract

Objective: to analyze the relationship between handgrip strength and lower limb strength and the amount of segmental skeletal muscle mass in middle-aged and elderly women. *Methods:* an observational, cross-sectional, observational study of 540 women aged between 40 and 80 years in the cities of Parnamirim and Santa Cruz, Rio Grande do Norte, was performed. Sociodemographic data, anthropometric measurements, handgrip dynamometry, knee flexors and extensors of the dominant limbs, as well as the segmental muscle mass of the limbs were evaluated. Data were analyzed using Student's t-Test, Chi-square test, Effect Size and Pearson's Correlation (CI 95%). *Results:* there were statistically significant weak and moderate correlations between handgrip strength and upper limb muscle mass, knee flexion strength and lower limb muscle mass, and between knee extension strength and lower limb muscle mass for the age groups 40-59 years and 60 years or more ($p<0.05$). *Conclusions:* muscle strength correlates with skeletal muscle mass. It could therefore be an indicator of the decrease in strength. It is not the only such indicator, however, as correlations were weak and moderate, which suggests the need for more studies on this theme to elucidate which components may also influence the loss of strength with aging.

Keywords: Muscle Strength. Women. Aging. Body Composition.

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INTRODUCTION

Aging generates many health challenges that cover psychological, social, biological and functional issues[1]. Both in Brazil and around the world population aging has been marked by feminization, a process in which women achieve greater rates of longevity than men[2].

The aging process is associated with a progressive reduction in skeletal muscle mass, related to a change in body composition and known as sarcopenia[3]. There is therefore a decrease in muscle strength, with a consequent increase in the risk of health problems and a decline in physical and functional abilities[4,5].

Loss of strength occurs more rapidly in women at around the age of 50 (the average age of the onset of menopause) while it is observed in men at around 60 years of age[6].

During the menopausal transition hormonal changes occur which are the result of the low number of functioning ovarian follicles[7]. Evidence suggests that changes in the hormonal state, especially a reduction in estradiol, lead to an increase in fat mass, a decline in lean and bone mass[8], and contribute, directly or indirectly, to a reduction in functionality[9].

Decreased muscle strength is mainly associated with loss of skeletal muscle mass, however, the reduction of muscle strength may also occur due to other factors such as increased non-contractile tissue[10], reductions in neural recruitment capacity and changes in muscle contraction properties[11].

It is assumed that a decrease in skeletal muscle mass occurs after the age of 50 and that this loss is more evident in the lower limbs[10]. Almeida & Greguol[7] suggest that there is a decrease in muscle mass of approximately 2.5% per decade, which can lead to changes in balance, proprioception and the ability to walk, resulting in a higher risk of falls, bed restrictions and increased functional dependence[5].

In terms of hand grip strength, which is recognized as a method of predicting body muscular-skeletal functioning[12], it has been demonstrated that low grip strength may result in a greater probability of functional limitations and consequently death[13,14]. In addition, elderly persons with a history of frequent falls have lower levels of hand grip strength and, consequently, lower limb strength levels, than elderly individuals without a history of falls[13].

Focusing on understanding female aging is relevant given the feminization of the elderly population. Studying the changes in muscle mass associated with menopause is important, given the high number of women going through this period and the risks associated with the physical incapacity it can create.

Therefore, the objective of the present study was to analyze the relationship between hand grip strength and lower limb strength and the amount of segmental skeletal muscle mass in middle-aged and elderly women in the municipalities of Parnamirim and Santa Cruz, in the state of Rio Grande do Norte, Brazil.

METHODS

An observational, cross-sectional analytical study was performed. The population was made up of women living in the municipal regions of Parnamirim and Santa Cruz, both cities located in Rio Grande do Norte, Brazil. In the city of Parnamirim women between 40 and 65 years were selected, while in Santa Cruz those between 40 and 80 years were included. The sample was convenience based and occurred after the disclosure of the project in basic health units of the cities.

Sample size calculation took into account the hand grip strength variable and considered a 95% confidence level, a mean difference between age groups of 2.0 kgf and an average standard deviation of 5.0 kgf, with a power of 95%, giving a minimum sample of 134 subjects in each group. Considering the sample availability, an additional 134 subjects were added to this total.

Participants who were present at the research site, met the inclusion criteria and signed a Free and Informed Consent Form (FICF) made up the sample of the present study, giving a total of 540 women, 406 of whom were aged between 40 and 59 years and 134 of whom were aged 60 to 80 years. The data of the present study were collected in Parnamirim in 2014 and Santa Cruz in 2016.

The inclusion criteria of the study were age between 40 and 80 years, an absence of diseases that would impair the measurement of limb dynamometry, such as degenerative and neurological diseases, limb fractures and pain. The project was submitted for evaluation by the local Ethics Research Committee and was approved under opinion no. 1,178,143, in accordance with the provisions of the Declaration of Helsinki and Resolution No. 466/12 of the National Health Council. Upon arrival at the evaluation, the objectives and procedures of the study were explained to the women and they were asked to sign the FICF.

Data collection was performed by interviewers previously trained in the collection procedures and a structured questionnaire was used to record identification data, sociodemographic information, and anthropometric measures such as weight and height. Body mass index (BMI) was also calculated.

An evaluation of hand grip strength of the dominant upper limb was initially performed, measured by the Saehan® 15 dynamometer calibrated by the manufacturers and never previously used. This measuring units used were kilograms/force(Kgf). The participants were placed in a sitting position, with the shoulder adducted and in a neutral rotation, the elbow positioned at 90º flexion, and the forearm and wrist, which could be moved to up to 30º of extension, in neutral positions, and the contralateral limb relaxed on the thigh. The participants were instructed and verbally encouraged to exert the greatest possible voluntary isometric force, with the dynamometer in the second position, referring to the size of the grip, according to the recommendations of the American Society of Hand Therapists[16]. Three sustained contractions of five seconds were performed, with a one-minute interval between measurements, and the arithmetic mean of the three measurements was considered[17].

Next, the muscle strength (MS) of the knee extensors and flexors of the dominant lower limb was evaluated with a MicroFET2® portable dynamometer model (West Jordan, UT, USA), duly calibrated by the manufacturers. Muscle strength was recorded in units of kilograms/force (Kgf).

To evaluate the strength of the knee extensors, the volunteer was placed on the evaluation table with the legs dangling, knees positioned at 90 degrees and hands on the thighs[18], with the dynamometer distal and anterior to the dominant leg. To dynamometric evaluation of the knee flexors, the volunteer was positioned in a unipedal orthostatic position, knees fully extended (0º), with the support of both upper limbs on the evaluation table and the dynamometer fixed to the distal surface of the dominant leg, near to the malleolus line[19].

To measure knee flexor and extensor strength, three maximum voluntary isometric contractions were requested, each with a duration of five seconds and an interval of one minute between each. The arithmetic mean of the three measures was considered[19].

To obtain muscle mass values, body composition was evaluated on a previously scheduled day with the InBody R20 electrical bioimpedance device, which automatically calculates muscle mass based on the manufacturer's prediction equations. The device uses eight electrodes, two in each foot and two in each hand and performs measurements in a segmented manner and in two frequencies, 20 kHz and 100 kHz, through an applied current of 250µA[20]. The bioimpedance evaluation correlates closely with the predictions made using dual energy radiological absorptiometry (DXA)[21] and is considered a reliable and useful alternative for the evaluation of skeletal muscle mass in middle-aged women[22]. Prior to the test, the volunteer received instructions and was asked to wear light clothing, to not eat or exercise at least two hours prior to the exam, and to go to the toilet to empty the bladder[20]. During the test, which lasts from 40 seconds to 1 minute, the women were position on the foot electrodes on the surface of the digital scale of the device, and instructed to hold the other electrodes that are attached to a bar. They were asked to remain in the same posture and to not move or speak[20].

Data analysis was performed using descriptive statistics by means of central tendency (arithmetic mean), dispersion (standard deviation) for the quantitative variables weight, height, BMI and dynamometry and muscle mass, and absolute and relative frequencies for the variable ethnicity. The findings were summarized according to the age groups (40 to 59 years, 60 years or more).

The Kolmogorov-Smirnov test was used to verify the normality of the data. The Student's t-test and the chi-square test were then performed to compare the quantitative and categorical variables in relation to the age groups. In addition, the Effect Size of the sample was calculated using Cohen's *d* to verify the magnitude of these associations. Finally, the Pearson correlation test was applied to evaluate the correlation between the strength measurements and the skeletal muscle mass of the upper and lower limbs measurements. Throughout the analysis, a 95% confidence interval (CI) and $p<0.05$ were considered.

RESULTS

The present study evaluated a total of 540 women. Table 1 shows the results of the characterization of the sample, summarized according to age group. The mean age of the 40-59 age group was 50.3 (4.6) years, while in the age group of 60 or over it was 67.2 (5.9) years. The group composed of elderly women had a lower mean number of years of study and a higher percentage of women who declared themselves to be mixed-race than in the younger group. In addition, the means of mass and muscle strength in the younger group were higher than those found in the group aged 60 years or older. The other characteristics of the sample related to anthropometric, mean strength and muscle mass measurements and effect size are shown in Table 01.

Table 2 shows the data related to the correlation between upper limb muscle mass and grip strength, lower limb muscle mass and knee flexor and extensor strength. It also shows data on muscle mass and upper and lower limb strength in relation to age. All correlations were weak and moderate.

Table 1. Characterization of sample study based on age ranges (n=540). Natal, Rio Grande do Norte, 2017.

Variables	Age range (years)				Total		Effect size (Cohen's d)	*p* value
	40-59		60 or over		n (%)			
	n (%)	Mean (±sd)	n (%)	Mean (±sd)		Mean (±sd)		
Years of schooling	8.74 (4.21)		5.00 (4.29)		7.81 (4.53)		0.87	<0.001[a]
Color/Ethnicity								
White/Caucasian		158 (38.90)		36 (26.90)		194 (35.90)	3.64	0.02[b]
Black/Afro-Brazilian		23 (5.70)		6 (4.50)		29 (5.40)	3.31	
Brown/Mixed-Race		255 (55.40)		92 (68.70)		317 (58.70)	2.13	
Body Mass Index	28.99 (4.67)		28.62 (4.75)		28.90 (4.69)		0.07	0.42[a]
Hand grip strength (Kgf)	26.81 (5.21)		24.07 (4.68)		26.13 (5.21)		0.55	<0.001[a]
Knee flexor strength (Kgf)	14.80 (5.54)		12.25 (4.19)		14.16 (5.35)		0.51	<0.001[a]
Knee extensor strength (Kgf)	22.77 (7.77)		18.73 (6.51)		21.77 (7.67)		0.56	<0.001[a]
Upper limb skeletal muscle strength (Kg)	2.37 (0.98)		2.09 (0.46)		2.30 (0.89)		0.36	0.002[a]
Lower limb skeletal muscle strength (Kg)	5.77 (0.97)		5.16 (1.09)		5.61 (1.03)		0.59	<0.001[a]

a- *p* value for Student's T-test; b- *p* value for Chi-squared test

Table 2. Correlation between mean segment muscle mass and upper and lower limb strength and age of middle-aged and elderly women (N=540). Natal, Rio Grande do Norte, 2017.

	Age range					
	40 - 59 years		≥60 years		Total	
Variables	r	*p*	r	*p*	r	*p*
Upper limb muscle mass and Hand grip strength	0.135	0.006[a]	0.460	<0.001[a]	0.195	<0.001[a]
Lower limb muscle mass and Knee flexor strength	0.280	<0.001[a]	0.217	0.01[a]	0.302	<0.001[a]
Lower limb muscle mass and Knee extensor strength	0.265	<0.001[a]	0.299	<0.001[a]	0.313	<0.001[a]
Upper limb muscle mass and Age	-0.009	0.85[a]	-0.291	0.001[a]	-0.140	0.001[a]
Lower limb muscle mass and Age	-0.070	0.15[a]	-0.343	<0.001[a]	-0.294	<0.001[a]
Upper limb muscle strength and age	-0.167	0.001[a]	-0.327	<0.001[a]	-0.302	<0.001[a]
Knee flexor strength and age	-0.081	0.10[a]	-0.127	0.14[a]	-0.220	<0.001[a]
Knee extensor strength and Age	-0.092	0.06[a]	-0.261	0.002[a]	-0.261	<0.001[a]

a – *p*: value for Pearson Correlation Coefficient.

DISCUSSION

The present study evaluated the relationship between muscular manual grip and knee flexor and extensor strength with the amount of skeletal muscle mass present in the dominant segments of the upper and lower limbs in middle-aged and elderly women. When the data was analyzed, a significant and positive correlation was observed regarding the variables segmental muscle mass and manual grip and knee flexor and extensor muscle strength in the two age groups. These findings agree with the studies by Alizadehkhaiyat et al.[23] and Charlier et al.[24], which state that muscle strength generation capacity is directly proportional to the skeletal muscle mass of these segments.

However, the correlations between upper limb muscle mass and hand grip strength and lower limb muscle strength and knee extensor and flexor strength in the age group of 40 to 59 years were weak in the present study. Throughout the aging process, there is a reduction in the number of motor units[25], which can influence the generation of muscle strength in middle-aged women, together with muscle mass, neural factors and characteristics related to muscle quality, such as fiber type, fat infiltration or the extracellular matrix[25,26]. These factors may justify the weak correlation between strength and muscle mass in this age group.

In older women (60 years of age or older), there was a moderate correlation between upper limb muscle mass and hand grip strength. With aging, the aforementioned factors related to muscle strength appear to diminish, resulting in a decline in muscle strength that occurs more markedly than the decline in muscle mass[27]. Thus, in this age group, muscle mass is more strongly correlated with skeletal muscle strength in the upper limbs.

In terms of knee extensor and flexor strength, the correlation between mass and muscle strength remained weak. Samuel et al.[28] found that the strength of the lower limbs declines more severely than that of the superior limbs during aging. This finding is due to the upper limbs being constantly used in all stages of life, while the use of the lower limbs diminishes with age[29].

Although muscle mass reduction has been found to be associated with loss of strength and performance over the years[6], Legrand et al.[30] suggested that poor physical performance is associated with low strength generation, even after considering other risk factors for sarcopenia in the elderly, thus supporting the hypothesis that muscle strength is a better indicator of physical performance than muscle mass[30].

It is therefore important to consider that although the amount of muscle mass may be a major contributor to strength generation, muscle strength tends to decrease faster than muscle mass, thus suggesting a decline in muscle quality[10,30].

Muscle strength results from a combination of muscle mass and muscle quality[26]. Variations in muscle quality[26] and factors such as low physical activity and protein intake, biological factors, oxidative stress, inflammation, estrogen deficiency[6], among other predictors of sarcopenia, may explain why muscle mass is a relatively weak indicator of functional capacity.

Thus, loss of muscle mass alone does not have such significant clinical implications, since muscle strength or performance does not depend exclusively on muscle mass, but also other factors involved in the generation of strength, such as neural and hormonal components[31].

The present study reveals the importance of the careful study and clinical evaluation of muscle strength, which can identify important aspects of the aging process. Low muscle strength in elderly individuals is an important marker of the risk of mortality in this population, with the amount of muscle mass presented by the individual of little relevance[4].

Also from the data obtained in this study, a negative result was found when correlating age with muscle mass and muscle strength. Although the values obtained show weak and moderate correlations for the two age groups, they indicate a reduction in muscle mass and muscle strength with advancing age. This finding is consensual in scientific research[4,31].

The main consequences of the loss of strength that occurs with advancing age are physical limitations, the mobility deficit and incapacity, which increase the risk of falls, fractures, hospitalizations, dependency, fragility and mortality[32,5].

This quantitative decline coupled with the qualitative decline in the functionality and structure of the muscular system results in significant implications for the functional capacity of the elderly[33]. These modifications that occur in the muscular system due to the aging process impair the performance of motor skills, directly altering the ability of elderly individuals to perform instrumental and basic activities of daily living and making it difficult to adapt to the environment in which they live[27].

Thus, for the population of this study, this evaluation may indicate important aspects relating to the physical performance, health and quality of life of women. Although women live longer, they have worse health outcomes throughout the aging process[34], especially regarding to the deficit of strength and muscle mass, which seems to occur at an earlier age than men at around the time of menopause[6].

Considering that satisfactory muscle strength is necessary for the accomplishment of functional activities, studies that investigate the relationship between the quantitative and qualitative aspects of skeletal muscle more closely, establishing the relationship between these aspects and corporal composition and other factors that influence muscle function, are important for identifying clinical parameters that are easy to access and interpret for health professionals.

From this perspective, effective diagnosis enables the development of effective strategies and interventions for prevention, such as physical activity and the treatment and rehabilitation of disabilities, optimizing functional independence, which will have repercussions on the health, longevity and quality of life of this population.

In terms of limitations, as a cross-sectional study the present study did not allow the exploration of the relationship between skeletal muscle mass and muscle strength over time, and a cause-effect relationship cannot be established, limiting research into factors that influence the correlation found in this study. Another possible limitation of the study was the sample formation process, which occurred in a non-random manner (for convenience). However, considering that the socioeconomic characteristics are similar to those found in another study in this area[34,35], and the consistency and robustness of the results, we believe that this limitation had a limited impact on the established inferences.

CONCLUSIONS

The results of the present study suggest that the grip strength and knee flexor and extensor strength of women aged between 40 and 80 years correlated positively with the skeletal muscle mass of the respective segment. The correlations were weak for grip strength in women aged 40 to 59 years and also for knee flexor and extensor strength in both age groups. In addition, a moderate correlation between grip strength and muscle mass was verified in women aged 60 years or older. These findings support the hypothesis that muscle mass is one of the aspects that determine the ability of muscles to produce strength. However, muscle mass does not fully explain the decrease in muscle strength, suggesting a decline in muscle quality which is also determined by other factors that were not addressed in the present study.

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