REV ASSOC MED BRAS. 2013;**59(2)**:128-135

Revista da
ASSOCIAÇÃO MÉDICA BRASILEIRA

www.ramb.org.br

Original article

Handgrip strength and flexibility and their association with anthropometric variables in the elderly☆

Nathalie de Almeida Silva, Tarciana Nobre de Menezes, Rômulo Lustosa Pimenteira de Melo, Dixis Figueroa Pedraza*

Universidade Estadual da Paraíba, Campina Grande, PB, Brazil

ARTICLE INFO

Article history:
Received 2 April 2012
Accepted 15 October 2012

Keywords:
Elderly
Anthropometrics
Flexibility
Muscular strength

A B S T R A C T

Objective: To verify the correlation between handgrip strength (HGS) and flexibility with age and anthropometric variables in the elderly.
Methods: This was a cross-sectional home-based study of elderly individuals enrolled in the Family Health Strategy of Campina Grande/PB. Gender, age, HGS, flexibility, arm muscle circumference (AMC), corrected arm muscle area (CAMA), and body mass index (BMI) were recorded.
Results: A total of 420 elderly individuals were evaluated. Correlations of HGS with age, AMC and CAMA, in both genders, were observed. BMI correlated with HGS only in females. Flexibility correlated with BMI in males. In the multivariate analysis, age and AMC were predictive variables of the HGS variation in females. In males, age was the only variable predictive of HGS, and BMI was the predictor of flexibility variation.
Conclusion: The results indicate a probable influence of age and anthropometric variables in muscular strength, as well as that of excess weight in flexibility limitation.

Força de preensão manual e flexibilidade e suas relações com variáveis antropométricas em idosos

Palavras-chave:
Idoso
Antropometria
Flexibilidade
Força muscular

R E S U M O

Objetivo: Verificar a correlação da força de preensão manual (FPM) e flexibilidade com idade e variáveis antropométricas em idosos.
Métodos: Este estudo é transversal, domiciliar, realizado com idosos cadastrados na Estratégia Saúde da Família de Campina Grande/PB. Foram verificados: sexo, grupo etário, força de preensão manual, flexibilidade, circunferência muscular do braço (CMB), área muscular do braço corrigida (AMBc) e índice de massa corporal (IMC).
Resultados: Foram avaliados 420 idosos. Verificaram-se correlações da FPM com idade, CMB e AMBc, em ambos os sexos. O IMC apresentou correlação com FPM apenas no sexo feminino.

☆Study conducted at the Universidade Estadual da Paraíba (UEPB), Campina Grande, PB, Brazil
*Corresponding author at: Rua Coronel Manoel Rafael, 98, Centro, Monteiro, PB, 58500-000, Brazil
E-mail: nathaliegmr@yahoo.com.br (N.A. Silva)

A flexibilidade correlacionou-se com IMC no sexo masculino. Na análise multivariada, idade e CMB foram variáveis preditivas da variação da FPM, no sexo feminino. No sexo masculino, apenas a idade foi variável preditiva da FPM. No sexo masculino, apenas o IMC foi preditivo da variação da flexibilidade.

Conclusão: Os resultados sugerem uma provável influência da idade e de variáveis antropométricas na força muscular, bem como do excesso de peso na limitação da flexibilidade.

Introduction

The aging process results in body alterations that can interfere with the functional capacity and independence of the elderly to perform daily activities. Thus, assessment of physical capacity of the elderly commonly involves functional tests, such as muscular strength and flexibility, which are directly involved in the performance of these activities.[1]

Handgrip strength (HGS) is an important indicator of overall muscular strength,[2] and is the most appropriate measure for evaluating strength, as it does not require great physical effort on the part of elderly.[3] This measure is of great scientific and outpatient value, as muscular strength deficit may be related to incapacity and dependence in elderly individuals.[4]

Flexibility, has also been used as a way to assess the functional capacity of the elderly, considering that impairment has major implications on movement efficiency.[5] The aging process is accompanied by a loss of flexibility, usually associated with mechanical and biochemical alterations in the musculoskeletal system, which compromise the range of motion, thus reducing flexibility in different segments.[6]

In addition to functional alterations, the aging process results in bodily changes, which can impair the strength and flexibility of the elderly. Muscle mass decreases substantially, which is the main factor related to loss of strength.[3] Body fat tends to increase during the first decades of aging, and to decrease in later decades of life.[3] Moreover, there is a redistribution of adipose tissue, decreasing in the region of the arms and legs and accumulating in the trunk and viscera.[7]

Considering the alterations in strength, flexibility, fat, and muscle mass caused by aging, studies have been performed in different areas of the world in order to evaluate the influence of age and body alterations on the functional capacity of the elderly,[8-12] considering that these alterations, as well as advancing age, can lead to functional limitations, affecting the quality of life of elderly individuals, exposing them to high morbidity and mortality risk.[13]

There are few studies conducted in Brazil that evaluated the correlation of anthropometric variables with handgrip strength and flexibility of the elderly.[4,7,11,14,15] Of these, only the study by Barbosa et al.[4] evaluated the influence of anthropometric variables on handgrip strength, in a representative sample of the population.

The scarcity of studies in Brazil evaluating the influence of anthropometric variables on strength and flexibility makes data comparison in elderly from different regions of the country difficult, leading to the use of international studies for this evaluation. This fact results in certain limitations, considering the differences between the populations.[16] Thus, Onis and Habicht[17] emphasize the need to determine reference values for the elderly population according to gender and local conditions.

Therefore, this study aimed to investigate the correlation between anthropometric variables and age on HGS and flexibility of the elderly. It is expected that this study can provide information on the factors associated with alterations in strength and flexibility, helping to compare with the elderly from different populations.

Methods

This was a home-based, cross-sectional study with primary data collection, and is part of a larger study that aimed to conduct a multidimensional health assessment of the elderly individuals enrolled in the Family Health Strategy in Campina Grande, state of Paraiba, Brazil.

According to information from the Department of Health in 2008, there were 23,416 elderly enrolled in the 63 basic family health units (*unidades básicas de saúde da família* – UBSF) in Campina Grande, distributed in the six health districts of the city. The sample size was calculated with an estimated prevalence of outcomes of at least 25%. The sample size calculation was performed using the following equation: $\{[E^2 \times p\ (1-p)] \times c\} / A^2$, where E is the confidence limit (1.96), c is the sample correlation coefficient (2.1), as it was a conglomerate sampling, and A is the acceptable accuracy for the estimated prevalence (A = 6%). The sample was proportional to each health district, consisting of 420 elderly individuals.

Individuals aged 60 or older, of both genders, were selected for the sample. Elderly individuals with diseases that had no therapeutic options, those with severe clinical weakness, and those who were absent from Campina Grande longer than the duration of the fieldwork in their respective UBSF were excluded. Moreover, exclusion criteria were established for each functional test (HGS and flexibility).

Fieldwork was carried out from August, 2009 to July, 2010, by three pairs of trained interviewers. The variables evaluated were: gender, age, HGS, flexibility, arm muscle circumference (AMC), corrected arm muscle area (CAMA), and body mass index (BMI).

Handgrip strength

HGS was measured using a manual hydraulic dynamometer (Takei Kiki Kogyo Dynamometer® TK 1201 – Japan), adjusted for each individual according to hand size. The test performance was conducted according to the techniques proposed by Rantanen et al.[18] Elderly submitted to arm or hand surgery in the three months prior to data collection were excluded from the test.

Flexibility/mobility

The flexibility/mobility test used in this study was the "pick up a pen" test proposed by Reuben and Siu.[19] The elderly submitted to cataract or retinal surgery in the six weeks prior to the interview were excluded from this test. The test was not performed with elderly individuals who were bedridden or wheelchair-bound or those that, for some reason, could not stand up.

Anthropometrics

Weight and height were measured to calculate BMI, which is the ratio between weight and height squared (kg/m^2). The weight (kg) was measured with a portable digital scale (TANITA UM080) with a 150-kg capacity and 100-g sensitivity. Height (m) was measured on a portable stadiometer (Altura Exata). Weight and height were measured according to the techniques proposed by Gordon et al.[20]

Muscle mass was assessed by AMC and CAMA. Triceps skinfold (TSF) and arm circumference (AC) were measured to perform the calculation. AC was measured based on the techniques by Callaway et al.,[21] using an inelastic tape with 1-mm accuracy. TSF was measured according to the techniques proposed by Harrison et al.,[22] using a Lange compass with a constant pressure of 10 g/mm^2. The AMC was calculated through the following equation:[23]

$$\text{AMC (cm)} = [\text{AC (cm)} - (\pi \times \text{TSF (cm)})]$$

CAMA was calculated through the equation proposed by Heymsfield et al.:[24]

$$\text{Men:} \quad \text{CAMA (cm}^2) = \frac{[\text{AC (cm)} - (\pi \times \text{TSF (cm)})]^2}{4\,\pi} - 10$$

$$\text{Women:} \quad \text{CAMA (cm}^2) = \frac{[\text{AC (cm)} - (\pi \times \text{TSF (cm)})]^2}{4\,\pi} - 6.5$$

Statistical procedures

The elderly were grouped according to gender (male and female) and age group (60 to 69 years, 70 to 79 years, and 80 years or older). HGS, flexibility, and anthropometric variables are shown as mean and standard deviation (SD). The statistical significance of differences of means between the genders was verified using Student's *t*-test. One-way analysis of variance (ANOVA) was used, with Tukey's *post-hoc* test, to verify the effect of the age group on HGS, flexibility, and anthropometric variables.

To determine the influence of age, BMI, AMC, and CAMA on the variability in muscular strength and flexibility tests, bivariate (Pearson's correlation) and multivariate (linear regression) analysis techniques were used. The stepwise method was used for the inclusion of variables in the multiple linear regression equation. A 95% confidence interval was used in all analyses. Statistical data were obtained by using the Statistical Package for Social Sciences (SPSS) software, release 17.0.

Ethical questions

The larger study, of which this study is part, was submitted to and approved by the Research Ethics Committee (REC) of the Universidade Estadual da Paraíba (UEPB) (CAAE: 0228.0.133.000-08). The elderly, after accepting to participate in the study, signed an informed consent, in accordance with the Resolution 196/96.

Results

A total of 420 elderly patients (68.1% women) were interviewed, aged from 60 to 104 years. Mean age was 71.57 years (± 9.19). Of the 420 elderly patients studied, 417 underwent the HGS test, and 368 underwent the flexibility test. It was not possible to calculate the BMI of 24 elderly, considering the difficulty or impossibility of measuring their weight and/or height. AMC and CAMA were calculated in 418 elderly.

Table 1 shows the information regarding the means and standard deviations of the HGS and flexibility test values and anthropometric variables, with respective significance values of the mean differences between the genders and age groups. The mean HGS value was significantly higher in men (31.0 ± 8.8 kg) when compared to women (19.1 ± 6.1 kg) ($p < 0.001$). The mean HGS was higher in the age group of 60 to 69 years in both genders. Women showed a significant difference in HGS among all age groups. However, men only showed a significant difference between the groups of 60 to 69 years and 80 years or older, and 70 to 79 years and 80 years or older.

No statistically significant difference was observed between men and women, nor between the age groups, in the flexibility test.

In the female gender, the mean BMI was higher (27.7 kg/m^2) than in males (25.8 kg/m^2), with statistically significant difference between means ($p < 0.001$). The mean AMC was significantly higher in males (24.8 cm) when compared to females (23.6 cm). No statistically significant difference was found between the mean values of CAMA and gender.

Regarding BMI, when comparing age groups, a significant difference was observed among them in women; this difference was observed between the groups of 60 to 69 years and 70 to 79 years with the group 80 years or older. Regarding AMC and CAMA, a significant difference was observed in both

Table 1 – Mean and standard deviation values of the handgrip strength and flexibility tests and of anthropometric variables, by gender and age group. Campina Grande, Paraíba, Brazil.

Variables	Gender							
	Female				Male			
	n	Mean	SD	p	n	Mean	SD	p
HGS (kg)[a]				< 0.001				< 0.001
60-69 years	138	21.7[b,c]	5.5		64	32.9[c]	8.7	
70-79 years	93	18.2[b,d]	5.3		42	32.7[d]	7.7	
80 years or older	52	13.9[c,d]	5.3		27	23.7[c,d]	6.7	
Total	283	19.1	6.1		133	31.0	8.8	
Flexibility/mobility (seconds)				0.21				0.58
60-69 years	132	2.75	1.9		62	3.04	2.0	
70-79 years	80	2.82	1.2		36	2.85	1.7	
80 years or older	34	3.33	1.8		23	3.38	1.7	
Total	246	2.85	1.7		121	3.05	1.9	
BMI (kg/m^2)[a]				< 0.001				0.19
60-69 years	138	28.5[c]	4.7		63	26.5	4.1	
70-79 years	91	27.7[d]	5.9		38	25.3	3.4	
80 years or older	40	25.0[c,d]	4.6		25	24.9	4.0	
Total	269	27.7	5.2		126	25.8	3.9	
AMC (cm)[a]				< 0.001				< 0.001
60-69 years	140	24.1[c]	3.1		64	25.5[c]	2.9	
70-79 years	92	23.5	3.5		42	24.8	2.1	
80 years or older	52	22.2[c]	4.2		27	23.3[c]	2.0	
Total	284	23.6	3.5		133	24.8	2.6	
CAMA (cm^2)				< 0.001				< 0.001
60-69 years	139	41.1[c]	11.8		64	42.4[c]	12.3	
70-79 years	92	38.7	13.6		42	39.3	8.5	
80 years or older	52	34.3[c]	15.9		27	33.7[c]	7.8	
Total	283	39.1	13.4		133	39.7	10.8	

AMC, arm muscle circumference; BMI, body mass index; CAMA, corrected arm muscle area; HGS, handgrip strength; SD, standard deviation.
[a] Statistically significant difference between genders (Student's t-test); p = statistical significance between age groups (ANOVA); Tukey's comparison.
[b] Significant difference between the groups aged 60 to 69 and 70 to 79 years.
[c] Significant difference between the groups 60 to 69 and 80 years or older.
[d] Significant difference between the groups 70 to 79 years and 80 years or older.

genders between the group of 60 to 69 years and 80 years or older.

Table 2 shows the results of the bivariate analysis between HGS and flexibility/mobility with age, BMI, CAMA and AMC, according to gender. Age showed a negative and significant correlation with HGS in both females (r = 0.49) and males (r = 0.37). A positive and significant correlation was found between HGS and BMI only among women. The variables AMC and CAMA were positively and significantly correlated with HGS in both genders.

In women, no significant correlations were observed between flexibility/mobility and age, BMI, AMC, and CAMA. In men, there was only a significant positive correlation between flexibility/mobility and BMI.

Table 3 shows the multiple linear regression model for the variables HGS and flexibility/mobility, according to gender. After testing all the variables that showed significant correlations, the results show that, in women, the variables age and AMC significantly predicted 24% (R^2 = 0.24) of the HGS variation. Among men, only age (R = 0.367) showed a predictive value, explaining HGS variation in 13% (R^2 = 0.13). The multivariate analysis was performed only for flexibility/mobility in men, as women did not show statistically significant correlations. Only BMI showed a significant correlation with flexibility/mobility (R = 0.188); however, with a low predictive value (R^2 = 0.036). The other variables were excluded from the model due to strong collinearity.

Discussion

Aspects related to bodily and physical changes resulting from the aging process have been studied worldwide.[6,13,15,19,25-27] Alterations in strength and flexibility, as well as in markers of reserve muscle mass and body fat, are subjects commonly assessed in studies in Brazil,[1,6,9,28,29] as well as in international

Table 2 – Pearson's correlation between handgrip strength and flexibility/mobility with age, body mass index, corrected arm muscle area, and arm muscle circumference according to gender. Campina Grande, Paraíba, Brazil.

	HGS (kg)	Flexibility/mobility (seconds)
Gender	R Pearson	R Pearson
Female		
Age	–0.49*	0.10
BMI (kg/m²)	0.22*	0.11
AMC (cm)	0.30*	0.00
CAMA (cm²)	0.29*	0.00
Male		
Age	–0.37*	0.03
BMI (kg/m²)	0.07	0.18**
AMC (cm)	0.25**	0.01
CAMA (cm²)	0.24*	0.01

AMC, arm muscle circumference; BMI, body mass index; CAMA, corrected arm muscle area; HGS, hand grip strength.
* $p < 0.01$.
** $p < 0.05$.

studies.[10,12,13,16,18,25] However, no studies were found in Northeastern Brazil and, therefore, in Campina Grande, state of Paraiba, aiming to evaluate the association between these variables, which makes it difficult to compare this information with national and international data.

This study verified the correlations between anthropometric variables and age with motor tests in an elderly population. The bivariate and multivariate analyses showed a correlation between age and anthropometric variables with motor tests, indicating a probable influence of these variables on physical performance in the elderly.

Table 3 – Multiple linear regression model to estimate prediction of the variables age, body mass index, and arm muscle circumference in hand grip strength and flexibility variation, according to gender. Campina Grande, Paraíba, Brazil.

	R	R²	F	*p*
HGS (kg)				
Women	0.490	0.24	41.516	
Age				< 0.001
AMC (cm)				< 0.001
Men	0.367	0.135	19.479	
Age				< 0.001
Flexibility/mobility (seconds)				
Men	0.188	0.036	4.309	
BMI (kg/m²)				0.04

AMC, arm muscle circumference; BMI, body mass index; HGS, hand grip strength.

The motor performance tests used in this study were those described in the SABE (*saúde, bem estar e envelhecimento* – health, well-being, and aging) study, performed in São Paulo – SP.[30] The HGS test was used to assess muscular strength, which is a measure of overall muscular strength. The flexibility/mobility "pick up a pen on the floor" test assesses the individual's capacity to bend to the ground in the shortest possible time, and is therefore an activity related to the flexion of the hip and lumbar spine. The term "mobility" was used together with "flexibility", considering that this test also depends on muscle power generated in the lower limbs and spinal column.

In this study, the mean value of the HGS in the elderly was significantly higher in elderly males when compared to females, corroborating the results found by Marucci and Barbosa,[1] in a study in the city of São Paulo, Brazil, which showed higher HGS values in men than in women. Studies conducted with elderly individuals from different countries have also showed similar results to those obtained in the present study.[2,8,26,31]

These findings may be due to the fact that men have higher reserves of muscle mass than women,[8,10,16,28,32] which may explain the greater muscular strength in men, considering that the skeletal muscle is the main organ responsible for the generation of physical strength,[33] with its decrease being specific for each muscle group and type of contraction.[34]

When assessing the mean flexibility/mobility value, a lower mean value was observed in women when compared to men; however, there was no significant difference between the genders. Differently from what was observed in this study, a study carried out in elderly individuals in São Paulo-SP, using a methodology similar to that of the present study, observed that men performed the flexibility test in a shorter mean time than women.[1]

It is noteworthy that this test assesses mobility through the time taken to complete the test and, therefore, limiting factors such as body differences between populations, and osteoarticular or muscle diseases could influence test results. Dantas et al.,[6] evaluating flexibility through goniometry, observed higher degrees of joint and muscle range of motion in females in almost all joints assessed. The higher degree of flexibility observed in women can be attributed to the fact that they have less dense tissues than men, which favors greater flexibility.[35] Furthermore, factors other than gender, such as exposure to nontransmissible chronic diseases, can influence flexibility.[6]

In this study, it was observed that men had a higher mean value regarding the time necessary to perform the flexibility test, but without statistical significance. In a study with physically active women, a higher mean flexibility value was observed in the group aged 60 to 69 years, when compared to the group aged 70 to 79 years.[36] Other studies with individuals of different ages have shown greater flexibility in younger age groups.[6,37]

The variables BMI, AMC, and CAMA are commonly used in studies with the elderly.[7,16,17,25,29,31] The mean AMC and CAMA values were higher in men than women. However, significant differences were observed between the genders only for AMC. Studies reporting greater muscle mass in men compared to women are common in the literature.[14,25,29,31] This is due to physiological factors such as the concentration of certain hormones (testosterone, growth hormone), which increase muscle regeneration in males who, therefore, have higher muscle concentration.[32]

It was observed in this study that both men and women in the group aged 80 years or older presented significantly lower mean AMC and CAMA values compared to the group of 60 to 69 years. Studies have shown lower mean values of the variables indicative of reserve muscle mass in the elderly at advanced age groups.[25,29] This reduction in muscle mass is expected, as the aging process results in alterations in nervous coordination and hence in innervated muscle action, in addition to a higher prevalence of stasis, thus contributing to muscle mass reduction.[33] The muscular atrophy is also associated with muscle disuse, often related to physical inactivity, whose prevalence is high among the elderly.[27]

When assessing BMI, a significantly higher mean value was observed in females, when compared to males. A similar result has been observed in other studies with the elderly.[13,16,25] The highest BMI in women can be attributed to the fact that women exhibit weight gain for a longer time than men, reaching a plateau, usually around age 75, while in men this plateau occurs around the age of 65, when it starts to decline.[38] When comparing the age groups, there were significant differences in mean BMI only among women. In a study of elderly individuals conducted in England, a lower mean BMI was observed in older participants;[26] similar results were found in the study of Perissinotto et al.[16]

In the bivariate analysis, where the correlation between the variables was evaluated, a significant negative correlation was observed between age and HGS. The results of the present study were similar to those found in a study of elderly individuals, in which there was significant negative correlation between age and HGS ($r = –0.62$).[28] Data from this study are also similar to findings in a study conducted with elderly men in São Sebastião-DF, in which there was a significant negative association between age and HGS ($r = –0.46$).[39]

This correlation between age and HGS can be explained by the fact that there is a linear association between age and the sarcopenia process, as the aging process results in muscle mass reduction.[32] Among the factors related to muscle mass decrease are the reduction in muscle area, decrease of motor units and type I and type II muscular fibers, and a reduction in the size of muscle cells, especially type II, responsible for fast contraction, which are required in muscular strength tests.[34]

When analyzing the correlation between HGS and anthropometric variables, this study showed that HGS had a significant positive correlation with BMI only in females. Similar to this study, a study in individuals aged between 20 and 70 years in Nigeria observed a positive and weak correlation between HGS and BMI only in the female gender ($r = 0.12$), albeit with no statistical significance.[8] However, a study carried out with individuals aged 18 to 65 years in Malaysia showed no correlation between HGS and BMI.[12]

Underweight individuals have less muscle mass and therefore have less muscular strength.[4] This statement confirms data from a study conducted in Malawi, with individuals aged 55 years and older, which showed a moderate and positive correlation between HGS and BMI in men ($r = 0.61$) and women ($r = 0.50$).[14] It is important to emphasize that the lower mean BMI found in this study may have influenced the correlation.

The low positive correlation observed between HGS and BMI in females, as well as the lack of correlation of these variables in males, suggests that excess weight verified by BMI is not a determinant factor for greater muscular strength in the elderly this study. On the contrary, a higher fat deposition may result from muscle disuse, which characterizes muscular strength decrease.[33]

It was observed that HGS had a positive and significant correlation with AMC and CAMA, in both genders. This result is similar to that observed by the study of Chilima and Ismail,[14] in which there was a positive correlation between HGS and AMA in men ($r = 0.39$) and women ($r = 0.37$). In a study of adults and elderly people living in São Paulo – SP, there was a significant positive correlation between HGS and AMC ($r = 0.45$).[15] Other studies evaluating the association between muscle reserve and HGS have also observed similar results.[4,18,31] This finding suggests that variations in anthropometric indicators of muscle reserve can interfere with the HGS of these elderly.

The linear regression result shows the contribution of age and AMC to HGS variation in women. In men, only age had a predictive value for HGS variation. In the model obtained by Ismail and Chilima,[14] the joint correlation of age, height, and AMA contributed to 30% of the HGS variation in men and to 24% in women. Variables evaluated together had a higher correlation rate for men ($R = 0.55$) and for women ($R = 0.49$) than when analyzed independently. The variable age was one of the factors that showed the greatest influence on muscular strength, as in this study. The equations generated from the linear regression have been found useful in HGS estimations.[10]

AMC also correlated positively and significantly with HGS among women, whereas the same was not observed among men. Other studies evaluating the association between HGS and AMC observed a positive and significant correlation between these variables; however, these studies did not stratify the assessment by gender.[15,31]

In this study, BMI correlated positively and significantly with flexibility/mobility only in males. Although this correlation was significant in the multivariate analysis, it was observed that BMI had a low predictive value. A study conducted in São Paulo, Brazil, which sought to investigate the association between the nutritional status with motor performance tests (among them, flexibility), found no significant association between BMI and flexibility in both genders. However, women with higher BMI took longer than those with a BMI equal to or below the normal value, indicating less flexibility in individuals with higher body mass.[9]

The influence of excess weight on worse flexibility performance has been reported by authors such as Bannerman et al.[13] in an anthropometric study with elderly individuals in Australia, suggesting that elderly who are overweight or obese are at risk for limitations in physical function and mobility. The concentration of adipose tissue around the joints possibly increases the friction between the joint surfaces, reducing myoarticular stretching capacity, thereby reducing flexibility.[40] Furthermore, a larger body size may hinder test performance, partially limiting the range of motion.[9] However, the presence of a correlation between BMI and flexibility, due to the effect of adiposity on the difficulty of test performance, does not exclude the possible influence of other factors.

A study carried out in young adults evaluated the correlation between muscular strength and flexibility through linear regression and showed no association between the variables, which were, therefore, independent.[41] This suggests that the variation of anthropometric indexes such as the AMC and CAMA, indicative of muscle reserve, would have influence on flexibility.

No studies using BMI as the variable predictor of alteration of flexibility in the elderly were found, making it difficult to compare the results observed in this study with others.

Conclusion

The results of this study suggest a possible influence of age and anthropometric variables on muscular strength in the elderly; age was the most important factor. Regarding flexibility, only BMI was shown to influence it, suggesting that older adults with higher fat accumulation have more limitations when performing flexibility tests. The reasons for the lack of a linear correlation between flexibility and the variables of muscle reserve (AMC and CAMA) for all the elderly are not clear.

Further investigations must be conducted to study the motor performance of the elderly, considering the physical alterations they experience. It is also suggested that other studies use tests to analyze lower-limb performance, as well as other anthropometric variables indicative of muscle mass and their possible associations, such as the "sit-to-stand test" described in the SABE study,[9] and calf circumference.

The present work, such as others, has limitations inherent to cross-sectional studies, since even though correlation has been demonstrated, it does not determine cause and effect among HGS and age and anthropometric variables. Thus, longitudinal studies on the functional capacity of the elderly and the probable factors related to these alterations in representative samples of the elderly population are needed in order to increase knowledge on this subject, and generate results that can be used for comparison in elderly from different regions of the country and the world. Additionally, it is recommended that the variables are stratified by gender and age group, due to alterations inherent to the aging process.

Conflict of interest

All authors declare to have no conflict of interest.

REFERENCES

1. Marucci MFN, Barbosa AR. Estado nutricional e capacidade física. In: Lebrão ML, Duarte YA. SABE - Saúde, Bem-estar e Envelhecimento – o projeto Sabe no município de São Paulo: uma abordagem inicial. Brasília (DF): Organização Pan-Americana de Saúde; 2003.
2. Wu SW, Wu SF, Liang HW, Wu Z, Huang S. Measuring factors affecting grip strength in a Taiwan Chinese population and a comparison with consolidated norms. Appl Ergon. 2009;40:811-5.
3. Matsudo SM, Matsudo VKR, Barros Neto TL. Impacto do envelhecimento nas variáveis antropométricas, neuromotoras e metabólicas da aptidão física. Rev Bras Ciênc Mov. 2000;8: 21-32.
4. Barbosa AR, Souza JMP, Lebrão ML, Marucci MFN. Relação entre estado nutricional e força de preensão manual em idosos do município de São Paulo, Brasil. Rev Bras Cineantropom Desempenho Hum. 2006;8:37-44.
5. Cristopoliski F, Sarraf TA, Dezan VH, Provensi1 CLG, Rodacki1 ALF. Efeito transiente de exercícios de flexibilidade na articulação do quadril sobre a marcha de idosas. Rev Bras Med Esporte. 2008;14:139-44.
6. Dantas EHM, Pereira SAM, Aragão JC, Ota AH. A preponderância da diminuição da mobilidade articular ou da elasticidade muscular na perda da flexibilidade no envelhecimento. Fit Perf J. 2002;1:12-20.
7. Sánchez-García S, García-Peña C, Duque-López MX, Juárez-Cedillo T, Cortés-Núñez AR, Reyes-Beaman. Anthropometric measures and nutritional status in a healthy elderly population. BMC Public Health. 2007;7:1-9.
8. Adedoyin RA, Ogundapo FA, Mbada CE, Adekanla BA, Johnson OE, Onigbinde TA, et al. Reference values for handgrip strength among healthy adults in Nigeria. Hong Kong Physiother J. 2009; 27:21-9.
9. Barbosa AR, Souza JMP, Lebrão ML, Marucci FN. Estado nutricional e desempenho motor de idosos de São Paulo. Rev Assoc Med Bras. 2007;53:75-9.
10. Günther CM, Bürger A, Crispin A, Crispin A, Schulz CS. Grip strength in healthy caucasian adults: reference values. J Hand Surg Am. 2008;33:558-65.
11. Geraldes AAR, Cavalcante APN, Albuquerque RB, Carvalho MJ, Farinatti PTV. Correlação entre a flexibilidade multiarticular o desempenho funcional de idosas fisicamente ativas em tarefas motoras selecionadas. Rev Bras Cineantropom Desempenho Hum. 2007;9:238-43.
12. Kamarul T, Ahmad TS, Loh WYC. Hand grip strength in the adult Malaysian population. J Orthop Surg. 2006;14:172-7.
13. Bannerman E, Miller MD, Daniels LA, Cobiac L, Giles LC, Whitehead C, et al. Anthropometric indices predict physical function and mobility in older Australians: the Australian Longitudinal Study of Ageing. Public Health Nutr. 2002;5:655-62.
14. Chilima DM, Ismail S. Nutrition and handgrip strength of older adults in rural Malawi. Public Health Nutr. 2000; 4:11-17.
15. Oliveira DR, Frangella VS. Adductor pollicis muscle and hand grip strength: potential methods of nutritional assessment in outpatients with stroke. Einstein. 2010;8:467-72.
16. Perissinotto E, Pisent C, Sergi G, Grigoletto F, Enzi G. Anthropometric measurements in the elderly: age and gender differences. Br J Nutr. 2002;87:177-86.
17. Onis M, Habicht JP. Anthropometric reference data for international use: recommendations from a World Health Organization Expert Committee. Am J Clin Nutr. 1996;64:650-8.
18. Rantanen T, Masaki K, Foley D, Izmirlian G, White L, Guralnik JM. Grip strength changes over 27 yr in japonese-american men. J Appl Physiol. 1998;85:2047-53.
19. Reuben DB, Siu AL. An objective measure of physical function of elderly outpatients: the physical performance test. J Am Geriatr Soc. 1990;38:1105-12.
20. Gordon CC, Chumlea WC, Roche AF. Stature, recumbent length, and weight. In: Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual. Champaign: Human Kinetics Books; 1988.

21. Callaway CW, Chumlea WC, Bouchard C, et al. Circumferences. In: Lohman TG, Roche AF, Martorell R, editors. Anthropometric standardization reference manual. Champaign: Human Kinetics Books; 1988. p. 39-54.
22. Harrison GG, Buskirk ER, Carter JEL. Skinfold thicknesses and measurement technique. In: Lohman TG, Roche AF, Martorell R, editors. Anthropometric standardization reference manual. Champaign: Human Kinetics Books; 1988. p. 55-70.
23. Gurney JM, Jelliffe DB. Arm anthropometry in nutritional assessment: nomogram for rapid calculation of muscle circumference and cross-sectional muscle and fat areas. Am J Clin Nutr. 1973; 26:912-15.
24. Heymsfield SB, McManus C, Smith J, Stevens W, Nixon DW. Anthropometric measurement of muscle mass: revised equations for calculating bone-free arm muscle area. Am J Clin Nutr. 1982;36:680-90.
25. Corish CA, Kennedy NP. Anthropometric measurements from a cross-sectional survey of Irish free-living elderly subjects with smoothed centile curves. Br J Nutr. 2003;89:137-45.
26. Health Survey for England (HSE). General health and function. The Health Survey for England series. London: The Information Centre; 2007.
27. Siqueira FV, Facchini LA, Piccini RX, Tomasi E, Thumé E, Silveira DS, et al. Atividade física em adultos e idosos residentes em áreas de abrangência de unidades básicas de saúde de municípios das regiões Sul e Nordeste do Brasil. Cad Saúde Pública. 2008;2:39-54.
28. Geraldes AAR, Oliveira ARM, Albuquerque RB, Carvalho JM, Farinatti PTV, et al. A força de preensão manual é boa preditora do desempenho funcional de idosos frágeis: um estudo correlacional múltiplo. Rev Bras Med Esporte. 2008;14: 12-6.
29. Menezes TN, Marucci MFN. Perfil dos indicadores de gordura e massa muscular corporal dos idosos de Fortaleza, Ceará, Brasil. Rev Bras Epidemiol. 2007;10:168-77.
30. Barbosa AR, Souza JM, Lebrão ML, Laurenti R, Marucci MFN. Functional limitations of Brazilian elderly by age and gender differences: data from SABE Survey. Cad Saúde Pública. 2005; 21:1177-85.
31. Hornby ST, Nunes QM, Hillman TE, Stangab Z, Nealc KR, Rowlandsa BJ, et al. Relationships between structural and functional measures of nutritional status in a normally nourished population. Clin Nutr. 2005;24: 421-6.
32. Gallagher D, Visser M, Sepulveda D, Sepúlveda D, Baumgartner RN, Pierson RN, et al. How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups?. Am J Epidemiol. 1997;143:228-39.
33. Pierine DT, Nicola M, Oliveira EP. Sarcopenia: alterações metabólicas e consequências no envelhecimento. Rev Bras Ciênc Mov. 2009;17:96-103.
34. Carvalho J, Soares JMC. Envelhecimento e força muscular: breve revisão. Rev Port Ciênc Desporto. 2004;4:79-93.
35. Rocha PECP. Medidas de avaliação em ciências do esporte. 4th ed. Rio de Janeiro: Sprint; 2000.
36. Matsudo SM, Matsudo VKR, Barros Neto TL, Araújo TL. Evolução do perfil neuromotor e capacidade funcional de mulheres fisicamente ativas de acordo com a idade cronológica. Rev Bras Med Esporte. 2003;9:365-76.
37. Ferreira L, Barbosa TD, Gobbi S, Arantes LM. Capacidade funcional em mulheres jovens e idosas: projeções para uma adequada prescrição de exercícios físicos. Rev Educ Física/UEM. 2008;19:403-12.
38. World Health Organization. Physical status: the use and interpretation of anthropometry. Geneve: WHO; 1995. p. 375-409 (WHO Technical Report Series, n. 854).
39. Pereira FB, Moraes LFS, Paula AP, et al. Efeito das variáveis antropométricas e da idade no comportamento da força muscular de homens idosos. Brasília Med 2010;47:26-34.
40. Silva TAA, Frisoli Junior A, Pinheiro MM, Szejnfeld, VL. Sarcopenia associada ao envelhecimento: aspectos etiológicos e opções terapêuticas. Rev Bras Reumatol. 2006;46:391-7.
41. Carvalho ACG, Paula KC, Azevedo TMCA, Nóbrega ACL. Relação entre flexibilidade e força muscular em adultos jovens de ambos os sexos. Rev Bras Med Esporte. 1998;4:1-8.