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Relationship between Handgrip Strength, Flexibility and Anthropometric Measures in Elderly Population: A Cross-Sectional Study

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Abstract

The aging process leads to biological changes that affect the physical performance and nutritional status of older adults. The objective this study is to determine the association between physical performance and anthropometric and body composition variables in the elderly. This is a cross-sectional study. To verify the correlation between handgrip strength (HGS) and flexibility with age and anthropometric variables in the elderly. This was a cross-sectional home-based study of elderly individuals. Gender, age, HGS, flexibility, arm muscle circumference (AMC), corrected arm muscle area (CAMA), and body mass index (BMI) were recorded. 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. The results indicate a probable influence of age and anthropometric variables in muscular strength, as well as that of excess weight in flexibility limitation.

Keywords: Handgrip Strength, Flexibility, Anthropometric, Elderly Population, Cross-Sectional

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.

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

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. 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.

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. Body fat tends to increase during the first decades of aging, and to decrease in later decades of life. Moreover, there is a redistribution of adipose tissue, decreasing in the region of the arms and legs and accumulating in the trunk and viscera.

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, 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.

There are few studies conducted in India that evaluated the correlation of anthropometric variables with handgrip strength and flexibility of the elderly. Of these, only the study by Barbosa et al. evaluated the influence of anthropometric variables on handgrip strength, in a representative sample of the population.

An important aspect of the elderly evaluation is related to functional performance, considering that the decline of physical function can be an important indicator of frailty, dependence and increased risk of institutionalization of this population. Muscle strength, balance and flexibility are physical qualities directly related to the elderly health, involved in the ability to perform daily tasks.

With aging, there is a reduction in the ability of the nervous system, involved in sensory processing and adaptive reflexes, generating situations of postural instability, changes in coordination, imbalance and increased susceptibility to falls. In addition, changes occur in the nervous coordination and musculoskeletal system, leading to muscle atrophy and bone demineralization, reducing the efficiency of the locomotor system, influencing the decrease in muscle strength and flexibility.

Besides functional status, nutritional status is an important indicator of health in the elderly. Changes in nutritional status with aging are related to important physical changes, such as lean mass reduction, mainly muscle mass and bone density, and increase in the redistribution of body fat, with accumulation in the trunk and viscera, and reduction in the limbs. Studies with the elderly have been using anthropometry as a way to measure and monitor body changes through markers of the accumulation of fat and muscle mass, due to its low cost and ease of obtainment.

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.

Literature Review

Mullerpatan et al. (2013) studied on the normative values of handgrip and pinch strength in 1005 healthy Indian adults. The normative values of handgrip and pinch strength were used to demonstrate the results of treatment, to determine patients' basic restraint and support a baseline for analysis of patient progress. With the differences in genetics, environmental and nutritional components, information accumulated from western populations cannot be utilized for associating with Indian populations. Handgrip and pinch strength were measured with the use of a Jamar dynamometer and Pinch gauge with the elbow positioned at 0 degree, 45 degree, 90 degree and full elbow flexion. They observed that men showed significantly greater values for handgrip strength ($p \leq 0.001$) at 0 degree of elbow flexion than women. For other positions of the elbow, men had the higher mean handgrip strength values than women. Men showed significantly greater values of tip, key and palmar pinch than women. Among men, handgrip strength was significantly different ($p \leq 0.001$) at different positions of the elbow; it was highest at 0 degree and lowest at 135 degree of elbow flexion. They interpreted that the observations provided reference values for handgrip, tip, palmar and key pinch strength for healthy Indian adult population. When compared with age and gender matched population from other continents, healthy Indian adults showed lesser handgrip and pinch strengths.

Sirajudeen et al. (2012) conducted the cross-sectional study on association of handgrip strength with the physical factors in men. It was stated that handgrip strength was extensively preferred marker of functional integrity of upper extremity, bone mineral content, nutritional status and muscular strength. The evaluation of handgrip strength played an important role in demonstrating the efficiency of different treatment procedures of hand. The cross-sectional study was conducted to study the association of handgrip strength with the physical variables, such as height, weight, body mass index, and hand and forearm anthropometric measurements in 50 healthy Indian male populations. The handgrip strength of both dominant and non-dominant hands was measured using Jamar dynamometer. They reported that in males, the dominant and non-dominant handgrip strength had significantly positive correlations ($p<0.05$/ - 0.001) with height, weight, BMI, hand breadth, hand length, hand span, wrist circumference and forearm girth.

Lee et al. (2012) conducted a population-based longitudinal study on assessment of variables affecting handgrip strength in 143 men and 123 elderly Koreans women older than 65 years. Variables evaluated for likely correlations with handgrip strength were age, gender, height, body mass index, bone mineral density, upper extremity functional status and mental health status. Multivariate analyses were applied to verify the variables independently correlated with handgrip strength. They found that strength of dominant hand in elderly Koreans was reported to decline mainly with aging. Significant sex differences were also noted. Their findings reported that handgrip strength was significantly correlated with age, height and BMI in men, and age and height in women

Shah et al. (2011) conducted a cross-sectional study on the correlation between handgrip strength and hand dimensions in healthy Indian females. The human hand was a very complicated framework and committed to the operations of manipulation. Handgrip strength was used in practical settings as a predictor of complete physical strength and health. The study was conducted to investigate the correlations between handgrip strength and anthropometric variables in healthy Indian female population. A total of 50 healthy females fulfilling the selection procedure were included in the study. The parameters included height, weight, body mass index, hand and forearm anthropometric variables. The dominant and non-dominant handgrip strength were measured by Jamar dynamometer. They observed that in females, dominant and nondominant handgrip strength had significantly positive correlations ($p< 0.05$ - 0.001) with height, weight, hand length, hand span, wrist circumference and forearm girth, whereas, no significant correlations of handgrip strength were found with BMI and hand breadth in healthy Indian females.

Wang (2010) studied the hand dominance and handgrip strength of elderly Asian population aged 60-89 years. The subjects comprised were free of pain, injury, and disease of the upper limbs; and had no limitations on use of upper extremities in activities of daily living. The dominant and non-dominant handgrip strength was examined with a Jamar hand dynamometer. Their findings reported that males of younger age group and using the dominant hand were significantly correlated with stronger handgrip than females of older age and using the non-dominant hand. The 28 interpreted that the dominant to non-dominant handgrip ratio differed from 1.05 to 1.10 among age-sex subgroups.

Kaur and Koley (2010) reported the correlations of nutritional status and handgrip strength in 100 female labourers and 100 sedentary women of north India aged 18-40 years. The selected anthropometric variables were measured by standard methods and nutrition indices were computed using standard equations. For the estimation of handgrip strength a digital handgrip dynamometer was used. The findings of the study demonstrated considerably significant differences ($p< 0.001$)

in BMI, triceps skinfold, arm circumference and arm muscle area between right hand dominant female labourers and the sedentary females. Also, the right hand dominant female labourers had lower mean handgrip strength than their sedentary correspondents. They reported that inspite of their greater level of physical activity, female labourers had both poor handgrip strength and poor values of nutritional indices than their sedentary correspondents because of their poor nutritional status.

Sindhu et al. (2006) carried out a pilot study to establish the importance of handgrip strength measurement in geriatric rehabilitation practice in evaluating and predicting physical disability. Functional and cognitive deteriorations were assessed. Handgrip strength was assessed at the second and third handle settings by a second examiner who was unknown to the patient's diagnosis or the functional status with computerized hand function examination system. Self-perceived health associated positively with peak handgrip strength. The study was in process and the part of handgrip strength measurement, a safe, simple, fast, cost-effective and durable test might prove valuable in the rehabilitation of the elderly.

Methods

This is a cross-sectional, household-based study, with primary data collection, and is part of a broader study that aimed to perform a multidimensional evaluation of health of the elderly enrolled in the Family Health Strategy in the city Bhopal, in the state of MP, India.

Individuals aged 60 and over, of both sexes, were included in the sample. The elderly who presented severe clinical weakness, with no resolute therapeutic possibility, and the elderly who were away from the city of Bhopal for a period greater than that of field research in their Family Health Basic Unit (FHBU) were excluded. In addition, specific exclusion criteria were set for each functional test: the elderly undergoing a surgery in the arm or hand within the three months prior to collection were excluded from the handgrip strength test. Elderly undergoing cataract or retinal surgery, within the six weeks prior to the interview, bedridden elderly, wheelchair users, or those who, for some reason, could not stand up were excluded from flexibility/mobility and balance tests.

Sample

According to the information by the Health Department, in 2018 there were 23,416 elderly in the city of Bhopal who were registered in the 63 Family Health Basic Units (FHBU), distributed in the six city Health Districts. For sample selection, a prevalence of outcomes of at least 25% was estimated. The calculation of the sample size was performed using the following equation: {[E2 x p (1-p)] x c}/ A2 , where E is confidence bound (1.96), c is the sample correlation coefficient (2.1), and A is the precision accepted for the estimated prevalence (A = 6%). From each district, one UBSF was randomly drawn, with the sample being proportionate to each Health District, with 420 elderly.

Fieldwork was performed, with three doubles of interviewers, duly trained, from August 2021 to May 2022. Information about gender, age group, physical performance, and anthropometry and body composition was evaluated.

Physical Performance

The tests used to evaluate physical performance were: handgrip strength (HGS), flexibility/mobility, and balance tests. Prior to each test the elderly received explanations and practical demonstrations, to ensure the correct implementation of the task with no risk for the elderly.

Handgrip strength was measured with the use a hydraulic hand dynamometer, adjusted for each individual according to their hands size. Testing was performed in the limb referred by the elderly as the one of greater strength (dominant limb). During the test, the elderly stayed sat with the elbow supported on a table, forearm extended forward, palm up, and then they were asked to perform the greatest possible grip.

The procedure for measuring HGS was performed twice, with an interval of one minute between them17 with the average being considered as final value. To assess performance in this test we used the classification used by Barbosa et al. 18, who consider the values (kg) distributed in percentiles, according to gender: poor (≤ P25), regular (> P25 and ≤ P75) and good (> P75).

The flexibility/mobility test used in this study was the "pick up a pen" test proposed by Reuben & Siu19. The elderly were told to stay upright, feet together, and when informed about the start of the test, should stoop down to pick up a pen, placed on the floor, 30 cm ahead of the toes. A stopwatch was used to check the time spent between stooping down and returning to starting position, with the pen in hand. The test was considered completed when the elderly could finish the exercise without support, in time ≤ 30 seconds.

For data analysis, we used the classification indicated by Barbosa et al. 18, which ranks flexibility according to the test runtime: poor (> 6 and ≤ 30 seconds), regular (> 2 and ≤ 6 seconds) and good (≤ 2 seconds).

The test to check balance consists of four measures of static balance, proposed by Guralnick et al. 20. Each measurement was performed only once. In a first measuring, the elderly should remain upright, keeping the feet together and the eyes open. In the second, the elderly should remain upright, placing the heel of one foot in front of the other, keeping the eyes open. In the third, the elderly should remain standing, with one leg raised, leaning on the other leg, without using any

other type of support. In the fourth, the later exercise was performed, but changing the position of the legs. Each measure was considered successfully completed when the elderly could stay 10 seconds in that position. If the elderly could not make the first measure, he/she should not perform the second and so on.
Performance was evaluated with the use of the classification used by Barbosa et al. that evaluates the elderly based on the amount of measurements performed in the test: poor (one measure), regular (two measures) and good (three or four measures).

Anthropometry and body composition

Anthropometric and body composition variables were: body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), triceps skinfold (TSF), arm circumference (AC), arm fat area (AFA), arm muscle circumference (AMC) and calf circumference (CC).
To calculate the BMI (kg/m2), weight and height were measured according to the techniques described in Lohman et al. 21. Weight (kg) was measured in a portable digital scale (TANITA UM080) for 150 kg and sensitivity of 100g. Height (m) was measured in portable stadiometer (Accurate Height). The WC (cm), hip circumference (HC) (cm), AC (cm) and CC (cm) variables were measured using an inelastic tape measure with a precision of 1 mm, according to the techniques described in Lohman et al. 21. The waist-hip ratio (WHR) was obtained by dividing WC by HC.
To calculate the AMC (cm) and AFA (cm2), triceps skinfold (TSF) and arm circumference (AC) were measured. TSF was obtained using Lange compass, which has constant pressure of 10g/mm2 , and measured according to the techniques described in Lohman et al. 21. AMC was calculated with the Gurney & Jelliffe's equation22:

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

To calculate AFA the equation proposed by Frisancho23was considered:

$$\text{AFA (cm}^2) = \frac{[\text{AC (cm)}^2]}{4\pi} - \frac{[\text{AC (cm)} - (\pi \times \text{TSF (cm)})]^2}{4\pi}$$

For BMI categorization, the classification proposed by the Pan-American Health Organization (PAHO)24was used, which defined specific cutoffs for the elderly population: low weight (< 23 kg/m2), eutrophy (≥ 23 and < 28 kg/m2), overweight (≥ 28 and < 30 kg/m2) and obesity (≥ 30 kg/m2). WC and WHR were classified according to the cutoffs proposed by WHO25, with the following being considered improper: WC > 102 cm for men and > 88 cm for women; WHR > 0.99 for men and > 0.97 for women.
The classification of WHR, AFA and AMC was made based on values described by Menezes & Marucci11, which are presented according to the gender and distributed in percentiles (P). Based on these values, the variables were classified as follows: AMC (malnutrition (≤ P25) and eutrophy (> P25)), TSF and AFA (insufficient (≤ P25), eutrophy (> P25 and < P75) and excessive (≥ P75)). For CC, the classification proposed by the WHO was considered25, which considers CC < 31cm malnutrition, and CP ≥ 31cm, eutrophy.

Statistic procedures

For statistical purposes, the functional performance variables were dichotomized and classified into good and bad. For good HGS, the elderly who presented regular performance (> P25 and ≤ P75) and good performance (> P75) were considered. Similarly, for the classification of good flexibility/mobility, the elderly with regular (> 2 and ≤ 6 seconds) and good (≤ 2 seconds) performance were considered. For good balance, the elderly who performed well (performed three or four measures) were considered. The others were classified as poor performance, considering that the elderly with regular balance also show some degree of instability, which may contribute to imbalance.

The data are presented in the form of frequencies. To check the association of functional performance variables with gender, age group (60 to 69 years, 70-79 years and 80 and over) and anthropometric and body composition variables, Pearson's chi-square test was used (X^2). Initially, simple logistic regression models were estimated to calculate gross odds ratio (OR). For the multivariable model the variables with $p < 0.20$ (Wald test) obtained in simple analysis were considered. The stepwise forward input method for calculating the adjusted OR was considered with 95% confidence interval (95%CI). In the final model, the variables that remained in the model with $p < 0.05$ were considered significant. The evaluation of the logistic model adjustment was performed using the Hosmer-Lemeshow test. Data were analyzed using SPSS 17.0 (IBM Corp., Armonk, United States) statistical packet.

Results

The study included 420 elderly (68.1% women) with a mean age of 71.57 years (± 9.19), whose ages ranged between 60 and 104 years. Elderly people who for some reason could not perform the functional performance tests were not included in the results. Thus, the total of elderly respondents: 417 performed the HGS test; 368 the flexibility/mobility test, and 393 the balancing test.
After the associations of all anthropometric variables were associated with HGS, the following was selected in the simple logistic regression test: CC (p < 0.0001), AMC (p = 0.006), BMI (p = 0.04), AFA (p = 0.009), WHR (p = 0.06) and WC (p = 0.19), adjusted by gender (p = 0.71) and age (p = 0.67). Table 1 presents the final model of multivariable regression for HGS. Malnourished elderly were more likely to have poor HGS (OR 3.32, 95% CI: 2.24-3.15) compared to the eutrophic elderly. The model was adjusted by AMC, WC, gender and age group.

	HGS						
Model	**Good %**	**Bad %**	**P'**	**Crude OR**	**P"**	**Adj.OR**	**CI 95%**
CC(cm)			<0.0001		< 0.0001		
Malnutrition	42.6	45.2		3.63		3.32	2.24-3.15
Eutrophic	74.3	25.5		2.00		2.00	

Table 1: Final multivariable logistic regression model for HGS Bhopal, India 2018

In simple regression test, only gender was associated with flexibility/mobility (p = 0.02), with age group and AFA being selected as adjustment variables for the multiple test. In the final model, adjusted for age group, the female was a protective factor for good flexibility (OR 0.24, 95% CI: 0.15-0.75) (Table 2). There was no significant association between the anthropometric and body composition variables and flexibility/mobility of the elderly in this study.

	Flexibility						
Model	**Good %**	**Bad %**	**P'**	**Crude OR**	**P"**	**Adj.OR**	**CI 95%**
Gender			0.025		0.022		
Male	81.3	8.9		2.00		2.00	
Female	95.2	4.6		0.24		0.24	0.15-0.75

Table 2: Final logistic regression model for flexibility/mobility Bhopal, India 2018

For association with balance, the following was selected in the simple regression test: age group (p < 0.0001), CC (p = 0.001) and AMC (p = 0.007). Gender was considered an adjustment variable. The final model for balance is shown in Table 3. The elderly aged 70 to 79 years (OR 2.58, 95% CI 3.26-5.16) and 80 years or more (OR 23.2, 95%CI 3.48-23.27); and malnourished (OR 4.00, 95% CI 2.30-6.42) were more likely to have poor balance. The best adjustment considered gender and TSF, which was therefore included in the model (Hosmer-Lemeshow = 0.84).

	Balance						
Model	**Good %**	**Bad %**	**P'**	**Crude OR**	**P"**	**Adj.OR**	**CI 95%**
Age group (years)			<0.0001		< 0.0001		
60 to 69 years	48.0	52.0		2.00		2.00	
70 to 79 years	230	68.0		2.53		2.58	3.26-5.16
80 years or older	6.3	83.7		23.4		23.2	3.48-23.27
CC(cm)			0.001		0.001		
Malnutrition	24.7	75.3		2.44		4.00	2.30-6.42
Eutrophic	35.2	72.6		2.00		2.00	

Table 3: Final logistic regression model for balance Bhopal, India 2018

WHR variable was not significantly associated with any of the functional performance variables, therefore not being considered in the logistic models. The corrected arm muscle area (CAMA) was not considered in this study because of its strong association with AMC (p < 0.0001). Therefore, as both variables are indicative of muscle mass reserve, we opted for AMC, considering that it presented the strongest association with physical performance variables.

Discussion

Functional capacity is an indicator of health and quality of life for the elderly, since it considers aspects such as independence and performance in their activities. The elderly, even without clinical diagnosis of chronic disease, present some degree of functional loss related to the reduction of the functions of organs and body systems, inherent to aging.

The physical decline, in particular, is related to greater predisposition to loss of autonomy, and fragility, greater frequency and duration of hospitalizations, and increased risk of mortality.
This study aimed to evaluate the joint association of different anthropometric and body composition variables in functional performance of the elderly, measured by physical tests of muscle strength, flexibility/mobility and balance. Studies aiming to investigate the association between physical performance and anthropometric variables and body composition have commonly used BMI, since it is a variable that is simple to be obtained and easy to be accessed. Other studies have considered the anthropometric evaluation through variables such as calf circumference, arm muscle circumference and arm muscle area to assess body composition.
The evaluation of muscle function has been used as a functional capacity indicator in elderly people. In this regard, handgrip strength has been the most commonly measured in muscle evaluation, since it reflects the maximum strength derived from the contraction of the hand muscles, and it has a good relationship with other muscle groups. Moreover, it is a readily available measure that makes its use feasible in research and in clinical practice with the elderly.
In this study we observed an independent association of BMI, indicative variables of fat (AFA) and muscle reserves (AMC and CC) with the HGS, but the CC was the variable with the best association, remaining in the final model. Malnourished elderly were more likely to show poor HGS, regardless of the adjustment for other anthropometric variables (AMC and WC), gender and age group, indicating that the reduction in muscle mass is associated with decreased muscle strength.
The calf circumference is considered a sensitive measure of muscle mass in the elderly because it reflects changes in fat-free mass; thus, it is recommended for malnutrition assessment in that population25. Data from Invecchiamento e Longevità nel Sirente Study, an Italian population study, observed a significant relation of calf circumference and HGS ($p < 0.001$), adjusted by gender and age. Malnourished elderly have a worse average of HGS (24.4 ± 1.4 kg) compared to normal weight (35.2 ± 1.1 kg). This difference remained even with adjustment for sex and age (26.5 ± 1.2 kg and 33.7 ± 1.0 kg)
In India, a study of elderly in the city of Bhopal, evaluated the relationship of anthropometric variables that are indicative of muscle mass to HGS. There was a positive and significant correlation between AMC ($r = 0.30$; $p< 0.01$) and CAMA ($r = 0.29$; $p< 0.01$) with HGS12. Another study, conducted in the city of Indore, in the state of MP, India, observed similar results for the correlation of AMA with HGS, in both genders.
With changes in nutritional status that occur with the aging process, there is a reduction of muscle fibers and remodeling of the motor units and consequently, decreased limb muscle strength, which may explain the association found in studies including this one, between malnutrition and muscle strength.
In addition to the amount of lean body mass, other factors seem to be associated with reduced muscle strength. A study comparing a group of old and young men observed 25% less muscle strength in the elderly compared to younger people, but there was no significant difference in the amount of muscle mass The authors also observed a reduction in the number of motor units and muscle protein in the elderly compared to the young. These results indicate that not only the reduction of the amount of mass, but also muscle quality, may be related to decreased strength.
Aspects that occur with aging, such as the reduction of the number of muscle fibers, changes in their structure and reduction of the neurological system efficiency to recruit motor units, lead to impairment of neuromuscular performance. Thus, there is increased muscle weakness, movement slowness and early fatigue, contributing to limitations to walk, get up, keep balance, among other daily activities, increasing the risk of falls and functional dependency.

Greater flexibility/mobility among women is observed in various stages of development. Women have less dense tissue than men do. It is believed that this occurs due to the concentration of estrogen, a female hormone, which induces a higher water retention and greater accumulation of adipose tissue, favoring better performance of women in the flexibility test. Furthermore, in general, women’s lumbar spine is proportionately longer and has better muscle stretch ability, which leads to increased mobility of this region.

In general, with aging, articular capsules and ligaments become stiffer due to the loss of elastic fibers and increased collagen. Thus, this may interfere on movements and on performance of the joint receptors, making movements slower or uncoordinated, affecting the range of motion of the elderly. In this study, a significant association of anthropometric and body composition variables was not observed in tests of flexibility/ mobility, suggesting that there is no influence of these variables on the motor performance of the elderly population studied.
The monitoring of the health status of a given population, as well as of factors associated with these conditions, is a key instrument for guiding strategies that lead to qualified approaches to ensure a healthy aging. Once a limitation is detected, it is possible to choose the most appropriate measure to eliminate the risk factor or reduce its progression. The promotion and prevention in the three health care levels mobilize the global policies discussions for a healthy aging in order to seek possible solutions to the factors involved in functional performance and contribute to the reduction of public spending on early retirement and health care and social assistance.

Conclusion

According to the results of this study, it is possible to conclude that BMI and AMA can be predictors of handgrip strength in community-dwelling elderly men with low HDI, but not in women. The results above show that malnourished elderly (lower CC) were more likely to have a poor HGS. There was no significant association of anthropometric and body composition variables with performance in tests of flexibility/mobility. The results also showed that women had higher levels in this test. The elderly of older age groups, and who are malnourished (lower CC), were more likely to have poor balance.

This study used a wider variety of anthropometric variables and functional tests, covering different areas to better understand aspects of nutritional status associated with reduced physical function in the elderly. It is believed that this may encourage the implementation of public health programs aimed at health maintenance, or even the recovery from morbidities such as malnutrition and other nutritional problems, and also to help health workers in the development of behaviors that allow delaying the occurrence of dependency, promoting a healthy aging with good quality of life.

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