original article

BJPT Brazilian Journal of Physical Therapy

Influence of *sarcopenia* and functionality *indicators* on the frailty profile of community-dwelling elderly subjects: a cross-sectional study

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ABSTRACT | **Background**: Frailty and sarcopenia are frequent conditions in the elderly and are related to inactivity and functionality. However, little is known about the influence of the sarcopenia indicators on the frailty profile or their functional implications. **Objective**: To evaluate whether the indirect indicators of sarcopenia and functionality influence the frailty profile in elderly subjects. **Method**: This was a cross-sectional study with 53 elderly subjects recruited by an active search in a secondary health care service. The indirect indicators of sarcopenia were body mass index (BMI), gait speed, Mini-Nutritional Assessment (MNA), Human Activity Profile (HAP), and handgrip strength. Frailty was characterized according to Fried's Frailty Phenotype. Functional capacity was assessed according to the Short Physical Performance Battery (SPPB). Physical activity level was assessed by HAP. Data were analyzed by analysis of variance (ANOVA) and multiple regression. **Results:** Overall, 75.5% of the subjects were women, with a mean age of 76.72 (±5.89) years; 15.1% were frail and 54.7% pre-frail; and the level of physical activity was the most prevalent indicator of sarcopenia. Significant differences ($p<0.05$) were observed in both the physical activity level and gait speed between the non-frail and pre-frail groups and between the non-frail and frail groups. In addition, some sarcopenia indicators were associated with functional capacity and geriatric depression score. **Conclusion:** The level of physical activity and gait speed appeared to be the most relevant factors in the development of frailty in the study sample, which may have functional implications.

Keywords: sarcopenia; frail elderly subject; physical inactivity; disability; rehabilitation.

HOW TO CITE THIS ARTICLE

Viana JU, Silva SLA, Torres JL, Dias JMD, Pereira LSM, Dias RC. Influence of sarcopenia and functionality indicators on the frailty profile of community-dwelling elderly subjects: a cross-sectional study. Braz J Phys Ther. 2013 July-Aug; 17(4):373-381. http://dx.doi.org/10.1590/S1413-35552012005000102

Introduction

The socio-demographic changes occurring in the world population are leading to new demands on health care systems. Aging is a factor that changes the profile of diseases, leading to a higher incidence of chronic-degenerative pathologies[1]. Among these phenomena, frailty syndrome and sarcopenia stand out because they influence the quality of life of the elderly, resulting in adverse outcomes such as falls, fractures, hospitalization, and high comorbidity, disability, and mortality rates[2-6].

Both frailty syndrome and sarcopenia have been widely studied, but their definition, diagnosis, and evaluation have still not been standardized[2,7,8]. However, it is well established that frailty is a state of progressive loss of body reserves, causing greater vulnerability and difficulty in maintaining homeostasis during stressful events[2,9].

Sarcopenia was initially described by Rosenberg as the universal loss of muscle mass and strength inherent to the aging process[10]. It is considered an important factor in the frailty cycle because all factors that trigger its development are related to the musculoskeletal system[2]. Frisoli et al.[3] showed that elderly people with sarcopenia were three times as likely to develop frailty [odds ratio (OR): 3.1; 95% confidence interval (CI): 0.88-11.1]. Xue et al.[11] showed that muscle strength would be the primary factor for the development of sarcopenia.

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Received: 10/08/2012 Revised: 12/18/2012 Accepted: 12/21/2012

Functional disability is closely related to frailty and sarcopenia. A longitudinal study in a French elderly population found that 82% of frail individuals exhibited mobility deficits, and 33% and 3.3% reported inability to perform more than one instrumental activity of daily living (IADL) and basic ADL (BADL), respectively[4]. The frailty phenotype introduced by Fried et al.[2] predicted impaired mobility and disability in BADL in all elderly patients after three years of follow-up. A positive association between appendicular muscle mass and functionality was found in Chinese elderly individuals[12], and a five-year follow-up study showed that changes in appendicular muscle mass were associated with physical performance measurements and the level of physical activity in the elderly[13].

In addition to the functional profile, physical inactivity is a major factor in the development or maintenance of frailty syndrome and sarcopenia. Physical inactivity results in loss of muscle mass because of an imbalance between synthesis and degradation of muscle proteins, and aging can exacerbate this state due to the gradual loss of functional capacity and metabolic reserves[14]. Hughes et al.[15] showed that elderly people with high levels of physical activity were able to slow down the development of sarcopenia.

The interaction between the above-mentioned factors emphasizes the need to understand which sarcopenia indicators can trigger the development of frailty and the influence of sarcopenia on the functionality of the elderly. The lack of validated diagnostic instruments also shows the need to develop tools that are simple and easy to apply in clinical practice for early detection of such adverse outcomes, with the goal of minimizing such outcomes and ensuring a healthier aging process with a higher quality of life. Thus, the aim of this study was to determine whether the indirect sarcopenia indicators and the functional profile exert some influence on the development of frailty, characterized by the phenotype developed by Fried et al.[2], in community-dwelling elderly subjects treated at a secondary health care service in a large Brazilian capital city.

Method

This was an observational cross-sectional study. The sample consisted of 53 elderly subjects who were selected by convenience through an active search and directly approaching patients in waiting rooms and from a patient list. The inclusion criteria were as follows: ≥65 years of age, score ≥17 on the Mini–Mental State Examination (MMSE)[16], having received any type of medical care from the Institution, and able to walk independently or with the aid of devices. Elderly with any disability that would prevent them from performing the physical and functional tests of this study, such as severe sequelae of stroke, and those subjects who, for whatever reason, refused to give free and informed consent or did not perform all the tests of the survey were excluded from the study.

The study was approved by the Ethics Committee of the Federal University of Minas Gerais (Universidade Federal de Minas Gerais - UFMG), Belo Horizonte, Minas Gerais state, Brazil, process ETIC #0115.0.203.000-11, and all individuals who agreed to participate signed a consent form.

Data were collected in a senior care service by researchers trained to apply a semi-structured questionnaire and physical-functional tests, which took on average 50 minutes to complete. All subjects were evaluated between March 2011 and July 2011. Individuals eligible for the study answered a socio-demographic questionnaire, self-reported episodes of falls in the last year, and self-reported the presence of comorbidities diagnosed by a physician in addition to having their depressive symptoms screened by the Geriatric Depression Scale Short Form[17] (GDS-5).

Five indirect indicators were used to evaluate sarcopenia: nutritional assessment with the Mini Nutritional Assessment Short-Form (MNA)[18]; body mass index (BMI) with values standardized according to the Nutrition Screening Initiative[19]; physical activity level, measured by the Human Activity Profile (HAP)[20]; handgrip strength (HGS), measured using the manual Jamar® dynamometer (Sammons Preston, Illinois); and gait speed, measured using the 4.6-meter walking test (the mean of three measurements was calculated). The reference values for the last two variables followed the recommendations of the European Consensus on Definition and Diagnosis of Sarcopenia[8].

Frailty was characterized according to the criteria proposed by Fried et al.[2]: self-reported weight loss of approximately 4.5 kg in the last year; exhaustion, assessed by two questions of the depression screening scale Center Epidemiological

Scale-Depression; physical activity level, assessed by HAP; reduction in muscle strength, measured using HGS with the manual Jamar® dynamometer; and gait speed, determined as the time spent to walk 4.6 meters. The HGS values and gait speed were each reported relative to the first quintile of the sample because there are no normative data for the elderly population in Brazil. Finally, the functional capacity of the elderly individuals was evaluated by the Short Physical Performance Battery (SPPB)[21]. The elderly individuals were divided into the following groups: frail (more than three positive criteria), pre-frail (one or two positive criteria), and non-frail (no positive criterion). For the regression analysis, the number of positive items scored among the five that constitute the phenotype[2] was used to characterize frailty.

The data are expressed in percentages for the categorical variables and mean ± standard deviation for the numerical variables. The normality of the distribution of the dependent variables of this study was tested. Because the data were homoscedastic and normally distributed, analysis of variance (ANOVA) followed by Tukey's post-hoc test was performed. In addition, multiple regression analyses were performed to measure the level of explanation of each variable - indirect indicators of sarcopenia and functionality - in relation to the frailty phenotype. No data from the evaluations were lost. All analyses were performed at a significance level of α=0.05 and confidence interval of 95%, using SPSS software version 16.0.

Results

Of the 70 individuals evaluated, 53 completed the assessment, and those who did not achieve the required score on the MMSE were excluded. The average age of the 53 participants was 76.72 (±5.89) years. The majority were females (75%). The remaining descriptive socio-demographic data and the data on the frailty profile of the sample are shown in Table 1. Regarding the frailty profile, 30.2% of subjects were considered robust, 54.7% pre-frail, and 15.1% frail.

The most prevalent comorbidities are shown in Table 2. Heart disease (26.4%), lung disease (15.1%), and cancer (5.7%) were the conditions least reported by the elderly subjects. Table 2 also shows the MMSE results with the total score and the score divided by educational level. Regarding falls, 54.7% of the individuals reported having fallen in the past year, and 35.8% of episodes were recurrent.

Among the indirect sarcopenia indicators analyzed in the total sample, the level of physical activity (41.5%) and gait speed (39.6%) were the most prevalent (Table 3).

Table 4 shows the results of the ANOVA of the indirect sarcopenia indicators between the frailty groups, as well as these same indicators between elderly fallers and non-fallers. The physical activity level was significantly different between the frail and non-frail groups and between the pre-frail and non-frail groups ($p<0.05$ for both), but not between the frail and pre-frail groups. Gait speed was significantly different only between the non-frail and frail groups ($p=0.007$). There was no significant difference between the remaining indicators or the frailty profiles ($p>0.05$). Differences were found between genders for BMI ($p=0.009$) and HGS ($p=0.000$).

Considering the indirect sarcopenia indicators, there were differences only in HGS ($p=0.00$) between elderly fallers and non-fallers, and HGS was not associated with the SPPB score. Regarding functionality, a weak negative correlation was found between the SPPB total score and MNA score ($p=0.00$), a good negative correlation between SPPB score and gait speed ($p=0.00$), and a moderate correlation between the SPPB score and HAP ($p=0.004$). Regarding the individual SPPB items, there was a moderate correlation between the equilibrium test and HAP ($p=0.04$) and between the walking test and gait speed ($p=0.00$) and HAP ($p=0.03$). The five-times-sit-to-stand test did not correlate with any sarcopenia indicator (Table 5). The GDS-5 score was correlated with gait speed and HAP ($p=0.003$).

The regression model for the frailty burden with all indirect sarcopenia indicators explained 62.5% ($R=0.625$) of the increase in the number of positive items. The model with frailty burden separating the sarcopenia indicators generated two models, one in which HGS and HAP together explained 61% ($R=0.610$) of the increase in positive items for frailty, and one in which HAP alone explained 54.5% ($R=0.545$) of the increase in positive items for frailty.

The statistical power of the multiple regression model was 0.78 and of the correlation analysis was 0.61.

Table 1. Descriptive analysis of the socio-demographic data and the frailty profile of the sample (n=53).

Variable	% (n)	Mean (±SD)	95% CI
Gender			
Female	75.5% (40)		
Male	24.5% (13)		
Age		76.72 (±5.89)	75.09-78.34
Marital status			
Married	37.7% (20)		
Single	7.5% (4)		
Divorced	3.8% (2)		
Widower	50.9% (27)		
Color/ethnicity			
White	35.8% (19)		
Black	17% (9)		
Mestizo	43.4% (23)		
Asian	3.8% (2)		
Working			
Yes	11.3% (6)		
No	88.7% (47)		
Live alone			
Yes	18.9% (10)		
No	81.1% (43)		
Frailty profile			
Non-frail	30.2% (16)		
Pre-frail	54.7% (29)		
Frail	15.1% (8)		

n: number of subjects; %: frequency distribution; SD: standard deviation; CI: confidence interval.

Table 2. Distribution of the clinical variables of the sample (n=53).

Clinical variable	% (number of subjects)
Hypertension	
Yes	77.4% (n=41)
No	22.6% (n=12)
Diabetes	
Yes	26.4% (n=14)
No	73.6% (n=39)
Osteoarthritis	
Yes	41.5% (n=22)
No	58.5% (n=31)
Number of falls in the past year	
One	18.9% (n=10)
Two or more	35.8% (n=19)
None	45.3% (n=24)
Fracture due to the falls	
Yes	1.9% (n=1)
No	52.8% (n=28)
Hospitalization due to the falls	
Yes	7.5% (n=4)
No	47.2% (n=25)
MMSE	
Total	22.44 (±3.33)
Illiterate	18.83 (±1.47)
1-4 years of education	22.62 (±3.15)
5-8 years of education	25.5 (±2.64)
9-11 years of education	22.66 (±4.5)
GDS	1.75 (±1.44)
SPPB	9.19 (±1.94)

MMSE: Mini-Mental State Examination; GDS: Geriatric Depression Scale; SPPB: Short Physical Performance Battery.

Discussion

The current study analyzed the influence of indirect indicators of sarcopenia and functionality on frailty syndrome in a community-dwelling elderly subjects treated at a secondary health care service. The features of the sample regarding the prevalence of comorbidities are similar to Brazilian epidemiological studies that found a hierarchy for the six most commonly reported diseases in the elderly. Systemic arterial hypertension is the most prevalent disease, followed by arthropathy and diabetes. Heart disease, lung diseases, and cancer are less significant[22].

Fried et al.[2] and Avila-Funes et al.[4] found identical prevalences (7%) of frailty in community-dwelling elderly populations in the United States and France. Brazilian studies have shown higher values, as demonstrated in the study by Santos et al.[23], in which 13.3% of the elderly subjects were frail and 59.3% were pre-frail, as well as that by Silva et al.[24], in which 10.4% of elderly subjects were frail and 48.8% were pre-frail. These data corroborate the findings of the present study. This high prevalence of frailty may be associated with the generally lower educational level and income and higher number of comorbidities and disabilities in the elderly compared to other populations[2,9].

More than half (54.7%) of the elderly in the current study reported at least one fall in the past year, and 35.8% admitted that falls were recurrent. Silva et al.[24] and Siqueira et al.[25] found lower prevalences of falls

Table 3. Frequency, mean, and standard deviation of the indirect sarcopenia indicators: body mass index, Mini-Nutritional Assessment, handgrip strength, Human Activity Profile and gait speed (n=53).

Variables	n (%)	Mean (±SD)	95% CI
BMI (kg/m^2)		27.36 (±6.34)	25.61-29.11
Yes	9 (17%)		
No	44 (83%)		
MNA		11.3 (±1.69)	10.84-11.77
Yes	8 (15%)		
No	45 (84.9%)		
HGS (kgf)		21.64 (±6.87)	19.74-23.53
Yes	11 (20.75%)		
No	42 (79.25%)		
HAP		57.45 (±14.71)	53.40-61.51
Yes	22 (41.5%)		
No	31 (58.5%)		
GS (m/s)		7.73 (±2.94)	6.92-8.54
Yes	21 (39.6%)		
No	32 (60.4%)		

BMI: body mass index; MNA: Mini-Nutritional Assessment; HAP: Human Activity Profile; GS: gait speed; m/s: meters per second; HGS: handgrip strength; kgf: kilograms-force; SD: standard deviation; CI: confidence interval**.**

Table 4. Differences between frailty groups and between fall groups in indirect sarcopenia indicators.

Groups	MNA *(p)***	BMI *(p)***	HGS *(p)***	GS *(p)***	HAP *(p)***
NF – PF	0.997	0.557	0.641	0.102	0.000*
F – NF	0.996	0.352	0.367	0.007*	0.001*
F – PF	0.989	0.763	0.72	0.177	0.846
Fa – NFa	0.602	0.245	0.000*	0.394	0.914

NF=non-frail; PF=pre-frail; F=frail; Fa=fallers; NFa=non-fallers; BMI: body mass index; MNA: Mini-Nutritional Assessment; HAP: Human Activity Profile; GS: gait speed; HGS: handgrip strength; * statistically significant difference (p<0.05); ** p values based on analysis of variance followed by Tukey's post-hoc test.

Table 5. Correlation analysis between the indirect sarcopenia indicators and SPPB scores (total and per-item) and GDS.

Groups	MNA		BMI		HGS		GS		HAP	
	p	**R**	*p*	**r**	*P*	**r**	*p*	**r**	*P*	**r**
SPPBt	0.00*	-0.088	0.110	-0.222	0.074	0.248	0.00*	-0.525	0.004*	0.394
SPPBe	0.488	0.097	0.077	-0.245	0.330	0.136	0.036	-0.288	0.003*	0.395
SPPBgs	0.317	-0.140	0.581	-0.077	0.468	0.102	0.00*	-0.607	0.004*	0.391
SPPBss	0.491	-0.097	0.349	-0.131	0.112	0.221	0.370	-0.126	0.607	0.072
GDS	0.914	0.015	0.183	0.186	0.942	-0.010	0.003*	0.397	0.003*	-0.368

SPPBt=Short Performance Physical Battery–Total; SPPBe=Short Performance Physical Battery–equilibrium; SPPBgs=Short Performance Physical Battery–gait speed; SPPBss=Short Performance Physical Battery–sit and stand; GDS=Geriatric Depression Scale; BMI: body mass index; MNA: Mini-Nutritional Assessment; HAP: Human Activity Profile; GS: gait speed; *statistically significant difference (p<0.05); R=correlation coefficient (-1 to 1); SPPBss: Short Perfomance Physical Battery- sit to stand.

in community-dwelling elderly subjects (34.4% and 34.8%, respectively). This fact is possibly due to the profile of our study sample, which included older subjects (mean age 76.72 years) and subjects with greater physical impairment than these other two studies. All subjects were patients at a secondary health care service and most likely exhibited more complex health problems than the populations evaluated in other studies.

The level of physical activity (41.5%) and gait speed (39.6%) were the most prevalent sarcopenia indicators. Likewise, they were the only items that showed differences between frailty groups and that correlated with the functional profile. Cesari et al.[26] found that physical inactivity and low gait speed were the frailty criteria more often associated ($p<0.01$) with muscle mass measurements. These authors also found that physical inactivity was the only criterion that remained associated with all muscle mass measurements after adjustment for co-variables, including biological markers. These results reinforce the findings of the current study, which showed, after the regression analysis, that physical inactivity was the sarcopenia indicator most closely related to frailty, explaining alone 51.8% of the model ($r=0.518$).

The study by Peterson et al.[27] showed that the odds of a sedentary individual developing frailty syndrome are almost twice as high compared to that for active individuals (OR=1.45; 95% CI: 1.04-2.01) and that the odds of progressing to a more advanced stage of the syndrome almost tripled for individuals who were frail and sedentary at baseline (OR=2.80; 95% CI: 0.98-8.02). The data from the present study suggest the same relationships, demonstrating a negative association between frailty and the level of physical activity and a difference in physical activity between non-frail and frail groups and between non-frail and pre-frail groups.

A Brazilian study[28] indicated that sedentary lifestyle, assessed only by physical activity, is not a good measurement to characterize frailty. In that study, sedentariness was associated only with comorbidities, while the weekly caloric expenditure was associated with HGS, gait speed, and fatigue, all the criteria of the frailty phenotype. However, it is noteworthy that the instrument used by those authors to assess the weekly caloric expenditure was the Minnesota Leisure Time Physical, which contains activities not practiced in Brazil, which may lead to a ceiling effect on the score, in addition to being difficult to apply in the Brazilin elderly population because it requires remembering activities of little relevance for this population.

Low gait speed shows an association with various negative outcomes in elderly subjects[29], including frailty syndrome[30]. Montero-Odasso et al.[30] found that all gait parameters evaluated (gait speed and quantitative parameters), both at normal and fast speed, were associated with frailty in univariate linear regression.

In the present study, gait speed was correlated with the SPPB total score, in agreement with Vasunilashorn et al.[31], who found associations between gait speed and functionality. They found, after adjustment for gender and age, that elderly subjects with SPPB scores below 10 had higher risks of developing mobility deficits compared to subjects with higher scores, while scores below 7 indicated a 32-fold-higher chance of being unable to walk four blocks.

The regression model used in the present study also showed that gait speed was the variable most strongly indicative of depression for both sarcopenia indicators (39.7%; $r=0.397$) and functionality (52.5%; $r=0.525$). These findings are similar to those of Chale-Rush et al.[32], who found an association between the level of physical activity and depressive symptoms, as well as to the findings of Perrino et al.[33], where depressive symptoms were associated with a decrease in the number of blocks walked per week.

Several authors emphasize the importance of gait speed in assessing the elderly individual. A recent systematic literature review highlighted that there is sufficient evidence to characterize gait speed as a consistent predictor of adverse events in the elderly. In that study, low gait speed was correlated with inability to perform BADL, dementia, mortality, falls, institutionalization, and hospitalization. The authors additionally emphasized the low cost and high clinical applicability of the marker[34].

There was a significant difference between the fallers and non-fallers in HGS in this study. This finding may suggest less muscle strength of the lower limbs in the faller group. Even though some studies did not assess HGS directly, HGS has been associated with total muscle strength[12] and associated with increased risk of functional limitation as assessed

by gait speed (OR=2.77; 95% CI: 1.70-4.54) and by the sit-to-stand test (OR=2.73; 95% CI: 1.19-6.27)[35].

No associations were found between MNA score and the frailty profile of the elderly subjects. However, MNA was significantly correlated with the SPPB total score, demonstrating a possible influence of nutritional status on the functionality of the elderly. This finding agrees with the results of Lee et al.[36], who demonstrated an association between of ADL measures and MNA. Bahat et al.[37], however, found no association between MNA and functionality but did find a correlation between functionality and lean mass as assessed by electrical bioimpedance. The authors hypothesized a possible influence of nutritional status on sarcopenia and, consequently, on frailty.

The main limitations of this study are related to the choice of the sample because it was specific to a secondary health care service, a factor that limits the external validity of the findings. In addition, the sarcopenia measurements were performed indirectly instead of using more accurate equipment to determine the loss of muscle mass and strength. Nevertheless, all the instruments used are easily applicable in clinical practice and can be included in daily evaluations by any health professional who cares for the elderly, facilitating the early detection of factors that may be primarily responsible for the onset of frailty and its negative outcomes.

Conclusion

This study confirmed the association between sarcopenia and frailty and showed that physical inactivity and gait speed may be the most important factors in screening for frailty syndrome. Identifying these factors is important for efforts to prevent or attenuate the deleterious effects of sarcopenia, especially in the functional profile of the elderly.

Acknowledgments

This study was funded by the National Council of Technological and Scientific Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq) and the Minas Gerais Research Foundation (Fundação de Amparo à Pesquisa do estado de Minas Gerais – FAPEMIG).

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