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Original article

Body composition and functional performance of older adults

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ABSTRACT

Objectives: To determine if anthropometric variables, body composition, medication and gender are associated with functional performance and to compare these variables between octogenarians with high and low functional performance.
Methods: Observational, cross-sectional study. Weight, height, body mass index (BMI), waist circumference (WC), and waist-to-height ratio (WHtR) were evaluated. Handgrip strength (HGS) was assessed. Participants' body composition was assessed by dual-energy X-ray absorptiometry (DXA) and functional performance by Short Physical Performance Battery (SPPB). A binomial logistic regression was performed.
Results: One hundred and twenty-two octogenarians were included and separated into high and low function groups. The high function group showed lower values of WHtR (mean difference [MD] = 0.047, P = 0.025) and body fat (BF%) (MD = 3.54, P = 0.032) and higher values of apendicular skeletal muscle mass (ALM) (MD = 3.03, P = 0.001), HGS (MD = 6.11, P = 0.001) and SPPB score (MD = 4.20, P = 0.001). Women were more likely to be classified as low function (OR = 3.66, P = 0.002) and males showed 5.21 odds ratio (P = 0.021) of having high functional performance compared to females. Also, each decrease in age and medication use displayed 1.30 (P = 0.007) and 1.26 odds ratio increases (P = 0.008) in high functional performance.
Conclusions: Older males display better functional performance than women, and decrements in age and medications increase the high functional performance odds ratio. Octogenarians with high functional performance displayed lower BF measurements and higher values of muscle mass and strength.

1. Introduction

For the first time in American history, the number of older adults will outnumber younger generations within the next 20 years. This trend toward aging populations is witnessed worldwide, with projections that this group will continue to grow faster than any other age group [1]. In parallel with increased longevity, countries will need to adapt to unique health consequences secondary to this movement. Aging antecedes a number of physiological changes that bring about risk for functional performance and independence. When aging is compounded with undesirable changes in body composition, which are common in this age group, the deleterious effects may be intensified [2].

Body shape and tissue quality are often negatively impacted by the aging process. Progressing in age is often met with the substitution of muscle mass and adipose, leading to an associative loss of strength [3] and declining anthropometric measures (eg, sarcopenia, adiposity). Older adults experiencing this shift in lean body mass to fat mass are at risk for the geriatric syndrome, sarcopenic obesity [4]. Physical inactivity associated with loss of functional ability compounds risk for reduced metabolic activity and unproductive weight gain [4,5]. One study found that older Brazilians had a high prevalence (48.7%) of obesity and overweight mainly among those age 60–79 years [6]. Men may experience similar sarcopenic obesity due to the inverse association between aging and testosterone levels, the hormone responsible for activating satellite cells which promote protein synthesis [7]. Post-menopausal women

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tend to deposit body fat viscerally and toward the midsection, directly impacting anthropometric measurements such as waist-to-hip ratio [8].

Changes in body composition resulting from aging are also related to the progressive loss of muscle function, with repercussions on functional performance [9]. A study of males 70 years or older found that those with functional limitations had lower lean body mass (both upper and lower body), higher fat mass and total fat percentage, and impaired handgrip and quadriceps muscle strength [10]. Furthermore, polypharmacy, common in aging, can also affect functional performance. Studies report that the use of 5 or more medications is a predictor of low functional performance in the elderly and is associated with lower gait speed and worse performance in mobility tests [11].

Functional performance in older adults can also be influenced by sex. Guede-Rojas et al. [12], revealed that older men out performed women on 2 functional tests, the 2-min step test and the sit-and-reach test. Tangen et al. [13] reported superior performance of older men compared to women on the muscle strength, balance, and endurance functional assessments. These findings suggest that men tend to fair better with the aging process compared to women in regard to retaining functional abilities.

Evaluating aging populations and functional ability is not a novel line of investigation, however, more can be known regarding the influence of anthropometric measures such as body composition, body mass index (BMI), waist circumference (WC), and WHtR on the functional performance of the oldest members society. The current literature's generalizability is skewed toward American and European people and large age ranges, highlighting the need for studies in developing countries, individuals who are in their last decades, and those with different ethnicities [14]. Honing in on a particular decade of life (eg, octogenarians) should produce more reliable results and less variability as differences in functional performance across age groups is reduced.

In light of this information, the primary aim of the present study is to verify whether anthropometrics indexes of abdominal visceral adipose tissue accumulation, body composition, medications or gender variables were associated with functional performance of older adults. The secondary aim was to compare independent variables between octogenarians of high and low functional performance.

2. Methods

2.1. Design of the study

This study was part of a population and multicenter study called “Patterns of physical, cognitive and psychosocial aging in long-lived elderly people living in different contexts”, conducted in the period from 2016 to 2018. This was an observational, descriptive, cross-sectional study with older adults 80 years and over living in Brasília (DF). The research was approved by the Research Ethics Committee of the Catholic University of Brasília (protocol nº 50075215.2.0000.0029) and was conducted in accordance with ethical standards established in the Declaration of Helsinki. All participants were fully informed about the risks associated with study participation and gave their written informed consent.

2.2. Population and sample

A sample of convenience was recruited from the geriatric and medical clinic of the Catholic University of Brasília. Volunteers were invited to participate in the research after presentation and clarification. A total of 220 older adults volunteered and were included in the study. Inclusion criteria required an age of 80 years or older, absence of visual and auditory deficits (not compensated by prostheses), and ability to understand and respond to the instruments applied. Older adults were excluded if they were unable to stand upright, presented with a physical deficiency that prevented independent walking (eg, lower limb amputations, hemiplegia or stroke sequelae), or if data were missing due a lack of participation.

2.3. Instruments and data collection

An interview was initially conducted between an investigator and participant with clinical evaluation. Next, participants completed physical, anthropometric, and muscle strength evaluation before functional performance tests. Before dismissal, a body composition exam using dual-energy X-ray absorptiometry (DXA) was performed.

Anthropometrics in this study consisted of weight (kg), height (cm), BMI, WC and WHtR. Older participants were weighed and measured on a digital electronic scale with a capacity of 300 kg and a stadiometer (Welmy® W300 brand, São Paulo, SP, Brazil). Participants were asked to take a deep breath and stand as completely upright as possible prior to height assessments. BMI was obtained by the ratio between weight (kg) and height squared (m^2). BMI classifications followed recommendations specific for older adults: low weight (BMI 22 kg/m^2), eutrophy (BMI 22 kg/m^2 - 27 kg/m^2) and overweight (BMI > 27 kg/m^2) [15].

WC was collected using a nonelastic measuring tape. The assessment landmark fell at the midpoint between the iliac crest and the last rib. The cutoff points for WC were $\geq$ 88 cm for women and $\geq$ 102 cm for men [16]. From the anthropometric measurements, the WHtR was calculated and the cut-off point of 0.55 was adopted for the classification of overweight/obesity [17].

Handgrip strength is often suggested and implemented as a measure of muscle function for older adults [4]. The handgrip strength of the dominant upper limb was measured using a hydraulic dynamometer (Jamar, Model 5030J1, Fred Sammons, Inc., Burr Ridge, IL, USA). Three consecutive measurements were taken, interspersed with 1 min of rest. The highest value was considered for statistical evaluation [18,19].

The Short Physical Performance Battery (SPPB) was used to assess functional performance. The battery is composed of 3 tests: static balance (3 different standing positions with increasing levels of difficulty); walking speed (3 m course, usual walking speed); and lower limb strength (sit to stand 5 times from a chair as quickly as possible). Each subtest is scored on a scale from 0 to 4 points, with a high cumulative score of 12 [20]. Participants with a total score of 7 or less were classified as having low functional performance [21].

Body composition variables were drawn from DXA assessments (GE Lunar Corporation - model DPX-IQ - type pencilbeam, software version 4.7, Chalfont St. Giles, United Kingdom); these included body fat percentage (BF%), appendicular skeletal muscle mass (ALM), and muscle quality (MQ). For the exam, older participants wore light clothing and no type of metallic material. Values $\geq$ 38% in women and $\geq$ 27% in men were considered excess body fat [4]. MQ considered the ratio of handgrip to the entire arm muscle (kgs) measured by DXA [19]. The validity and reliability of MQ is established and is commonly used in large-scale studies [22–24].

2.4. Statistical analysis

A post-hoc power analysis using $\alpha = 0.01$, determined a total sample of 113 participants to achieve 94% power. Seven predictors accounted for 30% of variance explained on functional performance. Including age in the model, increased the proportion of variance explained for 39%. The linearity of continuous variables in relation to the dependent variable logit (functional performance -

SPPB) was assessed using the Box-Tidwell procedure, and all continuous independent variables were linearly related to the dependent variable logit. The logistic regression model was statistically significant, χ^2 [8] = 31.68, P = 0.001. The model explained 39% (NagelkerkeR2) of the variance in functional performance and correctly classified 69.7% of cases. The sensitivity was 72.7%, the specificity 66.7%, the positive predictive value 68.08%, and the negative predictive value 71.42%. The area under the ROC curve was 0.83 (95% CI, 0.74–0.91), which is an excellent acceptable level of discrimination [25]. Binomial logistic regression was used to verify the effects of the following measures of body fat (Table 1). The binomial logistic regression also evaluated MQ and gender (female vs male) for the likelihood of participants having high functional performance based on the SPPB classification (0 = low functional performance; 1 = high functional performance). A Mann-Whitney *U* test was performed to determine if there were any differences in baseline characteristics between the low functional and high functional groups. A chi-square test (χ^2) was also performed to determine if an association between functional groups, anthropometric measures, body composition and sex exists. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS) software version 20.0 (SPSS Inc., New York, USA) and power was calculated using G*Power (3.1.6) [26]. Values of $P \leq 0.05$ were considered statistically significant.

3. Results

Recruitment yielded 220 volunteers, but only 122 older adults were included in the final evaluation (females n = 78 [63.9%] and males n = 44 [36.1%]). Fig. 1 outlines the path of inclusion and exclusion of volunteers.

Table 2 presents the sample characteristics. The group with high functional performance had lower WHtR (mean difference = 0.047, P = 0.025) and BF% (mean difference = 3.54, P = 0.032) compared to low functional performance group. They also had a higher ALM (mean difference = 3.03, P = 0.001), HGS (mean difference = 6.11, P = 0.001), static balance score (mean difference = 1.08, P = 0.001), walking speed score (mean difference = 1.63, P = 0.001), get up and sit from the chair score (mean difference = 1.55, P = 0.001), and SPPB score (mean difference = 4.20, P = 0.001) when compared to low functional performance group (Table 2). Furthermore, low functional performance group took more medications compared to high functional performance group (mean difference = 1.68, P = 0.010).

Besides, there was a statistically significant association between functional groups and sex and a higher observed frequency of women was at low functional performance group (OR = 3.66, p = 0.002). Also, there was a statistically significant association between functional groups and arthritis (OR = 1.40, P = 0.004), where a higher observed frequency was at high functional performance group. Furthermore there was a statistically significant association between functional groups and depression (OR = 2.71, P = 0.006) (Table 2), where a higher observed frequency was at low functional performance group.

Sex, age and medications were significant predictors of functional performance in the logistic regression (as shown in Table 3). Older male participants had a 5.21 odds ratio of having high functional performance compared to females. Also, each unit reduction in age, the odds ratio of having high functional performance increases by a factor of 1.26 (1/0.789). Futhermore, each unit reduction in medication, the odds ratio of having high functional performance increases by a factor of 1.30 (1/0.767).

Table 1
Dichotomous assignments for anthropometric variables.

	Yes	No
WC [16]		
Men	≥102 cm	<102 cm
Women	≥88 cm	<88 cm
BMI [15]		
Men	≥27 kg/m^2	<27 kg/m^2
Women	≥27 kg/m^2	<27 kg/m^2
BF% [4]		
Men	≥27%	<27%
Women	≥38%	<38%
WHtR [17]		
Men	≥0.55	<0.55
Women	≥0.55	<0.55

BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; BF%, body fat percentage.

4. Discussion

The current investigation was able to show that older adults categorized in the higher function group possessed preferable anthropometrics (lower WHtR and BF%, greater ALM) and HGS when compared to those in the low function group. We can also report that there is a probability of high functional performance among male older adults than females, echoing past literature that females struggle with functional performance as they age.

Our findings sustain the presence of a gender gap in older adult's functional ability. Others substantiate this conclusion, as another sample of older adults found that men had independence in mobility and locomotion assessments, while women needed supervision [27]. Similar findings are observable around the world. Older women in Brazil had a higher proportion of low functional performance when measured by the SPPB [28]. A prospective, observational and population-based cohort study of more than 500 older Belgium individuals found that men scored higher on the SPPB and HGS tests when compared to women [29]. With age controlled for, active Norwegian older men performed better in tests of muscle strength, balance and endurance when evaluated against comparable women [13].

The low functional performance among older, female participants may be associated with social and physiological issues. The social phenomenon, feminization of aging, presents how women have a higher life expectancy and longevity, yet they spend a longer period of time exposed to chronic diseases (eg, depression), morbidities, fragility, and consequently, functional dependence [27]. Men seem to be more physiologically prepared for the aging process as they be able to retain or regain muscle mass and strength with exercise interventions compared to women [30]. Sex-specific hormonal changes seem to favor the maintenance of a better muscle condition in men as they grow older. The hormonal changes at menopause put women at risk for increased body weight and visceral fat deposition, while also decreasing fat-free mass and reducing muscle mass. The reduction in muscle mass leads to a lower basal metabolic rate and a progressive reduction in total energy expenditure, also contributing to the increase in fat tissue [4,12]. This divergence in response to aging between sexes, yet greater longevity experienced by women highlight the challenge communities face when dealing with health and wellcare of aging women. Greater focus is needed to address the unique needs of women in both policies, therapeutic interventions and healthcare to prepare for this growing issue [31].

Similar to our findings, 392 older adults aged 65 years or older, participants who used 5 or more medications had a worse functional performance. Polypharmacy was independently associated with poor SPPB and chair sit-to-stand test [11]. A study investigating the effect of statin use and functional performance in the

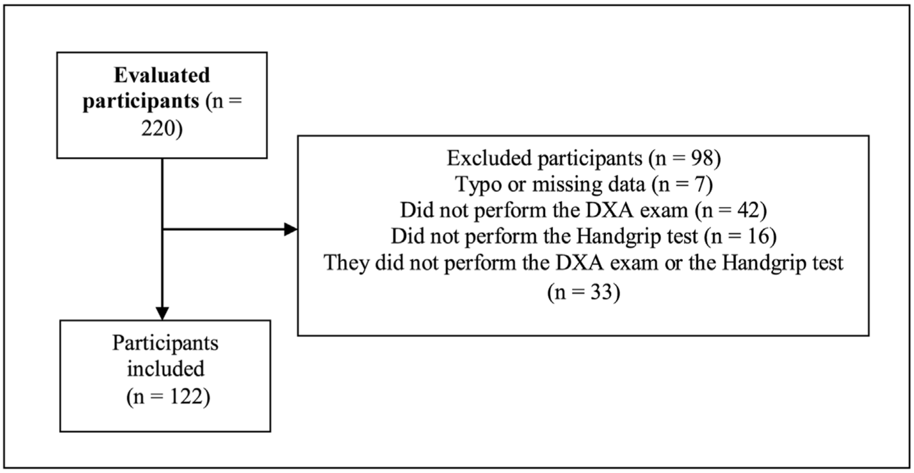

Fig. 1. Flowchart of study participants.

Table 2
Main characteristics of the participants.

	Low Functional Performance	High Functional Performance	P-value
Sex			0.002
Males	13 (22.8)	26 (52)	
Females	44 (77.2)	24 (48)	
Age, yr	84.94 ± 4.41	85.56 ± 2.92	0.003
Height, cm	1.53 ± 0.10	1.58 ± 0.07	0.002
Weight, kg	62.57 ± 12.69	65.74 ± 11.12	0.130
BMI, kg/m^2	26.80 ± 7.15	25.86 ± 3.95	0.854
WC, cm	96.04 ± 11.27	92.06 ± 10.84	0.252
WHtR	0.62 ± 0.09	0.58 ± 0.07	0.025
BF, %	35.21 ± 10.18	31.66 ± 8.89	0.032
ALM, kg	16.77 ± 3.23	19.81 ± 4.68	0.001
HGS, kg	18.28 ± 6.37	24.40 ± 8.13	0.001
MQ, kg/kg	4.04 ± 1.99	4.60 ± 2.01	0.081
Static Balance, Score	2.52 ± 1.23	3.60 ± 0.75	0.001
Walking speed, Score	2.26 ± 1.00	3.90 ± 0.30	0.001
Get up and sit from the chair, Score	0.82 ± 0.57	2.38 ± 0.87	0.001
SPPB, Score	5.63 ± 2.19	9.84 ± 0.88	0.001
Medications, number	5.28 ± 3.30	3.60 ± 2.57	0.010
			P-value
Cardiopathy	12 (25)	13 (28.9)	0.672
Hypertension	36 (69.2)	37 (77.1)	0.377
Stroke	7 (16.3)	5 (11.4)	0.506
Diabetes	15 (32.6)	8 (17)	0.082
Cancer	9 (21.4)	7 (17.1)	0.615
Arthritis	25 (59.5)	35 (87.5)	0.004
Pulmonary disease	7 (16.7)	5 (12.2)	0.562
Depression	19 (43.2)	7 (16.3)	0.006
Osteoporosis	18 (42.9)	14 (33.3)	0.369

Data presented as average ± standard deviation or frequency (percentage values) for categorical variables; BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; BF, body fat percentage; ALM, apendicular skeletal muscle mass; HGS, handgrip strength; MQ, muscle quality; SPPB, short physical performance battery.

elderly showed a significant decrease in handgrip strength (HGS) and gait speed compared to non-users; however, in the multiple regression analysis, the association between statin and functional performance was not maintained [32].

However, functional performance seems to be more associated with the number of drugs used concomitantly. A systematic review study showed a strong bidirectional association between polypharmacy and physical performance and highlighted that, in the elderly, the probability of drug-drug and drug-illness interactions is greater, resulting in negative functional outcomes [33].

Keeping citizens functional and independent should be a top priority of policy makers, as government provided healthcare costs taxpayers trillions of dollars each year. Similar to our findings, others report that excess of BF in older adults was associated with reduced functional performance in tests of balance, gait speed, and strength of lower limbs [34].

Opposing findings are also available, as Santos et al [2] found no association between body fat and mobility in individuals aged 80 years or older, though they did find lower leg strength in the group with sarcopenia. In a study by Sallinen et al [35], there is association between body fat and functional performance in participants aged 60–79 years, but the relationship was lost after participants aged above 80 years old. These findings may support the theory that the effects of excess body fat are especially detrimental to the functional performance of younger older adults since fat tends to decrease at older ages, potentially ameliorating the harmful effect

Table 3
Logistic regression predicting the probability of exhibiting high functional performance based on WC, BMI, WHtR, body fat (DXA), sex, age, medication, and MQ.

Variable	P-value	Odds ratio	95% CI for Odds ratio	
			Lower	Upper
WC, cm	0.966	1.039	0.180	5.991
BMI, kg/m^2	0.323	0.476	0.109	2.076
WHtR	0.902	0.905	0.185	4.424
BF, %	0.203	2.555	0.603	10.829
Sex, male	0.021	5.213	1.287	21.11
Age, yr	0.007	0.789	0.664	0.937
Medication, numbers	0.008	0.767	0.631	0.932
MQ, kg/kg	0.685	1.062	0.795	1.419

WHtR, waist-to-height ratio; BMI, body mass index; DXA, dual-energy X-ray absorptiometry; WC, waist circumference; MQ, muscle quality; BF%, body fat percentage.

[4,35]. These studies corroborate the current findings that older adults with high functional performance have lower body fat percentages.

In addition to a lower BF%, participants in the current study with high functional performance had a lower WHtR value. The average WHtR for the high functional group was close to the overweight and obesity cutpoint. The authors believe these data are unprecedented in the literature. WHtR is a well known predictor of obesity and a valuable anthropometric measure for evaluation in both sexes [17,36,37]. However, it may be argued that BMI and WC have a greater capacity to detect abdominal obesity than the WHtR in our oldest citizens [34]. Considering that WHtR is still poorly studied in relation to functional performance in octogenarians, and studies in this area become of great importance to better elucidate these conditions of aging.

When DXA is available, clinicians may utilize its sophistication to identify sarcopenic obesity in aging populations in order to directly evaluate its impact on functional performance. A sample of older adults (75 years or older) was evaluated and researchers found that the segmental skeletal muscle index of the calf was positively associated with functional performance in the SPPB test [38]. In addition, Patiño-Villada et al. [39], demonstrated that Spanish older participants (men and women 70 years old or over) with an adequate ALM performed better on tests of muscle strength and functional capacity. The authors did not find a relationship between obesity and function, but muscle mass seemed to be an important contributing fator [38]. Unfortunately, it appears that older women with sarcopenic obesity may not experience the positive adaptations to resistance type exercise (fat mass, fat free mass, WC, WHtR or functional performance) when compared to those without the condition [40]. Therefore, studies should be directed towards a better understanding of the real effect of resistance exercises in elderly women with sarcopenic obesity, as well as to prevent the exchange of muscle with adipose tissue in individuals as they age, as this condition may preclude their ability to offset the ramifications in the future.

Octogenarians with high functional performance also had a higher prevalence of osteoarthritis. A systematic review with more than 106 articles included with a sample of adults and elderly pointed to osteoarthritis as the second most prevalent condition in the USA, and the average costs of this pathology exceeded 450 billion dollars, evidencing a demand for treatment and rehabilitation [41].

Despite the high prevalence, older adults with osteoarthritis who practice physical exercises or participate in rehabilitation programs with physical therapy are able to diminish pain and maintain good joint function. Older adults who lead an active lifestyle also benefit, reducing pain and joint limitation [42]. Our hypothesis, therefore, is that the diagnosis of osteoarthrosis leads the elderly to seek treatments that optimize joint function and, consequently, functional performance. However, osteoarthrosis was more prevalent in octogenarians in the community with high functional performance and higher muscle mass and strength values. Thus, we can infer that even older adults who do not seek treatment maintain an active lifestyle, reducing osteoarthritis symptoms and maintaining independence.

Though this study was designed with intention and control, it is not without defect. Data were lost on 7 participants (secondary to a number of reasons) and the investigation could not consider data from 91 other participants due to no DXA or HGS assessment. The cross-sectional nature of the study prevents our ability to infer any causal relationships. With this large scale study, the team required data to be collected by several evaluators to maximize participant convenience. To minimize the potential interrater reliability limitation, all evaluators were properly trained prior to participant assessments. Because homogeneity of the sample is important to minimize variance, recruitment occured at a single outpatient facility. Therefore, the data presented can only be extrapolated to long-lived elderly people in the community and treated on an outpatient basis; therefore, the results may not be applicable to the general older population.

5. Conclusions

In conclusion, male older adults have a higher odds ratio of high functional performance than women. Besides, reducing age and medication use also increases the odds ratio of having high functional performance. Finally, octogenarians with favorable body fat measurements and muscle strength displayed greater functional performance.

CRediT author statement

Diane Nogueira Paranhos Amorim: Investigation, Writing - original draft. **Dahan da Cunha Nascimento:** Data curation, Formal analysis, Writing - review & editing. **Whitley Stone:** Writing - review & editing. **Vicente Paulo Alves:** Funding acquisition, Investigation, Methodology, Project administration. **Karla Helena Coelho Vilaça e Silva:** Investigation, Methodology, Supervision, Writing - review & editing.

Conflicts of interest

The authors declare no competing interests.

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