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ORIGINAL RESEARCH

Associations Between Gait Speed and Fat Mass in Older Adults

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Purpose: Although both gait speed and fat mass are crucial for healthy aging, evidence suggests that the associations between these components remain unclear. Therefore, the main purpose of the study was to examine the associations between gait speed and fat mass.

Patients and Methods: In this cross-sectional study, we recruited 643 older men and women aged >60 years. Fat mass was assessed using bioelectrical impedance analysis, while gait speed was determined by calculating the time an individual has taken to walk across a 4.6-m distance. Receiver operating characteristic (ROC) curves and odds ratios (OR) were performed to determine cut-off points and mutual associations.

Results: In older men, the optimal threshold of gait speed to detect high level of fat mass was 1.40 m/s with the area under the curve (AUC) being 0.82 (95% CI 0.76–0.89, $p < 0.001$). In older women, the optimal cut-off point was 1.37 m/s (AUC = 0.85, 95% CI 0.81–0.90, $p < 0.001$). Older men and women who walked below the newly developed threshold were approximately 12 times more likely to have high level of fat.

Conclusion: In summary, newly developed cut-off points of gait speed have adequate discriminatory ability to detect older men and women with high level of fat mass. Although gait speed may be considered as a satisfactory screening tool for fat mass, its utility in clinical practice needs to be further investigated.

Keywords: body composition, physical performance, aging, cut-points, associations

Introduction

In the last 50 years, the number of older adults has dramatically increased by 2%, and the projection estimates that the number will increase to 22% by 2050.[1] Evidence suggests that within the next 20 years, the number of older adults will outnumber younger generations worldwide.[2] Aging process is accompanied by many health-related consequences, including limitations and disabilities that are more prevalent in this population, compared to younger individuals.[3] The co-existing effect of aging and unwanted body composition changes may even accelerate the aging process,[4] leading to an increased risk of all-cause mortality.[5]

Body composition changes, which are described as a shifting process from lean muscle mass to fat mass, are particularly intensified during the aging process.[6] Thus, it is not surprising that approximately one-third of older adults are classified as being those with obesity, with an increasing trend being observed in the future.[7] Indeed, higher level of fat mass has been associated with a variety of metabolic measures, including an unproductive weight gain,[8] loss of strength,[9] and higher risk of sarcopenic obesity.[10]

Along with body composition, previous studies have shown that poor physical performance has been associated with aging, especially a decline in gait speed in the sixth decade.[11] From a practical point of view, gait speed is often used for functional assessment as it is a reliable and easy-to-administrate measurement.[12,13] The applicability of gait speed has been well established in longitudinal studies, as it may predict survival in older adults.[14] Even though a handgrip strength test is more commonly used to assess the functional status in older adults,[15] due to a more prevalent upper limb

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deformities occurring in this age group,[16] gait speed is often considered an appropriate and easy-to-administrate measure of physical performance.[15]

Previous cross-sectional[17–19] and longitudinal[20] studies have shown that body composition, ie, body-mass index or fat mass, is associated with gait speed in older adults. In general, the findings suggest that higher level of accumulated fat is related to slower gait speed.[18–20] Although a gait speed of ≤0.8 m/s is often used as a "proxy" of mobility impairment and reduced overall survival,[21] the threshold of gait speed to identify older adults with high level of fat mass is still unknown. In previous studies, very few older adults have exhibited gait speed values below 0.8 m/s, possibly limiting the significance in clinical practice.[17–20,22] By detecting an optimal cut-off point of gait speed to define high level of fat mass, one would be able to distinguish between healthy and unhealthy individuals. Also, the newly proposed cut-off values of gait speed may serve as a quick screening tool to detect older adults with high fat mass level.

Therefore, the main purpose of the study was to establish optimal cut-off points of gait speed to predict high level of fat mass in older adults. Based on previous findings,[17–20] we hypothesized that gait speed would give a relatively high diagnostic accuracy to identify those individuals, who might have high levels of fat mass.

Materials and Methods

Study Participants and Design

For the purpose of this observational prospective cross-sectional study, we recruited 843 older men and women using services of a single rehabilitation center in the "Lipik" county near the city of Zagreb from 2020 to 2022. This study was part of an internal project aiming to determine sociodemographic, physical, mental, and social factors of healthy aging through annual examinations in one of their rehabilitation centers. All participants were asked about the number of days during the week they spent in moderate-to-vigorous physical activity and were classified as "active", "not active enough", and "inactive". Participants included in initial analyses were apparently healthy older adults, who were considered physically active, based on a quick physical activity assessment prior the study. Of note, most of the participants included in this study (87%) attended Pilates, yoga, or corrective gymnastics classes organized for older adults approximately 2x per week. Socioeconomic status was part of the questionnaire and the participants needed to fulfill the question regarding their socioeconomic status in comparison to their sex- and age-specific peers with one-item question: "How would you rate your socioeconomic status, compared to your peers?" with the answers arranged along a 5-item Likert scale: i) very above average, ii) above average, iii) average, iv) below average, and v) very below average. Most of the participants were classified into the "average" socioeconomic group. Socioeconomic status was not significantly correlated to the level of physical activity ($r = 0.19$) and training class attendances ($r = 0.11$); therefore, socioeconomic status was excluded as a barrier towards being physically active. Individuals included in the study should be without chronic diseases, which included cardiovascular, locomotor, or neural complaints. After cleaning the data, 643 men (N=263, mean age: 67.4 ± 5.5 years) and women (N=380, 66.9 ± 5.2 years) met the inclusion criteria and were included in the final analysis. Sex and age were self-reported. Before initial measurements, all participants had been given information regarding general aims and hypotheses of the project. The participants were ensured confidentiality and informed that their participation was voluntary, and that they had the right to withdraw at any time. Data collection was done in the same setting by the same experimental team, minimizing the effect of a measurement error. All participants have read and signed the informed consent forms. The research related to human use has been complied with all the relevant national regulations, institutional policies and in accordance with the tenets of the Helsinki Declaration, and has been approved by the Ethical Committee of the Home of War veterans (Ethical code: 2022/4).

Fat Mass

The level of fat mass was assessed using bioelectrical impedance analysis (Omron BF500 Body Composition Monitor, Omron Medizintechnik, Vernon Hills, IL, USA). In brief, each participant stood barefoot and with light clothes on metal footpads holding a pair of electrodes attached to the device in front of the chest.[23] After a few seconds, the device used a pre-programmed equation based on sex, height, and weight to estimate the level of fat mass. Following the recommendations of the American College of Sports Medicine,[24,25] cut-off points for obesity were 28% and 35% for men and women, compared to their counterparts with obesity (<28% for men and <35% for women).

Gait Speed

As a proxy of physical performance, we determined gait speed by calculating the time an individual has taken to walk across a 4.6-m distance.[26,27] Specifically, the final time of the walk was obtained by dividing the distance of 4.6-m by the time to cover the same distance. For better transparency, a visible tape was placed from the starting to the finishing position. Each participant was instructed to walk at the usual pace for a distance of 4.6-m, while a stopwatch operated by the measurer recorded time to the nearest 0.01 s. To control for acceleration (a sudden movement from standing to walking) and deceleration (from walking at constant pace to slowing down),[26,27] an additional distance of 2 m before and after the 4.6-m distance was incorporated.

Data Analysis

Basic descriptive statistics are presented as means and standard deviations (SD) for normally distributed variables and as percentages (%) for categorical variables. Sex differences were examined with Student's *t*-test for independent samples and Chi-square test. The effect size of the comparisons between the sexes was calculated using Cohen's *D* effect size (ES). ES was classified as trivial (<0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0), very large (>2.0) and extremely large (>4.0).[28] To identify diagnostic accuracy of gait speed to predict high level of fat mass, we performed a set of receiver operating characteristics (ROC) curves quantified by the area under the curve (AUC). ROC curves analyses were used to determine a discriminatory power of a specific diagnostic test, where the curve of the test skews closer to the upper left corner.[29] To be able to correctly classify the accuracy of the test, Rice and Harris[30] proposed a classification of the AUC as follows: 1) 0.55–0.62 (small), 2) 0.63–0.71 (moderate), and 3) >0.71 (large). Sensitivity and specificity characteristics were calculated and presented as percentages (%). When the proposed cut-off values for gait speed were determined, we used odds ratios (ORs) with 95% confidence intervals (95% CI) to examine binary associations with higher level of fat mass. Finally, the correlation between newly-developed gait speed cut-off points in this study (slow vs fast) and fat mass (those without obesity vs those with obesity) proposed by the American College of Sports Medicine[24,25] was calculated using the Kappa coefficient (κ). Two-sided *p*-values were used, and the significance was set at $\alpha < 0.05$. All the analyses were calculated in Statistical Packages for Social Sciences v.23 (SPSS, Chicago, IL, United States).

Results

Basic descriptive statistics of the study participants are presented in Table 1. Older men were taller, heavier, and had lower heart rate values, compared to women. Older women had higher fat mass, compared to older men. Interestingly, both older men and women exhibited similar values in gait speed.

Table 1 Basic Descriptive Statistics of the Study Participants, Stratified by Sex

Study Variables	Total Sample (N=643)	Men (N=263)	Women (N=380)	Cohen *d*	p-value
	Mean (SD)	Mean (SD)	Mean (SD)		
Age (years)	67.4 (5.4)	67.8 (5.7)	67.2 (5.2)	0.11	0.295
Height (cm)	165.7 (8.6)	173.5 (6.2)	160.9 (6.0)	2.07	< 0.001
Weight (kg)	75.1 (13.3)	83.3 (10.7)	70.0 (12.2)	1.24	< 0.001
Body-mass index (kg/m^2)	27.1 (3.9)	27.4 (3.4)	26.9 (4.2)	0.15	0.201
Heart rate (beats/min)	67.3 (9.9)	64.9 (10.2)	68.8 (9.4)	0.38	< 0.001
Gait speed (m/s)	1.35 (0.21)	1.33 (0.22)	1.36 (0.20)	0.14	0.134
Fat mass (%)	34.5 (7.6)	30.8 (6.9)	36.7 (7.2)	0.86	< 0.001
Lean mass (%)	65.5 (7.6)	69.2 (6.9)	63.3 (7.2)	0.86	< 0.001

Note: $P < 0.05$.

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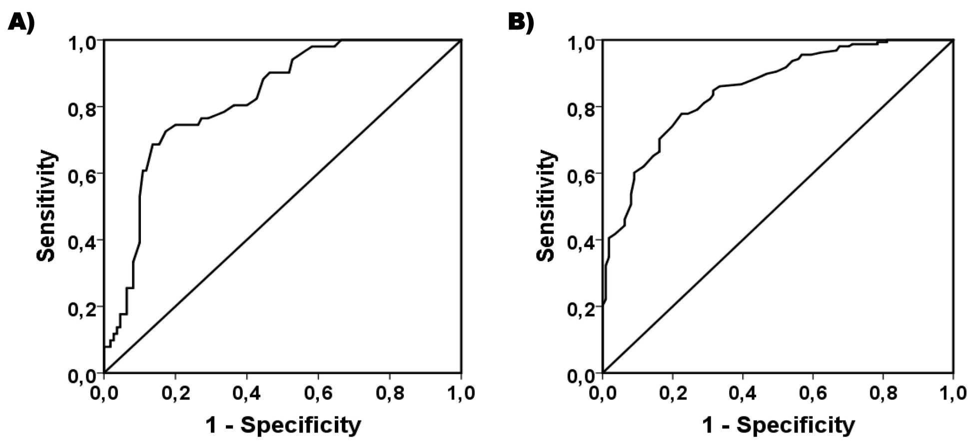

Figure 1 The ROC of gait speed to identify older men (**A**) and older women (**B**) with high level of fat mass.
Notes: Sensitivity: denotes a test's ability to designate an individual with condition as positive; Specificity: denotes a test's ability to designate an individual without condition as negative; Cut-off points of ≥28% and ≥35% denote individuals with obesity for older men and women.[24,25]

Figure 1 shows ROC curves of gait speed to identify older men and women with high level of fat mass. A diagnostic assessment for both sexes is presented in Table 2. For both older men and women, the AUCs were >0.80. Older men with low gait speed (<1.40 m/s) determined by the ROC were 12.66 (OR=12.66, 95% CI 5.75 to 27.86, p<0.001) more likely to have high level of fat mass (≥28%). In older women, low gait speed (<1.37 m/s) was associated with 12.09 (OR=12.09, 95% CI 6.75 to 21.65, p<0.001) higher likelihood of having high level of fat mass (≥35%).

True positive (TP), true negative (TN), false positive (FP), false negative (FN) and Kappa statistics are presented in Table 3. In older men, TP and TN values were 72.5% and 82.7%, while FP and FN were 17.3% and 27.5%. In older

Table 2 Receiver Operating Curve Cut-Offs for Gait Speed to Predict High Level of Fat Mass, Stratified by Sex

Study Variable	High Fat Mass (Men ≥28%; Women ≥35%)				
Gait Speed (m/s)	**AUC**	**95% CI**	**Std. Error**	***p*-value**	**Cut-Off Point**
Old men (*N*=260)	0.82	0.76–0.89	0.034	< 0.001	1.40 m/s
Old women (*N*=383)	0.85	0.81–0.90	0.023	< 0.001	1.37 m/s

Note: P < 0.05.
Abbreviations: AUC, Area under the curve; 95% CI, 95% confidence interval; Std. Error, Standard Error.

Table 3 Sensitivity, Specificity and Kappa Statistics for Gait Speed Cut-Offs and High Fat Mass, Stratified by Sex

Old Men (N = 263)	High Fat Mass (Men ≥28%; Women ≥35%)					
Gait Speed (m/s)	**Low**	**High**	**Chi-Square Test**	***p*-value**	**Kappa**	***p*-value**
≥1.40 m/s	72.5%	17.3%				
<1.40 m/s	27.5%	82.7%	46.934	< 0.001	−0.43	< 0.001
Old women (N = 380)						
Gait speed (m/s)						
≥1.37 m/s	77.8%	22.5%				
<1.37 m/s	22.2%	77.5%	80.638	< 0.001	−0.53	< 0.001

Notes: True positive (TP): denotes "low" fat mass and gait speed equal or above the threshold in men (≥1.40 m/s) and women (≥1.37 m/s); True negative (TN): denotes "high" fat mass and gait speed below the threshold in men (<1.40 m/s) and women (<1.37 m/s); False positive (FP): denotes "high" fat mass and gait speed equal or above the threshold in men (≥1.40 m/s) and women (≥1.37 m/s); False negative (FN) denotes "low" fat mass and gait speed below the threshold in men (<1.40 m/s) and women (<1.37 m/s) P < 0.05.

women, TP and TN values were 77.8% and 77.5%, while FP and FN were 22.5% and 22.2%. Kappa statistics showed moderate correlations between gait speed and fat mass for both sexes.

Discussion

The main purpose of the study was to examine whether gait speed had a sufficient discriminatory power for detecting older individuals with high level of fat mass.

The main findings of the study are as follows: i) gait speed accurately predicts high level of fat mass in both older men and women; ii) the optimal cut-off points of gait speed are 1.40 m/s and 1.37 m/s for older men and women; and iii) strong sensitivity and specificity properties and moderate inverse correlations between gait speed and fat mass are observed in both sexes. A well-documented body of evidence has shown that physical performance assessed through gait speed is associated with activity of daily living and mobility disability in non-disabled, community-dwelling older people.[31,32] The findings of these studies suggest that slow gait speed (arbitrarily considered as <1 m/s) increases the risk of negative health-related outcomes, including persistent lower extremity limitations,[33,34] incident activity of daily living disabilities and limitations[35–37] and all-cause mortality.[33–35] However, a study by Lee et al[32] showed that the optimal cut-off points of gait speed to predict activities of daily living were 0.76 m/s and 0.66 m/s for older men and women. A systematic review of Abellan van Kan et al[31] concluded that older adults who walked >1 m/s had a lower risk of health events and better survival. Individuals categorized as 'slow walkers' (<1 m/s) might suffer from functional and cognitive decline, be extremely dependent, and have higher rates of hospitalization. Although cut-points of 0.8 m/s[21] and 1 m/s[31] have been used to detect adverse outcomes, the findings of this study showed that the prevalence of older men and women who walked <0.8 m/s and <1 m/s was 1.2% and 5.3% for men and 0.9% and 4.3% for women, respectively. Thus, such cut-off points generated for geriatric assessment may not be applicable and sensitive enough for other populations of older adults. Indeed, we found that the mean gait speed values were 1.33 m/s and 1.36 m/s for older men and women, which surpassed the aforementioned recommended levels.

Although previous findings support the evidence that gait speed is associated with mutual health-related outcomes,[31] little information has been provided about the association between gait speed and body composition.[17–20] Excess body fat may impact hip, knee, and ankle joints, leading to shorter step length that may slower gait speed.[38] On the other hand, slow gait speed can lead to obesity through a decreased physical activity and more time spent in sedentary behaviors.[39] Studies investigating the optimal cut-off points to detect those with high level of fat mass are scarce.[18] A study by Mendes et al[18] showed that to be able to detect those with obesity, the cut-off point of gait speed normalized for height was 0.87 m/s with the AUC of 0.648 ($p<0.001$) for older women, while for men, the AUC was statistically non-significant and the cut-off value was not provided (0.525, $p=0.521$). Although evidence suggests adjusting gait speed for height,[18] we observed no correlations between height and gait speed ($r=0.06$, $p=0.474$ for older men and $r=0.07$, $p=0.259$ for older women). Therefore, previous cut-off points of gait speed to detect obesity seem to be sex-specific and a lot smaller, compared to our findings.[18] The discrepancy between the studies may be explained by using different methods to assess body composition. For example, body-mass index has been extensively used as a "proxy" of body size, especially in terms of undernutrition and overweight/obesity.[17–19] Although such measure has merit in population-based studies, it cannot adequately discriminate between fat mass and lean muscle mass in clinical practice, leading to a misclassification of nutritional status in older adults.[40] Also, it has been observed that poorer nutritional status is more related to slower gait speed in older women, compared to older men,[18,20] which corresponds to findings of the present study. This is not surprising, since the proportion of lean muscle mass to the body weight is much more evident in men, while in women, a higher ratio between fat mass and lean mass is observed.[41] In recent years, a growing public health challenge of obesity has been rapidly increasing in older adults.[42] With poor nutritional status, older adults experience a decline in physical performance, limiting their ability for independence and engaging in activities of daily living.[2,3,9,11] Thus, the coexistence between poor nutritional status and slow gait speed is a result of the aging process, where individuals with obesity may embrace slow walking, often accompanied by balance impairments and fatigue.[43]

This study has a few limitations. First, a cross-sectional design precluded the possibility of establishing causal associations and cut-points based on longitudinal data. Second, the criterion and convergent validity properties and measurement errors for the bioelectrical impedance were considered when compared with dual X-ray absorptiometry, resulting in fat mass values different from the "true" values. However, previous evidence suggests that bioelectrical impedance may yield good results in comparison to X-ray absorptiometry Third, we did not include potential residual covariates, such as diet and genetic factors, which might have influenced cut-points and the strength of the associations. Finally, the generalizability of the findings should be interpreted with caution, since older men and women in our study were Caucasians with a median age of 67 years. Thus, future multi-level studies aiming to investigate the associations between gait speed and fat mass should be investigated in different socioeconomic and ethnic classes with wider age range.

Conclusions

In summary, our findings suggest that gait speed is moderately associated with fat mass and newly developed cut-off points of 1.40 m/s and 1.37 m/s may adequately identify older men and women with high level of fat mass, respectively. Gait speed reveals potential utility as a marker for individuals with obesity, but future research is needed to determine its screening and tracking ability of nutritional dysfunctions during the aging process.

Availability of Supporting Data

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

Research involving human subjects complied with all relevant national regulations and institutional policies and is in accordance with the tenets of the Helsinki Declaration (as revised in 2013) and has been approved by the Ethical Committee of the Home of War veterans (Ethical code: 2022/4).

Consent for Publication

The informed consent was voluntarily signed by the participants.

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Disclosure

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