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Comparisons between body adiposity indexes and cutoff values in the prediction of functional disability in older women

Comparações entre índices de adiposidade corporal e pontos de corte na predição de incapacidade funcional em mulheres idosas

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Abstract – The aim of this study was to compare body adiposity indexes and to identify cutoff values in the prediction of disability in older women. Eighty-seven volunteers (67.27±6.45 years) underwent body composition assessment using dual-energy X-ray absorptiometry (DXA) and had five anthropometric indexes measured (Waist Circumference, WC; Waist-to-Height Ratio, WHtR; Body Mass Index, BMI; Body Adiposity Index, BAI; and conicity index). Functionality was assessed from three Senior Fitness Test Battery protocols: 30-second chair stand, 8-foot up-and-go, and 6-minute walk. Pearson's correlation was conducted to identify the relationship between body adiposity indexes and functionality results. Cutoff values to predict disability were obtained from ROC curves and odds ratio were calculated for the same outcome. Disability prevalence was 36.8%. Scores in the 30-second chair stand, 8-foot up-and-go, and 6-minute walk tests showed stronger associations with WC (r=-0.345; p<0.01), WHtR (r=-0.417; p<0.01) and BAI (r=0.296; p<0.01), respectively. The cutoff values identified were 89.5cm, 39.2%, 26.93kg/m^2, 34.6%, 0.51cm and 1.23 for WC, DXA-derived body fat percentage, BMI, BAI, WHtR and conicity index, respectively. WC showed greater odds ratio for disability outcome (odds ratio: 3.16; CI: 1.3–7.8). WC showed strong relationship with functional tests and its cutoff values exhibited predicting skill for disability in older women.

Key words: Aging; Obesity; Physical fitness.

Resumo – *Objetivou-se comparar índices de adiposidade corporal e identificar pontos de corte na predição de incapacidade funcional em mulheres idosas. Oitenta e sete voluntárias (67,27±6,45 anos) foram submetidas à avaliação de composição corporal através de Dual energy x-ray absorptiometry (DXA), e tiveram cinco índices antropométricos mensurados (perímetro de cintura, PC; relação cintura estatura, RCE; índice de massa corporal, IMC; índice da adiposidade corporal, IAC; e índice de conicidade). A funcionalidade foi avaliada a partir de três protocolos da Senior Fitness Test Battery: sentar e levantar em 30 segundos; 8-foot up-and-go; e caminhada de seis minutos. A correlação de Pearson foi conduzida para identificar o relacionamento entre as medidas de adiposidade corporal e os resultados de funcionalidade. Foram obtidos pontos de corte para incapacidade funcional a partir de curvas ROC, e o odds ratio foi calculado para o mesmo desfecho. A prevalência de incapacidade funcional foi de 36,8%. Os escores dos testes sentar e levantar em 30 segundos, caminhada de seis minutos e 8-foot up-and-goapresentaram associações mais consistentes para PC (r=-0,345; p<0,01), RCE (r=-0,417; p<0,01) e IAC (r=0,296; p<0,01), respectivamente. Os pontos de corte identificados foram 89,5cm, 39,2%, 26,93kg/m^2, 34,6%, 0,51cm e 1,23, para PC, percentual de gordura medido pelo DXA, IMC, IAC, RCE e índice de conicidade, respectivamente. O PC apresentou maior razão de chances para incapacidade funcional (odds ratio:3,16; IC:1,3–7,8). O PC apresentou associação mais consistente com os testes funcionais e seus valores de corte exibiram habilidade preditora para incapacidade em mulheres idosas.*

Palavras-chave: *Aptidão física; Envelhecimento; Obesidade.*

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INTRODUCTION

The aging process is associated with important changes in the various physiological systems. Changes in body composition are already well documented in literature, such as body fat accumulation, which can compromise health and quality of life[1,2]. Increased body fat has been associated with negative health indicators, such as cardiometabolic diseases in various populations, including in the elderly[2].

Among the current methods that assess adiposity, the dual energy x-ray absorptiometry (DXA) is considered the gold standard[3]. Although showing satisfactory results, the use of DXA becomes impractical for clinical evaluations in numerous populations[4]. Therefore, there is growing interest in investigating the predictive power of low-cost and easy-application clinical evaluations. In this scenario, some body adiposity indexes have been widely used to predict various risk factors of the population as a whole[2]. In an effort to improve the methods commonly used to estimate body fat percentage, Bergman et al.[5] proposed the body adiposity index (BAI), which was consistently associated ($r = 0.85$) with fat percentage measured by DXA. However, its ability to identify conditions related to excess body fat needs further investigations in specific populations[2].

Other indexes are commonly used to identify health risks, but studies are needed in the context of functional disability. Although body mass index (BMI) is widely used to classify obesity, this index has been criticized for not considering body fat distribution[6]. In this sense, indexes that consider body fat distribution to the central region of the body such as waist circumference (WC), Waist-to-Height Ratio (WHtR) and the conicity index (CI) have also been used to classify obesity[2].

Increased risk of cardiovascular and metabolic diseases is among the conditions imposed on health as effects of obesity[2,7-9]. Furthermore, excess body mass has been reported as a negative influence on the functionality of individuals with advanced age, representing an increased risk of disability in this population. It has well established that obesity assessed by BMI and / or WC is associated with reduced mobility in elderly individuals[10-14]. In this sense, Angleman et al.[15] showed that the body fat distribution appears to be an important indicator of mobility, valuing the evaluation of WC in relation to BMI for presenting positive correlation with the visceral adipose tissue of men and women[16]. Therefore, body adiposity measures that consider body fat distribution in the central region of the body can significantly predict the functional disability in older adults[15]. Currently, there is a gap in literature both regarding specific cutoffs for prediction of functional disability and in the comparison of these anthropometric indexes. In this sense, it is necessary to better understand the body adiposity indexes and their association with functional disability in older adults. Thus, the aim of this study was to compare body adiposity indexes and identify cutoffs in the prediction of functional disability in older women.

METHODOLOGICAL PROCEDURES

Sample

Two hundred women aged over 60 years participated in a project aimed at assessing body composition of residents in the Federal District, Brazil. Participants were recruited by convenience by announcement in posters fixed on sites with high incidence of the target audience, such as churches, parks and community centers. Of the most comprehensive sample, 87 volunteers were selected for this study, which is characterized as an analytical cross-sectional study. Exclusion criteria were: being unable to walk without assistance, to have metallic prosthesis, to have unilateral or bilateral hip prosthesis, and to show abnormality of conduction or cardiac perfusion that would contraindicate the practice of physical activities.

This study was approved by the Ethics Research Committee on Human Beings of FS / UnB (Protocol No. 001/13) and all participants signed the Informed Consent Form. Data collection was conducted at the laboratories of the University of Brasilia, Brasilia, Federal District, Brazil.

General health assessment

Initially, anamnesis was applied to identify metabolic abnormalities, smoking and use of drugs. Then, the short-version IPAQ[17] was used to verify the level of physical activity of volunteers.

Assessment of body adiposity indexes

Volunteers were submitted to anthropometric measurements to obtain the following measures: body weight, height, and waist circumference (WC). Body mass was measured by a digital scale (model E150-INAN Filizola, São Paulo, Brazil), with 0.1 kg accuracy; height was measured using a stadiometer, model Wood with specificity of 0.1 cm (WCS / CARDIOMED, Curitiba, Paraná, Brazil); and waist and hip circumferences were measured using Sanny® anthropometric tape, adopting the umbilicus and the point of maximum extension of the buttocks, respectively, as reference [2]. From the measurements obtained, BMI, WHtR, CI and BAI were calculated according to the following formulas:

$$\text{BMI} = \frac{\text{Body weight}}{\text{Height}^2}$$

$$\text{CI} = \frac{\text{Waist Circumference}}{0{,}109\sqrt{\frac{\text{Body weight}}{\text{Height}}}}$$

$$\text{WHtR} = \frac{\text{Waist Circumference}}{\text{Height}}$$

$$\text{BAI} = \frac{\text{Hip Circumference}}{\text{Height}^{1{,}5}} - 18$$

Body Composition Assessment

Body composition was measured by DXA (General Electric-GE model 8548 BX1L, 2005, DPX lunar type, Encore 2010 software), using procedures previously described[2]. After analysis of the entire body area, tissues were fractionated into fat mass and fat-free mass and bone. Furthermore, specific values for trunk and limbs were provided. A single individual was evaluated for six consecutive days and its variation coefficient was 0.9% and 1.9% for fat-free mass and bone, and fat mass, respectively.

Functional capacity assessment

To evaluate functional performance, three Senior Fitness Test Battery validated protocols were used[18]. Tests were conducted in the morning in the following order: 1) 30-second chair stand; 2) 8-foot up-and-go; and 3) 6-minute walk. An interval of four to six minutes between protocols was adopted; and before starting the test battery, light and global warm-up exercises consisting of calisthenics and stretching, with five minutes of duration, was conducted by an experienced professional[18]. In addition, volunteers were instructed on the use of light and comfortable clothing. Tests were performed in the gymnasium of the Olympic Centre of the Physical Education School.

The classification of the functional disability outcome was based on normative values previously published by Rikli and Jones[18]. In the present study, were classified with this outcome, participants who presented values below the reference in at least two of the three tests applied were classified with this outcome.

Statistical analysis

To check the normality of data, the Kolmogorov-Smirnov test was applied. After identification of normal distribution, parametric tests were applied. The Pearson correlation was used to test the association between body adiposity indexes and the Senior Fitness Test Battery. The same correlation was used between WC and trunk and lower limb fat. A cutoff point was then calculated for each body adiposity index through the Receiver Operating Characteristic (ROC) to identify the functional disability condition. After the classification of body adiposity indexes, the mean values of groups were compared using the t test for independent samples. Descriptive statistics (cross-tabs), followed by of chi-square and risk selection were used to generate odds ratio and confidence interval, considering the functional disability outcome according to each body adiposity classification. Then, the odds ratio was adjusted for age, level of physical activity and smoking. The significance level was set at $p \leq 0.05$ and the software used for analysis was the Statistical Package for Social Sciences (version 20.0).

RESULTS

Eighty-seven older women participated in this study (67.27 ± 6.45 years, 1.55 ± 0.06 m, 65.53 ± 11.09 kg). Of these, 25% were considered physically active and only one was classified current smoker. The prevalence of poor functionality was 28.7% for the 30-second chair stand, 54.0% for the 8-foot up-and-go, and 50.6% for the 6-minute walk tests. Regarding the functional disability outcome, volunteers had to present at least two unsatisfactory scores in the above tests; therefore, its prevalence was 36.8%. Subjects classified with and without the functional disability outcome showed no significant differences in the variables that characterize the sample (data not shown).

Table 1 shows the relationship between body fat indexes and functional tests. This table shows that variables BMI, WC, WHtR and CI showed significant and inverse association with the 30-second chair stand test. The 8-foot up-and-go test showed positive and significant correlation with BMI, WC, WHtR and BAI. The 6-minute walk test, in turn, showed a significant inverse correlation with all body adiposity indexes.

Table 1. Correlation between body adiposity indexes and functional tests

Variable	30-sec chair stand	8-Foot Up-and-Go	6-minute walk
BMI	-0.258*	0.248*	-0.403**
WC	-0.345**	0.255*	-0.365**
WHtR	-0.311**	0.252*	-0.417**
CI	-0.291**	0.174	-0.241*
BAI	-0.112	0.296**	-0.388**
Fat (%)	-0.135	0.118	-0.381**

BMI: Body Mass Index; WC: Waist Circumference; WHtR: Waist-to-Height Ratio; CI: Conicity Index; BAI: Body Adiposity Index; Fat (%): Fat Percentage measured by DXA. * P <0.05; ** P <0.01.

Table 2 shows the area under the ROC curve of each body adiposity index for the Senior Fitness Test Battery protocols. BMI, WC and WHtR showed discriminatory performance for all outcomes of the above battery tests. When considering only the 30-second chair stand test, the CI also showed significantly greater area under the curve (p <0.01) when compared to the reference curve (0.5). For the 6-minute walk test, the BAI and total fat percentage also showed significantly greater area under the curve (p <0.01) when compared to the reference curve (0.5). WC presented higher area under the ROC curve for the 30-second chair stand test (0.712; p <0.01). However, no significant differences were observed for the area under the ROC curve among body adiposity indexes, considering the Senior Fitness Test Battery protocols individually (Table 2). However, considering the functional disability outcome, WC was the only body adiposity index showing significant importance for its sensitivity and specificity (Figure 1). Furthermore, the same index showed significant difference for the functional disability outcome when compared to other body adiposity indexes (p = 0.05). Figure 2 shows the association between WC and the fat distribution of trunk and lower limbs. It was observed that WC presented strong association with trunk fat (r = 0.863, p <0.01) and moderate with lower limb fat (r = 0.583, p <0.01) (Figure 2).

Table 2. Area under the ROC curve (95% confidence interval) of each body adiposity index for the Senior Fitness Test Battery protocols

BMI	30-sec chair stand	8-Foot Up-and-Go	6-minute walk
WC	0.650 (0.540-0.749)*	0.640 (0.530-0.740)*	0.703 (0.595-0.796)*
WHtR	0.712 (0.605-0.804)**	0.624 (0.514-0.726)*	0.664 (0.555-0.762)**
CI	0.655 (0.546-0.754)*	0.620 (0.510-0.722)*	0.685 (0.577-0.780)**
BAI	0.695 (0.587-0.789)**	0.598 (0.487-0.702)	0.559 (0.488-0.703)
Fat (%)	0.519 (0.409-0.627)	0.578 (0.468-0.684)	0.674 (0.566-0.771)**
BMI	0.549 (0.439-0.656)	0.547 (0.437-0.654)	0.678 (0.569-0.774)**

BMI: Body Mass Index; WC: Waist Circumference; WHtR: Waist-to-Height Ratio; CI: Conicity Index; BAI: Body Adiposity Index; Fat (%): Total Body Fat Percentage. * P <0.05 (area 0.5); ** P <0.01 (area 0.5).

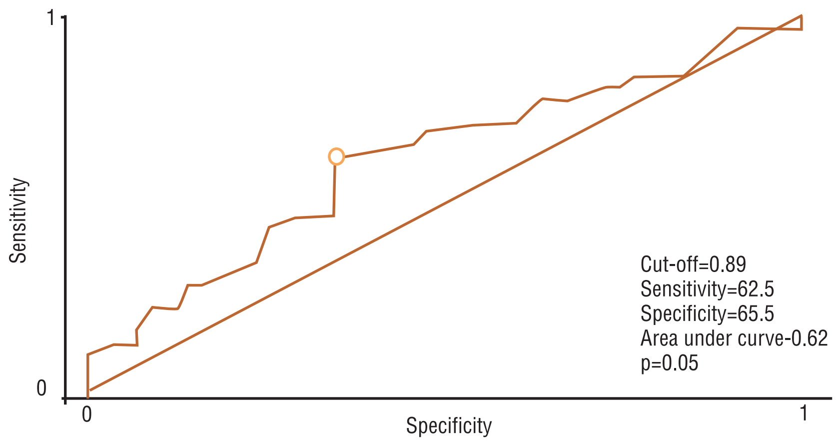

Figure 1. ROC curve according to the sensitivity and specificity of Waist Circumference with the Functional Disability outcome

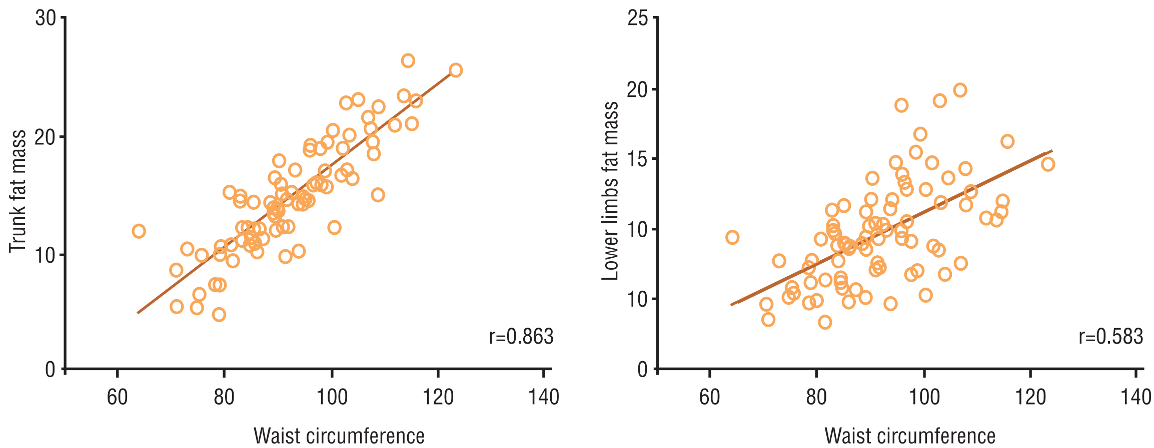

Figure 2. Correlation between waist circumference and fat distribution measured by DXA. A) trunk fat; B) lower limb fat.

Table 3 shows cutoffs for each body adiposity index related to functional disability. WC was the only index used that presented increased and significant odds ratio with and without adjustment for the functional disability outcome. However, after adjusting for age, level of physical activity and smoking, BMI was also due to increased and significant chances to the above outcome.

Table 3. Cutoff points (sensitivity, specificity) for each body adiposity index regarding the presence of functional disability and Odds Ratio (95% Confidence Interval) for the functional disability outcome according to the cutoff points for body adiposity classifications.

Variable	Cutoff point	Odds Ratio	Adjusted *Odds Ratio*
BMI (kg/m^2)	26.93 (59.4;63.6)	2.37 (0.97-5.77)	2.49 (1.01-6.09)*
WC (cm)	89.50 (62.5;65.5)	3.16 (1.28-7.82)**	3.07 (1.24-7.61)*
WHtR(cm/cm)	0.51 (96.9;20.0)	7.75 (0.95-63.17)	7.93 (0.93-64.67)
CI (UA)	1.23 (78.1;43.6)	2.57 (0.95-6.94)	2.46 (0.91-6.67)
BAI (%)	34.60 (53.1;61.8)	1.70 (0.71-4.10)	1.65 (0.68-3.98)
Fat (%)	39.20 (75.0;41.8)	2.17 (0.82-5.64)	2.23 (0.85-5.84)

Odds Ratio adjusted for age, level of physical activity and smoking. BMI: Body Mass Index; WC: Waist Circumference; WHtR: Waist-to-Height Ratio; CI: Conicity Index; BAI: Body Adiposity Index; Fat (%): Total Body Fat Percentage. * P <0.05; ** P <0.01.

DISCUSSION

Anthropometric indexes were more consistently related with functional tests than body fat measured by DXA, especially those that considered abdominal adiposity in their calculations. By observing participants classified with high adiposity, the odds ratio for the functional disability outcome was increased for both WC and BMI. In addition, WC was the only measure that had discriminatory power for the functional disability outcome.

Anthropometric measures are important indicators of functionality during the aging process, as it has been reported that excess adiposity negatively influences the functionality of elderly individuals. In this sense, Angleman et al.[15] have evaluated for the first time the association of five anthropometric measurements (body weight, BMI, WC, BAI and waist-to-hip ratio) with the risk of functional disability in elderly subjects. Among female participants (n = 1030; 55-74 years), body fat distribution was presented as an important indicator of mobility, valuing the WC measure in relation to the other measures for being directly related to visceral fat [15]. The results of this study corroborate the above findings, confirming that there is a more consistent relationship between WC and trunk fat (r = 0.863, p <0.01) compared with lower limb fat (r = 0.583, p <0.01). Similarly, Oliveira et al.[16] demonstrated a significant association between WC and the visceral adipose tissue area of older women (r = 0.677; p = 0.01). Gomes et al.[19] also demonstrated an association between the same anthropometric index with the trunk fat distribution of older women. In addition, increased WC presented higher odds ratio for difficulties in performing activities of the daily living (ADLs).

Recently, Lisko et al. [20] examined whether obesity (measured by BMI and / or WC) would be associated with functional disability in Finn nonagenarians (n = 569; 416 women). Functionality was assessed using the Barthel Index and the chair stand test. Corroborating the findings previously presented, it was observed that subjects with higher WC had worse functional performance. The same was observed in Asian nonagenarians regarding the relationship between WC and ADLs[21].

When considering BMI, WC, bioimpedance and triceps skinfold thickness, Donget al.[22] found association between obesity and functionality of individuals with advanced age. However, among the above measures, the authors observed that only WC was related with the instrumental activities of octogenarian individuals, corroborating the results of this study. In addition, when comparing the physical function of normal weight (n = 30), overweight (n = 29) and obese women (n = 24), classified according to BMI, there was less functionality among obese women only compared with those with normal weight[22], which reinforces the need to identify cutoffs for specific populations, as proposed in this study.

It is understood that excess body fat, particularly in the abdominal region, is an indicator of low functionality in older individuals. Although this is a fairly established risk factor, the mechanism responsible for this association is not yet entirely clear. Angleman et al.[15] point out that, when in excess, omental and mesenteric adipose tissue compromise the metabolism of macronutrients and negatively influence the cardiovascular system. In this sense, these cardiometabolic alterations may impair the functionality of individuals with visceral obesity. Another possible explanation for the above-mentioned condition is the fact that obesity imposes a direct physical overload[23], contributing both to the wear of locomotor system structures and to a more sedentary lifestyle and consequent reduction of the overall fitness of obese individuals[24].

Fat infiltration in organs such as liver and striated skeletal muscle[25] is also observed, which could impair the metabolism and specific torque (muscle quality)[26] during the functional demands of obese older individuals. Furthermore, it is known that central obesity is a risk factor for coronary heart diseases, diabetes and other cardiometabolic disorders, which, in turn, can contribute, even if indirectly, to functional disability[27]. Finally, these findings can also be explained by biomechanical changes imposed by the excessive increase in central adiposity, as this condition changes the individual's center of gravity, imposing an anterior postural overload, which damages the maintenance of balance, changes the gait patterns and influences the functionality of individuals with central obesity outcome[28].

The limitations of this study should be stressed. First, the sample size does not represent the population of older women living in the Federal District. However, the procedure adopted included assessment of body composition made by DXA, which hindered the sample expansion. In addition, functionality was assessed using a battery of field tests[18], unlike most previously published studies in which this evaluation was conducted through self-reports and questionnaires. In this sense, it was decided to increase the internal validity of the study. Based on the results obtained, it is suggested the development of studies with larger samples. In addition, the cross-sectional nature of the study does not establish a cause and effect relationship, making it impossible to identify the impact of excess body fat according to different adiposity indexes on the functional disability of volunteers. Therefore, further longitudinal studies comparing the body adiposity indexes and identifying the importance of these measures on the functional disability of older women should be carried out.

CONCLUSIONS

Based on the results shown above, there is an important relationship between body adiposity indexes and functional tests, especially for indexes that consider abdominal adiposity in their calculations. Furthermore, cut-offs have been suggested for each index based on their sensitivity and specificity for the prediction of functional disability. In this sense, WC showed higher odds ratios for the functional disability outcome and demonstrated a strong correlation with trunk fat. Finally, the potential applicability of these results should be highlighted, since the body adiposity indexes that showed more consistent associations with functionality outcomes are of easy application and low cost.

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