Brazilian Journal of Physical Therapy 25 (2021) 311–318

abrapg-ft
Associação Brasileira de Pesquisa e Pós-Graduação em Fisioterapia

Brazilian Journal of Physical Therapy

https://www.journals.elsevier.com/brazilian-journal-of-physical-therapy

BJPT

ORIGINAL RESEARCH

Obesity is associated with postural balance on unstable surfaces but not with fear of falling in older adults

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Received 15 January 2020; received in revised form 27 July 2020; accepted 6 August 2020
Available online 13 August 2020

KEYWORDS
Accidental falls;
Aged;
Body mass index;
Obesity;
Overweight;
Postural balance.

Abstract
Background: There are inconsistent findings regarding the relationship between body mass index (BMI), fear of falling and body balance, especially on unstable surfaces.
Objectives: To investigate whether obesity is associated with worse postural balance and fear of falling in older adults.
Methods: A cross-sectional study was conducted with 201 older adults, classified as normal weight, overweight, or obese according to BMI. Postural balance was evaluated on stable and unstable surfaces on the Biodex Balance System platform under three visual conditions: with and without visual feedback and with eyes closed. Fear of falling was identified by a dichotomous question and the Falls Efficacy Scale. These data were compared between groups and included in adjusted multiple linear regression analysis.
Results: The study showed no significant differences ($p > 0.05$) in body oscillations on a stable surface between the three groups. On an unstable surface, the obese older adults exhibited body oscillations from 0.61° [95% CI 0.07, 1.30] to 1.63° [95% CI 0.84, 2.41] greater than those with normal weight in the three visual conditions. The obese older adults also displayed larger mediolateral oscillations with visual feedback (mean difference: 0.50° [95% CI 0.01, 0.98]) as well as greater global oscillations without visual feedback (mean difference of 0.82° [95% CI 0.18, 1.81]) and with progressive instability (mean difference: 0.80° [95% CI 0.05, 1.66]) than the overweight older adults. BMI explained from 6 to 12% of body swings investigated on unstable surface. Obesity was not associated with fear of falling.

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https://doi.org/10.1016/j.bjpt.2020.08.003
1413-3555/

Conclusion: Obesity was associated with reduced postural stability on unstable surfaces but not with fear of falling in older adults.

Introduction

Obesity is defined as the degree of lipid storage or excess body fat.[1] Initial assessment of this excess weight can be conducted using the body mass index (BMI) - a low-cost and easy-to-apply measure - with obesity being classified as BMI of more than 30 kg/m^2.[2] It currently affects around 40% of people older than 60 years[3] and is a complex multifactorial problem influenced by environmental conditions, genetic factors, and energy imbalance caused by changes in the lifestyle of older people.[4]

The increased prevalence of obesity among older adults is worrisome due to its association with functional limitations.[2] Changes in body composition and their consequences for the locomotor system compromise stability,[5] requiring older adults to pay more attention to postural control,[6] increase the likelihood of postural disorders[7] and falls,[8] and may be accompanied by a greater fear of falling.[9] Body fat accumulation in older people is associated with greater postural instability, investigated using a force platform with and without foam pads,[5,10–12] electromagnetic sensors with foam,[7] limits of stability[7,9] and body mobility tests.[2,9,11] In more challenging situations, obese older adults have exhibited greater stiffness with lower limits of stability, which may heighten the risk of falling due to external disorders.[7]

However, there are controversial findings regarding the relationship between BMI and body balance. The results of studies on this topic are inconsistent with respect to the association between obesity and stability limits in older adults,[7,9] with the maintenance of balance on stable surfaces,[2,5,9,10,12–14] and fear of falling,[2,8,9,12] and few have investigated the extent to which obesity is related to imbalance on unstable surfaces.[7,9] Some of these studies used small sample sizes[6,7,15,16] and included only physically active older adults[7] or those with postural instability.[9] In clinical practice, knowledge of the relationship between BMI and postural balance contributes to a better understanding of the imbalance and falls experienced by obese older adults,[17] with a view to implementing strategies to improve functional capacity in this population. Thus, the objective of the present study was to determine whether obesity is associated with worse postural balance on stable and unstable surfaces and fear of falling in older adults.

Methods

Study design

This cross-sectional observational study was conducted at the Human Functional Performance Laboratory of the Universidade de Brasília, Brazil. It was approved by the Ethics Committee for Human Research at the Federal District Health Department (Process no. 174/2011) and at the Universidade de Brasília (Process no. 1.748.207). All participants gave written informed consent.

Participants

The sample consisted of older individuals from a database of two different studies. In both investigations, individuals were community-dwelling seniors (age $\geq$ 60 years), of both sexes, exhibiting independent gait, no severe visual disorder, no history of amputation, not using prosthesis, no recent leg fractures, no neurological or psychiatric problems, no history of acute vestibular dysfunctions in the previous month and no report of Parkinson's disease, stroke sequelae, and/or occlusive peripheral arterial disease. Excluded were older adults with missing BMI data, BMI of less than 18.5 kg/m^2, or cognitive disorders based on the Mini-Mental State Examination.[18]

Between July 2011 and October 2017, community-dwelling older adults referred by basic health units were recruited by convenience in health care programs in the city of Ceilândia, Federal District, Brazil. A total of 255 older adults from the dataset were assessed for eligibility, 33 of whom were excluded due to cognitive impairment, 19 for lack of BMI data on their medical chart, and two with BMI < 18.5 kg/m^2. Thus, included in analyses were 201 participants with data regarding fear of falling and balance on an unstable surface (dataset from the two studies), 96 of whom were also assessed on a stable surface (dataset from only one of the studies) (Fig. 1).

Sample size was calculated using GPower 3.1, comparing balance variables between the three groups considering an effect size f of 0.25 (medium), resulting in a total of 159 individuals to provide a power of 80% at a significance level of 0.05.

Variables and instruments

The following covariables were investigated to characterize the participants: sex, age, number of regularly used drugs, complaints of leg pain, history and number of falls, and regular physical activity.[11] Regular physical activity was considered at least 150 min per week of moderate exercise.[19]

BMI was the independent variable. The dependent variables were balance on stable and unstable surfaces and fear of falling.

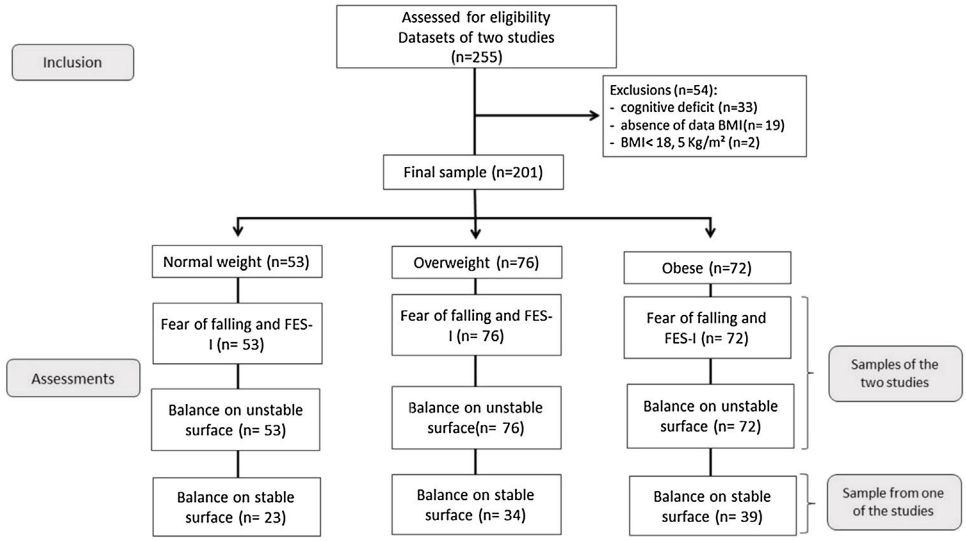

Fig. 1 Flowchart of sample selection and assessments. BMI = body mass index; FES-I = Falls Efficacy Scale − International.

BMI

BMI was calculated based on weight (kg)/height^2 (m). Height was measured using a Marte® stadiometer with a range between 0.9 cm and 2 m and accurate to 1 mm. Weight was measured on a Marte® scale, accurate to 0.1 kg, with individuals barefoot and wearing their usual clothing. According to BMI, the older adults were categorized as normal weight (BMI from 18.5 to 24.99 kg/m^2), overweight (BMI from 25.0 to 29.99 kg/m^2) or obese (BMI $\geq$ 30.0 kg/m^2). The obese category included grade 1 (BMI 30.0 to 34.99 kg/m^2), grade 2 (BMI 35 to 39.99 kg/m^2), and grade 3 obesity (BMI $\geq$ 40 kg/m^2).[1]

Postural balance on stable and unstable surfaces

Balance on stable and unstable surfaces was studied using the center of pressure (COP) data collected on the Biodex Balance System - BBS platform (Biodex Medical Systems, Shirley, NY, USA). The BBS is a freestanding computerized balance platform consisting of a flat circular platform that allows degrees of inclination, enabling simultaneous movements in the anterior-posterior and mediolateral axis, and a digital visor placed at eye level, which provides real-time feedback on the position of the COP at the time of the test. The system analyses changes in the center of body mass on stable or unstable surfaces. Under unstable conditions, the degree of instability can be controlled in 12 levels of resistance varying from level 1 (most unstable) to 12 (most stable).[20]

Postural balance on a stable surface was measured in the static platform mode (constant stability) and on an unstable surface in the unstable platform mode using two protocols: constant instability and progressive instability. Postural balance with constant stability or instability was measured under three visual conditions: with visual feedback, without visual feedback, and with eyes closed. In the test with visual feedback, participants could visualize the information regarding COP position on the monitor of the device. In the test without visual feedback, the screen was covered with a white sheet of paper. In the test with eyes closed, participants were instructed to close their eyes. To assess balance on a stable surface, oscillations in COP were obtained using a repetition for each visual condition with the platform constantly static, for 20 s. To evaluate balance on an unstable surface with constant instability, COP oscillations were obtained using a repetition for each visual condition with the platform unstable, at level 4, for 20 s. Analyses were conducted using the indices of global (GSI), anterior-posterior (ASI), and mediolateral stability (MSI) of each visual condition. Higher index values (in degrees) characterize greater platform oscillations and, as such, worse postural balance in the participants.

Balance on an unstable surface with progressive instability was measured only with visual feedback in the unstable platform mode, with a variation in spring resistance progressing from level 6 to 2. Three repetitions were conducted, with a 10-second rest period between them. Analyses were carried out using the average oscillation in the three repetitions indicated by the global stability index of this test.

For all balance assessments, participants were briefly informed about the tests and instructed to stand barefoot on the static platform, assuming a central and comfortable position, with their arms at their sides.[20] During the tests, the older adults had to keep their balance and the indicator in the center of the target on screen, requiring them to adopt compensation postures due to the instability of the platform, without removing their feet from the initial position or holding onto the bars of the instrument. If the instructions were not adhered to, the test was interrupted and then resumed (maximum of two attempts).

Fear of falling

Fear of falling was studied using the data collected on the dichotomous question ''Are you afraid of falling?'' and the level of concern about falling was measured via the Falls Efficacy Scale − International (FES-I-Brazil).[21] FES-I is a reliable questionnaire containing 16 items that assess the concern of individuals about falling during activities of daily living. The score ranges from 16 (not at all) to 64 (very concerned), and values >23 points correspond to worse fall-related self-efficacy and greater fear of falling.[8,21] All the participants in the database presented data for fear of falling-related variables.

Statistical analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS; version 22.0; Chicago, IL, USA) and G. Power version 3.1. Descriptive statistics, normality tests (Kolmogorov-Smirnov), and equality of variances (Levene) were calculated for all outcomes. Parametric data (BMI) are presented as mean and standard deviation and non-parametric data (age and stability indexes) as median and the respective interquartile range (25th; 75th percentiles). The chi-squared test was applied to compare the categorical variables between the three groups. One-Way ANOVA with Bonferroni's post hoc was used for intergroup comparison of BMI data. The Kruskal-Wallis and Dunn's post hoc tests were used to compare continuous data with non-normal distribution. The Bonferroni post hoc was used for normally distributed data to control the type I error rate given the small number of comparisons. Dunn's post hoc test was used for non-normal data to ensure goodness of fit. The stability indexes that were significantly different between study groups and showed a linear relationship with BMI were included in adjusted multiple regressions analyses. Thus, six multiple linear regressions were performed to identify the extent to which BMI (independent variable) explains body oscillations of older adults (dependent variable). The covariables sex, age, medications, leg pain, number of falls, and physical activity were included in the multiple regression analyses as adjustment variables. For the four multiple regression analyses with at least one variable inserted in the final model, the assumptions of at least 20 cases per independent variable, independence between residuals (Durbin-Watson), little multicollinearity (VIF < 10 and Tolerance>0.1), and residual normality were met. Homoscedasticity was met in three of the analyses. The stepwise procedure was used for all analyses. The significance level was set at 5%.

Results

Of the 201 participants, 54 (26.4%) were normal weight, 76 (37.8%) overweight, and 72 (35.8%) obese. Of the 72 participants from the obese group, 53 (73.6%) were grade 1 and 19 (26.4%) grade 2. Most of the sample were women (86.1%), with no complaints of pain in the lower limbs (80.6%), 48.3% reported falling in the year before the study, and 66.7% were afraid of falling. The three groups evaluated on an unstable surface (n = 201) were homogeneous in terms of characterization variables (Table 1) and the three subgroups assessed on a stable surface (n = 96) also showed no significant differences in these variables (data not shown).

The three study groups showed no significant differences in body oscillations on a stable surface ($p > 0.05$) (Table 2). In assessments of constant instability, the older obese adults exhibited oscillations from 0.61° (95% CI 0.07, 1.30) to 1.51° (95% CI 0.49, 2.52) greater than those of normal weight individuals in the three visual conditions investigated (p-values 0.03). They also showed higher mediolateral oscillations with visual feedback (mean difference of 0.50° [95% CI 0.01, 0.98], $p = 0.001$) and higher global oscillations without it (mean difference of 0.82° [95% CI 0.18, 1.81], $p = 0.04$) when compared to their overweight counterparts. In the assessments with progressive instability, the obese older adults displayed greater oscillations than those of normal weight (mean difference of 1.63° [95% CI 0.84, 2.41], $p < 0.001$) and overweight (mean difference 0.80° [95% CI 0.05, 1.66], $p = 0.01$) participants. Obesity was not associated with fear of falling ($p = 0.99$) or with fall-related self-efficacy ($p = 0.09$) (Fig. 2).

In the adjusted analysis on an unstable surface (Table 3), BMI explained global body oscillation with progressive instability influenced by physical activity ($F[2,81] = 2.677$, $p = 0.005$; $R^2 = 0.12$) and independently explained global body oscillation with constant instability without visual feedback ($F[1,82] = 5.407$, $p = 0.02$; $R^2 = 0.06$). BMI also explained mediolateral oscillation with visual feedback, influenced by physical activity ($F[2,81] = 5.295$, $p = 0.01$; $R^2 = 0.12$).

Discussion

The aim of the present study was to determine whether obesity is associated with the ability of older adults to maintain their balance on stable and unstable surfaces and the fear of falling. Our results showed that obesity is associated with greater body oscillation on an unstable surface, characterizing a decline in postural stability in more challenging situations. In these older adults, obesity was not accompanied by fear of falling.

Body oscillation on a stable surface did not differ between normal weight, overweight, and obese older adults. It is important to underscore that our results may be a consequence of the small subsample size evaluated on a stable surface, which may have been inadequate in detecting intergroup differences. Nevertheless, results of earlier studies,[2,7,9,11] which also showed no association between obesity and postural imbalance, assessed postural balance using clinical tests,[2] an electromagnetic sensor system,[7] and the Neurocom® platform.[9] However, conflicting findings showed that when obese older adults were assessed on force platforms (stable surface) they exhibited greater oscillations[6,10] and average displacements[11–13] of the COP and higher oscillation areas[13] when compared to the non-obese individuals in different visual conditions. These differences in study results may be due to the fact that the force platform makes it possible to collect more accurate linear measures that estimate the amplitude of COP oscillations, something not provided by the BBS. These higher COP oscillations on the force platform may be a type of physiological adaptation in older adults to keep their balance on a stable surface and not necessarily the reflection of an impaired postural system.[5]

On an unstable surface, overweight older adults showed no significant difference in oscillation compared to their nor-

Table 1 Sample characteristics (n = 201).

Variables	Total sample (n = 201)	Normal weight (n = 53)	Overweight(n = 76)	Obese (n = 72)	p-value
BMI (kg/m^2)[a],[*]	28.28 ± 4.50	22.90 ± 1.64	27.37 ± 1.45	33.20 ± 2.40	<0.001
Sex[c] Women Male	173 (86.1) 28 (13.9)	46 (86.6) 7 (13.2)	63 (82.9)13 (17.1)	62 (88.9)8 (11.1)	0.57
Age (years)[b]	71.0 [65.5; 75.0]	72.0 [66.5; 77.5]	7.0 [65.2; 74.0]	69.5 [65.0; 75.0]	0.16
Regular physical activity (yes)[c]	102 (50.7)	29 (54.7)	41 (53.9)	32 (44.4)	0.41
Medications (number)[b]	5.0 [3.0; 6.0]	4.0 [3.0; 6.0]	5.0 [3.0; 6.0]	5.0 [3.0; 6.75]	0.80
Lower limb pain (yes)[c]	35 (19.4)	8 (16.7)	12 (17.4)	15 (23.8)	0.55
Report of falling (yes)[c]	97 (48.3)	23 (43.4)	37 (48.7)	37 (51.4)	0.67
Falls (number)[b]	1.0 [1.0; 2.0]	2.0 [1.0; 2.0]	1.0 [1.0; 2.0]	1.0 [1.0; 2.0]	0.37

[a] Means ± standard deviation compared using One-way ANOVA.
[b] Medians [25th and 75th percentiles] compared using the Kruskal-Wallis test.
[c] Frequency (percentage) compared applying the chi-square test. BMI, body mass index; FES-I, Falls Efficacy Scale – International.
[*] $p < 0.05$.

Table 2 Comparison of body oscillation measures on a stable and unstable surface among normal weight, overweight, and obese older adults.

Variable	Normal weight	Overweight	Obese	p-value
Stable Surface[a]				
Open eyes - with visual feedback				
GSI[c]	1.00 [0.70; 1.50]	1.05 [0.80; 1.52]	0.90 [0.70; 1.30]	0.50
ASI[c]	0.70 [0.40; 1.20]	0.60 [0.47; 1.22]	0.60 [0.40; 0.80]	0.68
MSI[c]	0.50 [0.30; 0.80]	0.65 [0.40; 0.90]	0.50 [0.30; 0.80]	0.39
Open eyes - no visual feedback				
GSI[c]	1.70 [1.20; 2.32]	1.50 [0.80; 2.70]	1.45 [1.05; 2.22]	0.74
ASI[c]	1.15 [0.45; 1.87]	0.60 [0.40; 1.70]	0.80 [0.50; 1.32]	0.73
MSI[c]	1.15 [0.52; 1.40]	0.60 [0.30; 1.70]	0.80 [0.47; 1.22]	0.93
Closed eyes				
GSI[c]	2.10 [1.20; 2.80]	2.25 [1.37; 2.97]	1.90 [1.20; 2.30]	0.28
ASI[c]	1.30 [0.70; 2.70]	1.30 [0.80; 2.40]	1.10 [0.80; 1.80]	0.90
MSI[c]	0.80 [0.70; 1.20]	1.30 [0.57; 1.85]	1.00 [0.60; 1.30]	0.09
Unstable surface - Constant instability measures[b]				
Open eyes - with visual feedback				
GSI[c]	1.80 [0.90; 2.85][d],**	2.00 [1.40; 3.47]	2.70 [2.00; 4.45]	<0.001
ASI[c]	1.30 [0.55; 2.20][d],*	1.50 [0.90; 2.77]	1.85 [1.10; 3.30]	0.006
MSI[c]	0.80 [0.45; 1.20][d],**	0.90 [0.70; 1.47][d],*	1.45 [0.90; 2.57]	<0.001
Open eyes - no visual feedback				
GSI[c]	2.50 [1.92; 3.97][d],*;	2.80 [2.00; 5.65][d],*	3.80 [2.60; 5.70]	0.002
ASI[c]	1.90 [1.10; 2.77][d],*	1.90 [1.25; 4.10]	2.60 [1.80; 3.90]	0.009
MSI[c]	1.35 [0.80; 2.47][d],*	1.50 [1.05; 2.45]	2.10 [1.30; 3.30]	0.007
Closed eyes				
GSI[c]	5.20 [3.15; 7.85][d],*	6.90 [4.62; 9.42]	6.90 [4.80; 9.30]	0.02
ASI[c]	3.40 [1.95; 5.15][d],*	4.40 [3.15; 6.47]	4.90 [3.30; 6.70]	0.01
MSI[c]	3.30 [1.75; 4.75]	3.80 [2.50; 5.92]	3.60 [2.80; 4.90]	0.13
Unstable surface - Progressive instability measures[b]				
Open eyes - with visual feedback				
GSI	2.50 [1.60; 3.70][d],**	2.80 [1.90; 4.65][d],**	3.85 [2.80; 5.70]	<0.001

*$p < 0.05$. **$p < 0.001$. GSI, Global Stability Index; ASI, Anteroposterior Stability Index; MSI, Mediolateral Stability Index.
[a] Analyses performed with 23 normal weight, 34 overweight, and 39 obese older adults.
[b] Analyses performed with 53 normal weight, 76 overweight, and 72 obese older adults.
[c] Median [25th and 75th percentiles]. Kruskal-Wallis H test (Dunn's post-hoc).
[d] oscillation smaller than that of the obese older adults.

mal weight counterparts and exhibited less oscillation than obese individuals in only a few of the conditions investigated. This similarity in postural balance between normal weight and overweight individuals are consistent with earlier findings showing that these two groups do not differ in the mobility tests.[2] Comparison of the ability to maintain balance between overweight and obese seniors reveals differences only in more challenging scenarios and conditions,

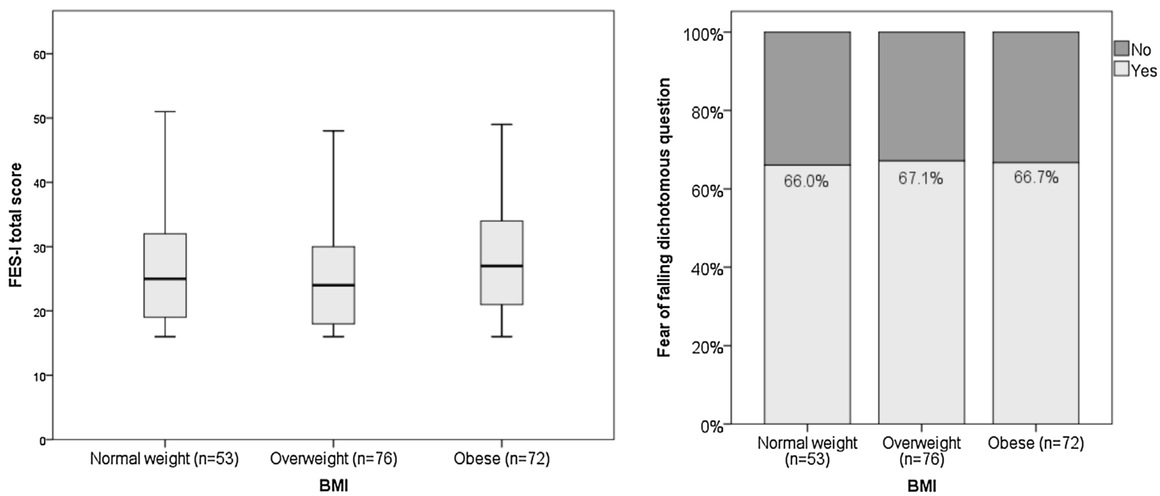

Fig. 2 Comparison of fear of falling between normal weight, overweight and obese older adults (n = 201).

Table 3 Results for the stepwise multivariate linear models.

Dependent variable	Independent variable that entered in the model	Multiple Regression				
		R^2 (R^2_{adj})	Unstandardized ß Coefficient	Standard error	95% CI	Individual Significance (*p* value)
Constant instability measures						
Open eyes - with visual feedback						
GSI	Physical Activity	0.07 (0.06)*	−1.24	0.51	−2.25, −0.22	0.02
MSI	BMI	0.12 (0.09)**	0.08	0.04	0.01, 0.16	0.04
	Physical Activity		−0.78	0.36	−1.50, −0.06	0.03
Open eyes – without feedback						
GSI	BMI	0.06 (0.05)*	0.18	0.08	0.03, 0.33	0.02
ASI	No variables were entered into the equation.					
Closed eyes						
GSI	No variables were entered into the equation.					
Progressive instability measures						
Open eyes - with visual feedback						
GSI	BMI	0.12 (0.10)**	0.13	0.06	0.01, 0.26	0.04
	Physical Activity		−1.30	0.57	−2.43, −0.17	0.02

*p < 0.05. **p < 0.01. GSI, Global Stability Index; ASI, Anteroposterior Stability Index; MSI, Mediolateral Stability Index.

such as in assessments with progressive instability and with eyes closed.[6]

The results of the present study between older adults with different BMI showed that the state of obesity is in fact associated with postural imbalance, especially in more challenging situations (unstable surfaces). On an unstable surface, the older obese individuals exhibited greater body oscillation than that of normal weight individuals in most of the conditions investigated. This finding is consistent with studies on older adults demonstrating that BMI values above 30—35 kg/m[2] seem to increase susceptibility to mobility limitations,[2,9,11,22,23] showing correlations between high BMI and low gait speed[9] and between a higher percentage of body fat and lower limits of stability.[7] The greater postural imbalance exhibited by obese participants has been explained based on biomechanical aspects.[5,11,24] Excess weight and a decline in lower limb strength, added to greater intrinsic foot muscle weakness,[25] and lower plantar sensitivity due to hyperactivation of the plantar mechanoreceptors, are believed to result in greater body oscillation, an indicator of postural instability.[7,11] Moreover, obesity may increase the distance between cutaneous mechanoreceptors, lowering somatosensory perception, providing altered information to the cortical area and changing the representation of the body scheme.[6,15,26]

In the present study, the obese older adults showed greater global and anterior-posterior oscillations than their normal weight counterparts on an unstable surface without visual feedback. Irrespective of body weight, vision influences postural control in older adults, because the ability of the body to adapt to a change in sensory conditions declines, thereby raising the likelihood of falls.[27] Previous studies showed that obese adults[15,26] and older people[6,10,12] with eyes closed oscillated more than the non-obese, and that excess weight compromised anterior-posterior control in particular.[10,26] The greater anterior-posterior oscillations in the obese individuals may be due to the increased abdominal volume and consequent anterior position of the center of mass in relation to the ankle joint in addition to greater weight to stabilize the support base.[10] The greater mediolateral oscillations as a function of obesity may be associated with excessive weight on the hips[19] and the limited leg and hip range of sideward motion.[10]

Despite the association between obesity and reduced postural balance on an unstable surface, in the adjusted linear regression analysis, BMI explained between 6% and 12% of the oscillation on the platform. Previous findings showed that BMI explained 3% of gait with obstacles and 14% of gait speed in the older adults.[2] For each one-unit increase in BMI, there was an expected rise of 0.08° to 0.18° in the mediolateral and global stability of the older adults. This linear increase is greater than that observed in young individuals, where for each one-unit increase in BMI, there was an expected rise of 0.115 units in the global stability index assessed by the BBS.[28] These data reveal the complexity underlying the multifactorial nature of human postural control.[5] As such, although balance on an unstable surface declined linearly with increasing BMI in older adults, other age and obesity-related factors may have contributed to the postural instability observed.[2] The physical overload with direct wear on locomotor system structures,[24] changes in body fat distribution,[2,5,26] poor postural alignment[29] combined with abnormal muscle activation patterns and flaws in the production of neuromuscular strength,[29] sarcopenia,[2,22,30,31] fat infiltration into the muscle,[5] reduced muscle quality,[5,24,29] confused sensory information coming from the greater contact and plantar pressure area[15] and diseases associated with excess weight[24] likely explain the body instability of obese individuals more than BMI alone. Thus, future investigations on the relationship between obesity and body imbalance in older adults should consider skeletal muscle mass and strength as well as body fat distribution.

Despite the fact that the present study showed that obese older adults exhibit worse balance than normal weight individuals and that earlier studies demonstrated a relationship between obesity in older adults and fear of falling and fall-related self-efficacy,[8,9,12,22] the complaint of fear of falling and self-efficacy for falls did not differ between the three groups studied. The decline in fall-related self-efficacy and increased fear of falling seem to be associated with the social and psychological consequences of falls,[9] history of falls, and restricted activities. Thus, the homogeneous fall frequency between the groups investigated may be driving these results.

The main strong points of the present study include the sample size for analyses on an unstable surface and the control of possible confounding factors related to sex, age, physical activity level,[11] lower limb pain, and history of falls, which were similar between the groups at the time of assessment. Furthermore, the use of a platform made it possible to assess balance on a stable and unstable surface in all the older adults, including those with high BMI and different body sizes. However, the present study exhibits some limitations that could affect interpretation of the results. Despite being an acceptable tool for investigating obesity in clinical practice and studies, the use of BMI is not the gold standard and may underestimate body fat. In addition to not including anthropometric assessments, such as the waist-hip and abdominal circumference ratio, or more sophisticated measures of total body fat investigated using dual-energy X-ray absorptiometry and computerized tomography would guarantee more comprehensive findings. In addition, the absence of grade 3 obesity among participants limits generalizing the results for this category. Furthermore, we recognize that the sample size may not have been sufficient to detect the small effect sizes observed on a stable surface. Despite this, we believe that small measured differences in body oscillations between the groups are of no clinical relevance.

We acknowledge the abovementioned limitations; however, the results of the present study demonstrate that obese older adults exhibit reduced postural balance and, therefore, may have greater risk of falling caused by external disturbances. These findings indicate that physical therapists and other professionals should incorporate strategies to reduce body mass and/or implement postural balance training on unstable surfaces for obese older adults.

Conclusion

Obesity was associated with a reduction in postural balance on an unstable surface, but not with fear of falling in older adults. In addition, normal weight and overweight older adults showed similar performance in balance tests on unstable surfaces. In clinical practice, the information that obese older adults display decreased postural balance on unstable surfaces can be used by physical therapists to implement balance training exercises and prevent falls in this population.

Acknowledgement

This work was supported by the National Council for Scientific and Technological Development – CNPq (research grant).

Conflicts of interest

The authors declare no conflicts of interest.

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