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DYNAMIC POSTURAL BALANCE IS MEDIATED BY ANTHROPOMETRY AND BODY COMPOSITION IN OLDER WOMEN

EQUILÍBRIO POSTURAL DINÂMICO É MEDIADO PELA ANTROPOMETRIA E COMPOSIÇÃO CORPORAL EM IDOSAS

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ABSTRACT

Objective: To investigate the relationship between anthropometry and body composition with dynamic postural balance in elderly women with low bone mineral density (BMD). Methods: 45 older women (≥ 60 years), low BMD and nutritional diagnosis of low weight to overweight. For the assessment of body composition, Dual energy X-ray emission densitometry and anthropometric examination were used to measure: body mass (kg), height (cm) and BMI (k/m^2). The assessment of dynamic postural balance was performed by the mini Balance Master Evaluation System clinical test and the computerized Balance Master® System test by the Sit to Stand and Step Up/Over tests. Results: There was a negative correlation between miniBESTest ($r = -0.566$; $p \leq 0.001$) and time to ascend and descend step ($r = -0.393$; $p \leq 0.007$) with fat mass, and positive correlation with miniBESTest ($r = 0.526$; $p \leq 0.001$) and time to go up and down a step with muscle mass ($r = 0.297$; $p \leq 0.04$). As for anthropometric variables, only height showed a positive correlation ($r = 0.296$; $p \leq 0.04$) with the speed in the sit and stand test. Conclusion: Lean mass reduces postural oscillations; in contrast, fat mass negatively interfered with dynamic postural balance in women with low BMD. Height was related to dynamic postural balance, the taller the elderly, the worse their balance. ***Level of Evidence II, Prognostic Studies – Investigating the Effect of a Patient Characteristic on the Outcome of Disease.***

Keywords: Aged. Body Composition. Postural Balance. Bone Density.

RESUMO

Objetivo: Investigar a relação da antropometria e composição corporal com o equilíbrio postural dinâmico em idosas com baixa Densidade Mineral Óssea (DMO). Métodos: 45 idosas (≥ 60 anos), baixa DMO e diagnóstico nutricional entre baixo peso e sobrepeso. Para a avaliação da composição corporal utilizou-se a densitometria por emissão de raios x de dupla energia e exame antropométrico para aferir: massa corporal (kg), estatura (cm) e índice de massa corporal (IMC) (k/m2). A avaliação do equilíbrio postural dinâmico foi realizada pelo teste clínico mini Balance Master Evaluation System, pelo teste computadorizado Balance Master® System e pelos testes Sit-to-Stand e Step Up/Over. Resultados: Houve correlação negativa do miniBESTest ($r = -0{,}566$; $p \leq 0{,}001$) e tempo de subir e descer um degrau ($r = -0{,}393$; $p \leq 0{,}007$) com a massa gorda, e correlação positiva do miniBESTest ($r = 0{,}526$; $p \leq 0{,}001$) e tempo de subir e descer um degrau com a massa muscular ($r = 0{,}297$; $p \leq 0{,}04$). Quanto às variáveis antropométricas, apenas a estatura apresentou correlação positiva ($r = 0{,}296$; $p \leq 0{,}04$) com a velocidade no teste de sentar-se e levantar-se. Conclusão: A massa magra reduz as oscilações posturais. Em contrapartida, a massa gorda interfere de forma negativa no equilíbrio postural dinâmico de mulheres com baixa DMO. A estatura esteve relacionada ao equilíbrio postural dinâmico: quanto mais altas as idosas pior era seu equilíbrio. ***Nível de Evidência II, Estudos prognósticos – Investigação do efeito de característica de um paciente sobre o desfecho da doença.***

Descritores: *Idosos. Composição Corporal. Equilíbrio Postural. Densidade Óssea.*

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INTRODUÇÃO

During the aging process, one of the comorbidities that most affect older women is the decrease in bone mineral density (BMD), osteopenia and osteoporosis. They are characterized by the gradual loss of bone mass and the weakening of bones, making them more fragile and susceptible to fractures[1] due to decreased levels of hormones that act in the process of bone remodeling, mechanical load imposed on the skeleton, inadequate feeding, calcium absorption

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The study was conducted at University of São Judas and developed in partnership with the Laboratory Study of Movement, Orthopedics and Traumatology Institute, Universidade de São Paulo.
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and vitamin D. Studies show an association between lower BMD with lower BMI in young[2] and older men.[3]

Falls are prevalent in older adults; however, in those with osteoporosis and osteopenia, falls can be more disastrous, being related to hip fracture. One in 15 older adults die in the hospital phase, and 30.35% die in one year due to complications resulting from these falls, and fractures.[4]

Several risk factors are associated with falls and fractures, including: increasing age, female gender, osteoporosis, early menopause, sedentary lifestyle, decreased balance, etc., and are considered the major public health problems, affecting mainly older women.[5]

The decrease in the capacity of the postural control system to maintain balance increases postural instability.[6] Changes in the central nervous system (CNS) and peripheral nervous system (PNS) that act directly on the vestibular, visual and somatosensory systems[7] compromise neuromuscular responses, modify postural strategies and cause loss of balance.[8] In aging, these changes are constant and aggravate both static and dynamic stability, generating changes in the support base and center of gravity, associating with the loss of motor and sensory strategies, occurring falls.[9]

Body composition presents significant changes with aging and its increase and redistribution is concentrated more in the abdominal cavity than in the lower limbs, so in overweight older women, a higher prevalence of fat is observed among muscle fibers[10] that are associated with muscle weakness, consequently, decreases balance and leads to falls.[11] In this context, some studies have shown that high levels of visceral fat are associated with lower lean mass, greater frailty, higher frequency of sarcopenia and a higher risk of fractures, besides contributing to functional decline.[12]

Greve et al.[13] correlated body mass index (BMI) with postural balance in unipodal support on an unstable platform. The results showed that the higher the BMI value, the greater the displacement demands to maintain postural balance. Zhang et al.[14] and Sheu et al.[15] stated that a higher fat mass is associated with a lower lean mass, greater fragility and an increased risk of fractures. Regarding body composition, fat mass at adequate levels is a relevant factor for bone biomechanical improvement, since it stimulates osteoblasts and may indicate smaller changes in BMD during the aging process.

Postural balance is multifaceted and it is important to map all possible influences it can suffer, so that programs aiming at preserving falls are better elaborated. Literature is controversial regarding the influences of body composition and postural balance due to anthropometric variables, justifying the need to find reliable parameters that can be used for evaluations and programs to prevent falls.

Thus, the aim of our study is to investigate the relationship between body composition and anthropometry with dynamic postural balance in older women with low BMD.

METHODS

This is a cross-sectional design study conducted at The Universidade São Judas Tadeu (USJT) in partnership with the Laboratory of Movement Study (LEM) of the Institute of Orthopedics and Traumatology and the Laboratory of Bone Metabolism of the Discipline of Rheumatology of the Faculdade de Medicina da Universidade de São Paulo. The study was approved by the Research Ethics Committee of the Faculdade de Medicina of Universidade de São Paulo under protocol number no. 306/15.

Participants

Forty-five older women (age ≥ 60 years), with low BMD and low to overweight nutritional diagnosis classified by BMI (according to the WHO), from nearby communities invited via radio calls and social media, participated in our study. The inclusion criteria were being able to perform independent gait and without pain for at least 100 meters; not presenting injury or trauma in the lower limbs in the last three months; be independent in their activities of daily living; diagnosis of osteoporosis or osteopenia. Although none of the participants was excluded from the study, such exclusion criteria were considered: inability to perform some of the tests; systolic blood pressure equal to or above 160 mmHg and diastolic blood pressure equal to or above 120 mmHg at the time of the test.

Procedures

First, the participants were subjected to anthropometric evaluation to assess body mass (kg), height (cm) and BMI (Kg/m^2) – estimated by the equation BMI = weight/height^2.

For the evaluation of body composition, lean and fat mass were measured by dual energy x-ray absorptiometry (DXA), using aHologic QDR 4500A Densitometry Equipment (Hologic Inc. Bedford, MA, USA, model – Discov).

The evaluation of *dynamic postural balance* was performed through two tests:

1) *Balance Master Evaluation System* (BESTest) miniBESTest adapted version and translated into Portuguese. It is a test with 14 tasks and scores from zero to two points that evaluates balance according to postural responses to external disturbances and verticality. It involves biomechanical restrictions, stability limits, postural responses, anticipatory postural adjustments, sensory orientation and dynamic balance during gait and cognitive effect.[16]
2) *NeuroCom Balance Master®* (*NeuroCom International, Inc., Clackamas, OR, USA*) was used to assess functional balance, which includes a computer with a force platform, in which information is recorded via piezoelectricity transducers. Force platform information includes X (± 0.08 cm) and Y (± 0.25 cm) positions of the center of vertical force and total vertical force (± 0.1 N) at a sampling frequency of 100 Hz. In this system, the transducers transmit pressure every 10 ms to the computer, so that the center of gravity of the participant and the dynamic balance over a certain period can be estimated.[17]

The following instruments were used for collecting data:

Sit-to-Stand – the participant was instructed to sit on a backrest bench with her feet apart, knees flexed (90°) and to get up quickly and safely while standing for a few seconds. The test was repeated three times in an interval of 30 seconds. The parameters measured were weight transfer (% body mass), the center of gravity in the balance when the participant was raised within the time used and the speed of balance (%/s).[18,19]

Step Up/Over – a 20 cm step placed on the platform was used in front of the participant and she was instructed to climb with her left leg on the step keeping the trunk upright. Subsequently, she lowered the step with his right leg and then with his left leg leaning on the platform. The test consisted of three attempts with an interval of 10 seconds between each of them and changing the sequence of the sides. The variables analyzed were the survey index, movement time and affect index on both sides. Each participant's movement was recorded in seconds from the initiation of the first step of the first leg with the platform. The lifting index was recorded by the percentage of body mass to be elevated, so that the first leg was brought to the top of the step. The affect index measured the percentage of body mass used to descend on the platform.[18,19]

Statistical analysis

The Statistical Package for Social Sciences (SPSS) software version 20 presented by mean, standard deviation, minimum and maximum. The Kolmogorov Smirnov normality test was applied to verify the normal distribution and the Spearman Test to evaluate the correlation between the tests and the $p \geq 0.05$ value was adopted for the significance level. The simple linear regression test was applied to verify the association between fat and bone mass and miniBESTest. This study was approved by the Ethics Committee from the Faculdade de Saúde Pública of Universidade de São Paulo – FSP/USP (Opinion 306/15). All participants signed an informed consent form.

RESULTS

Forty-five older women with a mean age of 65.4 years and mean BMI of 25.6 kg/m² were evaluated. Table 1 shows the characteristics of the study population.

Table 1. Characterization of the population according to age, anthropometry and body composition of older women with low bone densitometry.

Variables	Mean (SD)	Minimum	Maximum
Age	**65.4 (4.26)**	**60.00**	**75.00**
Anthropometrics			
Body Mass (Kg)	62.3 (7.82)	41.50	77.50
Height (cm)	1.55 (0.06)	1.41	1.77
BMI (kg/m²)	25.63 (2.54)	19.47	30.63
Body Composition			
Lean Mass (Kg)	30.93 (8.83)	14.22	48.43
Fat Mass (Kg)	28.62 (12.61)	23.40	43.85
BMD Lumbar spine (g/cm²)	0.75 (0.22)	0.00	1.27
BMD Femur neck (g/cm²)	0.63 (0.08)	0.50	0.86

SD: standard deviation; BMD: bone mineral density.

We observed a negative correlation between the miniBESTest balance test ($r = -0.566$; $p \leq 0.001$) and fat mass; and a positive correlation ($r = 0.526$; $p \leq 0.001$) with lean mass.

Negative correlation between the time of going up and down a step on the left side ($r = -0.393$; $p = 0.007$) with fat mass and positive correlation ($r = 0.297$; $p = 0.04$) with lean mass.

Regarding anthropometric variables, only height showed a positive correlation ($r = 0.296$; $p = 0.04$) with the speed of balance in the sitting and lifting test, as shown in Table 2.

Table 2. Correlation of dynamic postural balance with anthropometry and body composition of old women with low bone mineral density (BMD).

	Body mass (Kg) r (p)	Height (cm) r (p)	BMI (Kg/cm²) r (p)	Fat mass (kg)* r (p)	Lean body mass (kg) r (p)	BMD Lumbar Spine (g/cm²) r (p)	BMD Femur neck (g/cm²) r (p)
miniBESTest	–.113 (0.46)	–.060 (0.69)	–.093 (0.54)	–.566 (p 0.001)*	.526 (p 0.001)*	–.173 (0.25)	.111 (0.46)
Up and down a step							
Time R(s)	–.175 (0.24)	–.118 (0.43)	–.102 (0.50)	–.211 (0.16)	.139 (0.35)	–.149 (0.32)	–.207 (0.16)
Time L(s)	–.199 (0.18)	–.256 (0.86)	–.020 (0.89)	–.393 (0.007)*	.297 (0.04)*	–.159 (0.09)	–.251 (0.09)
Impact R	.095 (0.53)	–.048 (0.75)	.139 (0.35)	.209 (0.16)	–.114 (0.44)	.140 (0.25)	.181 (0.22)
Impact L	.047 (0.75)	.079 (0.59)	–.111 (0.46)	.163 (0.27)	–.163 (0.28)	.080 (0.59)	.131 (0.38)
Sit-to-stand (STS)							
Time (s)	–.106 (0.48)	–.279 (0.06)	.079 (0.60)	–.114 (0.45)	.102 (0.50)	–.016 (0.91)	.074 (0.62)
Balance Speed (º/s)	.130 (0.39)	.296 (0.04)*	–.068 (0.65)	.120 (0.42)	–.055 (0.71)	.017 (0.90)	–.050 (0.74)

Spearman Test *p ≤ 0.05
R: right side; L: left side; s: seconds; º/s: Degrees per second; STS: sit-to-stand.

In the simple regression analysis, lean mass could predict 17% of the best equilibrium value and fat mass 20% (Figure 1).

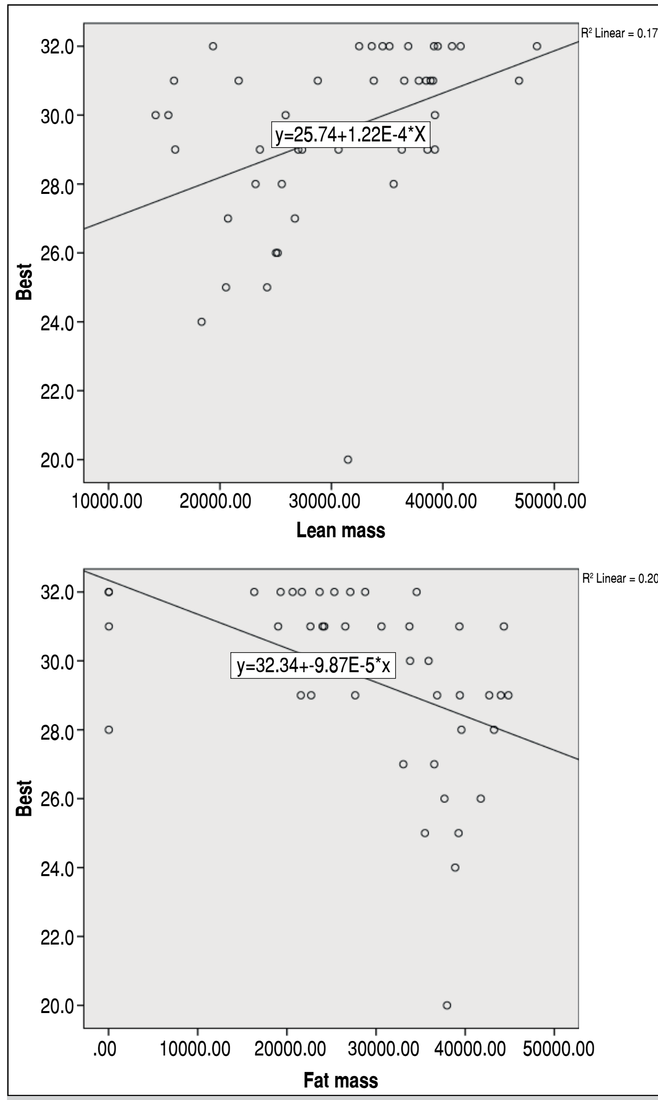

Figure 1. Simple linear regression analysis between balance and lean and fat mass values.

DISCUSSION

The main finding of our study was that fat mass negatively affects dynamic postural balance, whereas lean mass can lead to a preventive effect in women with low BMD. Height acts as an inverted pendulum, taller older adults have higher oscillation speed during postural balance. The miniBESTest, with which the following conditions were tested: a) sensory changes such as vision (open and closed eyes); b) changes of position (sitting to standing); c) different surfaces and support base (unipodal, bipodal, tiptoe, stable and stable surfaces) that stimulate the proprioceptive system; d) walking with changes in head direction to stimulate the vestibular system; e) compensatory anticipation and f) mobility. These conditions help identify postural instability, since the individual relies on sensory information and spatial orientation to minimize situations of sensory conflict that causes imbalance.[16]

In this condition, older women with higher fat mass presented worse performance in balance, and could to explain 20.7% of the test value, in addition to increasing the time of climbing and descending stairs. These results corroborate the study by Carneiro et al.[20], which using the Modified Clinical Test of Sensory Interaction in Balance (CTSIB-M), showed that obese women had lower postural stability than eutrophic women. Increased fat mass reduces the ability to maintain postural balance in response to external disorders, consequently increasing instability and greater propensity to fall. Moreover, obesity affects the selection of motor strategies used to maintain balance.[17] According to Zhang et al.[14] and Sheu et al.,[15] aging changes the distribution of body fat and is associated with a higher proportion of visceral fat (intra-abdominal) that increases the risk of metabolic diseases, sarcopenia, and functional decline. High visceral fat levels are associated with lower muscle mass, greater frailty and an increased risk of falls and consequently fracture by intramuscular fat infiltration. Another aspect to be discussed is lifestyle, individuals with higher percentage of fat, in general, are more sedentary, consequently presenting lower muscle mass and lower motor ability to maintain postural balance.

On the other hand, the higher the lean mass, the better the performance of postural balance measured by MiniBest. These results can be explained. A more developed and trained musculature, individuals with higher lean mass have a more active lifestyle, with more appropriate diet patterns.[3] The study by Scott et al.[21] showed that the higher muscle density of the leg decreases postural oscillations, suggesting that the increased risk of fractures in sarcopenic obesity can be explained by the low quality of the muscle, which can lead to worsening of postural balance.

Regarding anthropometric variables, the higher the height, the higher the speed of balance in the sit-to-stand test. These findings corroborate previous studies by Alonso et al.[17] and Alonso et al.[22] that state that postural balance can be modeled by the inverted pendulum in the sagittal plane, which increases the oscillations around the ankle joint and the response of the gastrocnemius (ankle strategy). In the frontal plane, the posture is modeled by an inverted double pendulum (hip strategy). The speed of balance is a response to the control of the position of the center of masses.

The limitations of the study are related to the nature of the postural balance, which is multifactorial, and in our study, we evaluated only body composition and anthropometry that can affect balance and consequently lead to falls. However, with the habits of modern life, they often lead to increased global obesity and a sedentary lifestyle aggravates the risk of falls in already vulnerable women.

Therefore, our study clinically proves that not only a motor exercise, but also an association of exercises that promote muscle mass gain and decrease in fat mass is necessary to obtain improvement of postural balance in people with higher fat mass and low BMD.

CONCLUSION

Lean mass reduces postural oscillations and therefore can reduce the risk of fracture. On the other hand, the fat mass negatively interfered with dynamic postural balance in women with low BMD. Height was the only anthropometric variable related to dynamic postural balance, i.e., the higher the older women, the worse their balance.

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