Maturitas 79 (2014) 322–328

Contents lists available at ScienceDirect

Maturitas

journal homepage: www.elsevier.com/locate/maturitas

Association of bone mineral density with postural stability and the fear of falling in Spanish postmenopausal women

Fidel Hita-Contreras [a,b,*], Emilio Martínez-López [d,1], Pedro González-Matarín [a,1], Nicolás Mendoza [c,2], David Cruz-Díaz [a,1], Alberto Ruiz-Ariza [d,1], Antonio Martínez-Amat [a,b,3]

[a] Department of Health Sciences, Faculty of Health Sciences, University of Jaén, E-23071 Jaén, Spain
[b] Institute of Biopathology and Regenerative Medicine (IBIMER), Department of Human Anatomy and Embryology, Faculty of Medicine, University of Granada, 18071 Granada, Spain
[c] Department of Obstetrics and Gynecology, Faculty of Medicine, University of Granada, 18071 Granada, Spain
[d] Department of Music, Plastical Expression and Body Language, University of Jaén, E-23071 Jaén, Spain

ARTICLE INFO

Article history:
Received 26 June 2014
Received in revised form 15 July 2014
Accepted 17 July 2014

Keywords:
Bone mineral density
Postural stability
Fear of falling
Fall risk

ABSTRACT

Objective: The purpose of our study was to investigate the relationship between bone mineral density (BMD) and postural stability and the fear of falling in a 50- to 65-year-old postmenopausal population.
Study design: A cross-sectional, observational study was conducted on 118 postmenopausal women. According to their BMD values, participants were divided into two groups: BMD > −2.0 SD ($n = 95$) and ≤−2.0 SD ($n = 23$).
Main outcome measures: Postural stability, assessed with a resistive multi-sensor platform, fear of falling (FoF) and the history of falls in the last 12 months were investigated.
Results: Women with BMD ≤ −2.0 SD reported a significantly increased FoF when compared to women with BMD > −2.0 SD ($P = 0.024$, $\eta^2 = 0.045$, $1 - \beta = 0.624$). In the postural stability analysis, the group with BMD ≤ − 2.0 SD showed, under the eyes-open condition, statistically significantly higher values for the velocity (VEO) ($P = 0.040$, $\eta^2 = 0.037$, $1 - \beta = 0.539$) and the anteroposterior mean displacement of the center of pressure (YEO; $P = 0.017$, $\eta^2 = 0.049$, $1 - \beta = 0.669$). No significant differences between groups were observed in the history of falls or in the rest of the stabilometric analyses.
Conclusions: In Spanish postmenopausal women under 65 years, a BMD ≤ −2.0 SD is significantly associated with postural instability (elevated VEO and XEO) and an increased FoF, which are two highly influential factors in the risk of falling.

1. Introduction

Loss of bone mineral density (BMD) has been proven to be related to hormonal imbalance, aging, several environmental factors, life style, and genetic predisposition [1]. BMD reduction and structural integrity deterioration result in an increased risk of osteoporosis and fractures in women [2], of which one-third of those older than 60 years fall at least once a year [3]. The high morbidity and mortality associated with these diseases can intensify both individual and governmental financial burdens [4]. Loss of BMD in women accelerates with the onset of menopause [5]. This rapid process is estrogen-dependent, lasts from 5 to 10 years and it is followed by a constant stage that is age-related [1,6].

Factors such as increased fear of falling (FoF) or postural change present a great impact on the fall risk in women with osteoporosis, although potential fall risk factors unique to low BMD have not been identified [7]. FoF refers to the lack of self-confidence that normal activities can be performed without falling [8] and has been described to be associated with a history of falls in postmenopausal women [9], but is also present in older people without previous falls [10]. Apart of being a risk factor of falls, FoF is a common sequel to falls [11], and may lead to secondary degeneration of postural control, thus completing a vicious loop [12]. Individuals with bone

* Corresponding author at: Department of Health Sciences, Faculty of Health Sciences, University of Jaén, E-23071 Jaén, Spain. Tel.: +34 953 212921; fax: +34 953 212943.
E-mail addresses: fhita@ujaen.es (F. Hita-Contreras), emilioml@ujaen.es (E. Martínez-López), pjgonzalezmatarin@hotmail.com (P. González-Matarín), NICOMENDOZA@telefonica.net (N. Mendoza), dcruz@ujaen.es (D. Cruz-Díaz), alberto_ruyz@hotmail.com (A. Ruiz-Ariza), amamat@ujaen.es (A. Martínez-Amat).
1 Fax: +34953212943.
2 Fax: +34 958246296/958242867.
3 Fax: +34953212943.

http://dx.doi.org/10.1016/j.maturitas.2014.07.015
0378-5122/

density of below-normal values appear to be related to increased FoF and subsequent function [7,13].

Postural instability, frequently evaluated by a measurement of the center of pressure (CoP) with force platforms, is directly related to the risk of falling [14,15], and Cheng et al. [16] described how balance deteriorates during the transition through menopause. Several opinions coexist regarding the relation between BMD and postural balance. While some authors have shown that elderly women with osteoporosis have greater postural imbalance and a greater predisposition to falls [17,18], other studies did not find a direct relation between bone mineral density and postural stability [19,20]. Most of these studies have been carried out on an elderly population, which is why the very influence of age itself on balance may play an important role, aside from BMD values, but to our knowledge, not many studies have been conducted in a young postmenopausal population [21,22]. The goal of our research was to analyze the relation between BMD and postural balance, as measured with a stabilometric platform, and the fear of falling, two important fall risk factors, in postmenopausal women under 65. We hypothesized that low BMD levels are linked to deteriorated postural balance and an increased fear of falling, which lead to a greater risk of falling.

2. Methods

2.1. Participants

For this analytical, cross-sectional research, 133 postmenopausal women from Eastern Andalusia were initially contacted, of which 118 finally took part in this study. They were recruited by contacting the staff of a local community health program for postmenopausal women supported by the University of Granada and the Spanish Menopause Society. A flow diagram of the participants is presented in Fig. 1. Data collection took place from February to May 2013. All participants signed a written informed consent before the beginning of the study, which was conducted in accordance with the Declaration of Helsinki, good clinical practices, and applicable laws and regulations.

Ambulant women with at least 12 months of amenorrhea, and aged between 50 and 65 years were included in the protocol. Exclusion criteria were as follows: current hormone therapy, conditions that limit balance and physical activity, functional blindness (acuity level worse than 20/200), severe auditory or vestibular alterations, and central or peripheral neurological disease. Those who were undergoing treatment with vestibular sedatives or other central nervous system depressants were also excluded from the study.

2.2. Study parameters

All women were interviewed by well-trained interviewers, who collected demographic, morphologic, and clinical data such as age, weight, height, marital status, academic education, age of menopause, smoking habits, history of falls in previous 12 months, physical activity, and fear of falling.

Falls were defined as “an unexpected event in which the participants come to rest on the ground, floor, or lower level” [23]. The question “have you experienced a fall to the ground in the last 12 months?” was used for collecting the women’s history of falls. To assess self-reported FoF, the question “are you afraid of falling?” was used. It has been shown that a single question regarding FoF has a high validity with continuous measures of FoF [24]. Physical activity was defined as weekly energy expenditure in leisure-time physical activity only [25] (given the similar origin of the participants, activities like house chores and gardening are considered similar to all them, and therefore not accounted). Weight was measured with a 100 g–130 kg precision digital weight scale (Tefal) and height was obtained with a T201-T4, Asimed adult height scale. Body mass index (BMI) was calculated by dividing the individual’s weight (kg) by her height squared (m^2). A BMI < 25 kg/m^2 indicates normal weight, 25 ≤ BMI > 30 kg/m^2 shows overweight and BMI ≥ 30 kg/m^2 is a sign of obesity [26].

BMD was measured through dual-energy X-ray absorptiometry (central DXA) [27]. A Norland Xr 26 Densitometer (Norland Corp., WI, USA) was used to assess BMD at the lumbar spine (L1–L4) and the femoral neck. Participants with total spine and/or femoral-neck *T*-score values ≤−2.0 SD were considered to have low BMD [28].

Stabilometric measures were performed with a resistive multisensor platform (Sensor Medica, Rome, Italy) with an active surface of 400 mm × 400 mm and an acquisition frequency of 30 Hz. The reliability of this platform has been proven in previous studies [29]. Calculations of center-of-pressure (CoP) movements were performed with the FreeStep© Standard 3.0 (Italy) software. The Romberg test was performed under both-eyes-open (EO) and eyes-closed (EC) conditions. Participants stood barefoot and as still as possible, with arms on their sides, feet separated at a 30° angle, and heels placed 2 cm apart. Each session lasted 52 s, with a 1-min interval between tests.

The stabilometry test measured the following parameters related to the participants’ CoP under each condition: mediolateral (*X*) and anteroposterior (*Y*) mean displacements of CoP (mm), the length covered by the CoP (Length, in mm) and the velocity of CoP movement (Velocity, in mm/s).

2.3. Statistical analyses

The differences in BMD levels were analyzed using Student’s *t* for the continuous variables and the chi-squared test for the categorical variables. In order to find out about the differences in the number of falls, FoF, and the quality of life of participants an analysis of covariance (ANCOVA) was performed, with the dichotomized bone density (BMD ≤ −2.0 SD vs. BMD > −2.0 SD) as a fixed value and age, BMI, and education level as covariates. Not-normal variables (Kolmogorov–Smirnov test) were transformed. All analyses were carried out separately for each variable. Results were considered statistically significant at a p value ≤0.05. Percentage of change between groups of high and low bone density ((high density measurement − low density measurement)/low density measurement × 100) was calculated. Statistical analyses were performed using the Statistical Package for Social Sciences version 19.0 for Windows (SPSS Inc., Chicago, IL, USA).

3. Results

Descriptive characteristics of the sample group and the mean and SD for all variables split by BMD > −2.0 SD (n = 95) and ≤−2.0 SD (n = 23) are presented in Table 1. The mean ± SD age was 60.16 ± 3.80 years and the mean ± SD BMI of the sample was 28.14 ± 5.01 kg/m^2. No statistical differences were detected between these two groups, although some almost significant differences were found between body weight and BMI (P = 0.050 and P = 0.051 respectively).

Regarding the analysis of falls, 24.58% (n = 29) of all participants and 34.79% (n = 8) of those with BMD ≤ −2.0 SD declared having fallen at least once in the last year, although no significant differences appeared when these were compared with the BMD > −2.0 SD group (P = 0.075; Fig. 2). In relation with FoF, 33.90% (n = 40) of the sample declared being afraid of falling, and in the by-group analysis women with low BMD were significantly more afraid of falling (52.18%, n = 12) than those with BMD > −2.0 SD (P = 0.024, η^2 = 0.045, $1-\beta$ = 0.624; Fig. 2).

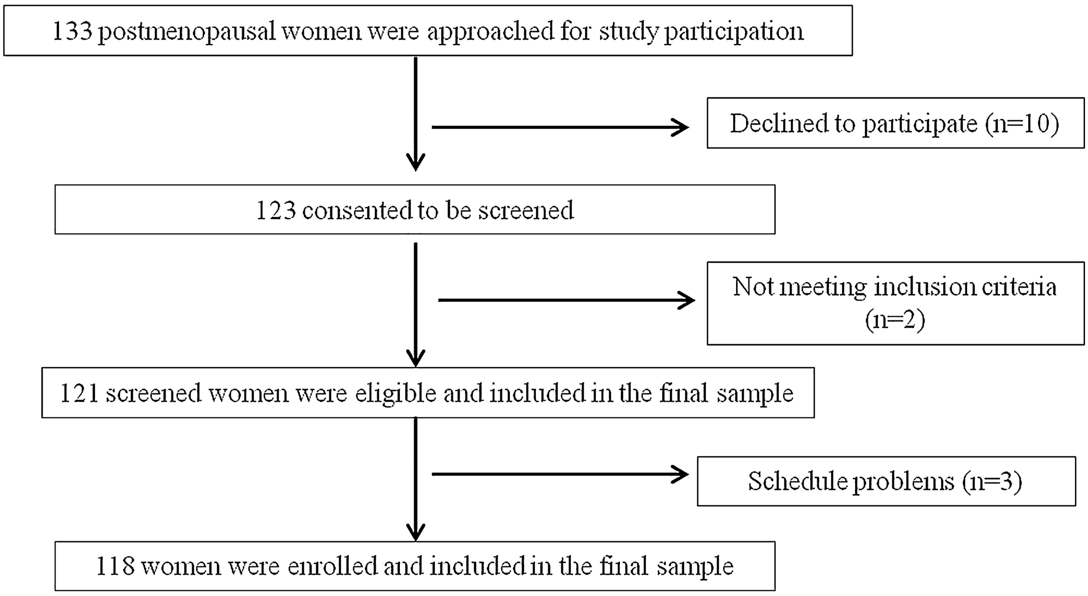

Fig. 1. Flow diagram of the participants.

Fig. 3 displays the results of the ANCOVA analysis in which each result of the X and Y stabilometric variables (with eyes open and closed) was used as a dependent variable. No significant differences between groups appeared in the comparison of CoP movement in the mediolateral axis, either with eyes open (XEO) or closed (XEC). The same can be said of the anteroposterior axis with eyes closed (YEC; $P = 0.269$, $P = 0.357$, and $P = 0.607$, respectively). However, when testing CoP movement on the anteroposterior axis with eyes open (YEO), the BMD ≤ −2 SD group showed significantly larger values ($P = 0.017$, $\eta^2 = 0.049$, $1 - \beta = 0.669$).

Finally, results pertaining to length and speed are displayed in Fig. 4. No significant differences were found for length in the eyes-open test (LEO), in the eyes-closed test (LEC), or for velocity with eyes closed (VEC; $P > 0.05$). However, the velocity for women with low density levels was significantly higher with eyes open (VEO) than in the case of the BMD > −2.0 SD group ($P = 0.040$, $\eta^2 = 0.037$, $1 - \beta = 0.539$).

4. Discussion

The goal of our research was to determine whether bone mineral density could be associated with postural stability and the fear of falling in a 50–65 year-old Spanish postmenopausal population.

Table 1
Morphological and demographic characteristics of the sample and groups.

	All (N = 118)	BMD ≤ −2 SD (N = 23)	BMD > −2 SD (N = 95)	P[a]
	Mean (SD)	Mean (SD)	Mean (SD)	
Age (year)	60.16 (3.80)	60.30 (3.26)	60.13 (3.93)	0.823
Weight (kg)	70.07 (12.91)	65.34 (8.84)	71.21 (13.50)	0.050
Height (m)	1.57 (0.06)	1.57 (.06)	1.57 (.05)	0.862
BMI (kg/m²)	28.14 (5.01)	26.31 (3.68)	28.58 (5.19)	0.051
Age of menopause (year)	53.75 (3.29)	54.00 (3.19)	53.68 (3.32)	0.685
Time since menopause, (year)	6.19 (3.85)	5.74 (2.76)	6.31 (4.08)	0.530
Physical activity, days/week	2.60 (1.18)	2.70 (1.57)	2.58 (1.34)	0.718
Lumbar spine T-score	−0.65 (1.41)	−2.44 (.43)	−.22 (1.21)	<0.001[b]
Femoral neck T-score	−0.84 (0.89)	−1.73 (.47)	−.62 (.84)	<0.001[b]
Occupational status (%)				
Working	55 (46.6)	10 (43.5)	45 (47.4)	0.944
Unemployed	53 (44.9)	11 (47.8)	42 (44.2)	
Retired	10 (8.5)	2 (8.7)	8 (8.4)	
Educational status (%)				
Not finished	5 (4.2)	2 (8.7)	3 (3.2)	0.402
Primary	30 (25.4)	4 (17.4)	26 (27.4)	
Secondary	27 (22.9)	4 (17.4)	23 (24.2)	
University	56 (47.5)	13 (56.5)	43 (45.3)	
Marital status (%)				
Single	7 (5.9)	2 (8.7)	5 (5.3)	0.908
Married/cohabiting	92 (78)	18 (78.3)	74 (77.9)	
Divorced/separated	12 (10.2)	2 (8.7)	10 (10.5)	
Widowed	7 (5.9)	1 (4.3)	6 (6.37) 5.9	
Smoker				
No	98 (83.8)	20 (87)	78 (83)	0.459
Yes	19 (16.2)	3 (13)	16 (17)	

BMD, bone mineral density; BMI, body mass index.
[a] Student's t analysis for continuous variables and χ^2 test for categorical variables.
[b] $P < 0.001$.

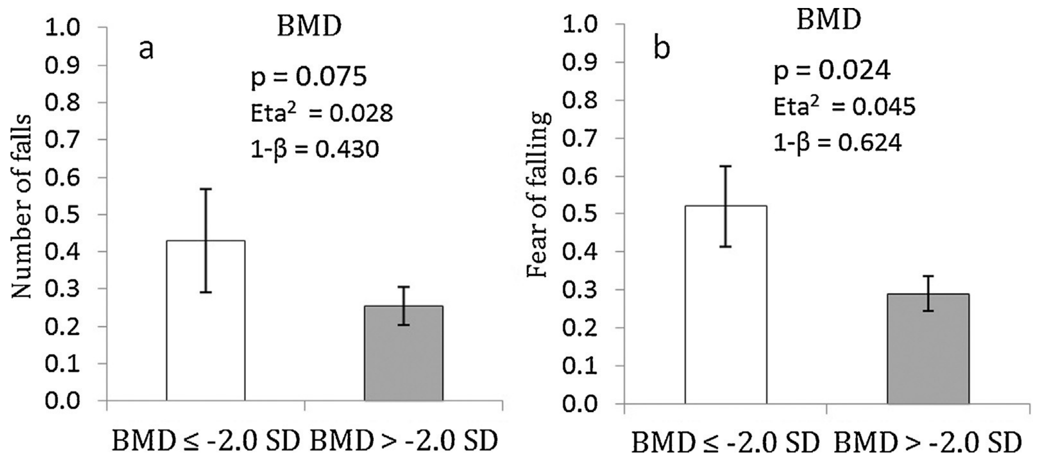

Fig. 2. Analysis of number of falls in the last year and FoF according to BMD groups. FoF: fear of falling. BMD: bone mineral density.

In our study, 24.58% of the participants and a 34.79% of women with low mineral density reported one or more falls in the last 12 months. These results are similar to those described by Sukhee et al. [30] and Pua et al. [31] respectively. Da Silva et al. proposed that a greater percentage of women with postmenopausal osteoporosis had a history of one or more falls within the previous year [32]. The analysis of results showed that women with low mineral density reported a higher number of falls in the by-group comparison, but these differences were not statistically significant, matching the conclusions of Ersoy et al. [20] and Cangussu et al. [21].

Several authors have proven that women with low BMD levels showed increased FoF [20,33], which has been associated with falls and activity restrictions in this population [7,20,34]. Our findings match with these observations, as participants in our study who had BMD ≤ −2.0 reported a significantly higher FoF than those with BMD > −2.0. It has been hypothesized that previous knowledge of BMD levels may have a direct influence on FoF [36]. In our study, participants were aware of the results of their densitometry tests, and it could be therefore argued that, as stated by Park et al. [35], the difference in their FoF might be more related with such awareness than with their actual condition.

It has been described that people diagnosed with osteoporosis show vertebra height decrease, spinal deformities and muscle weakness, which may be related to the development of postural

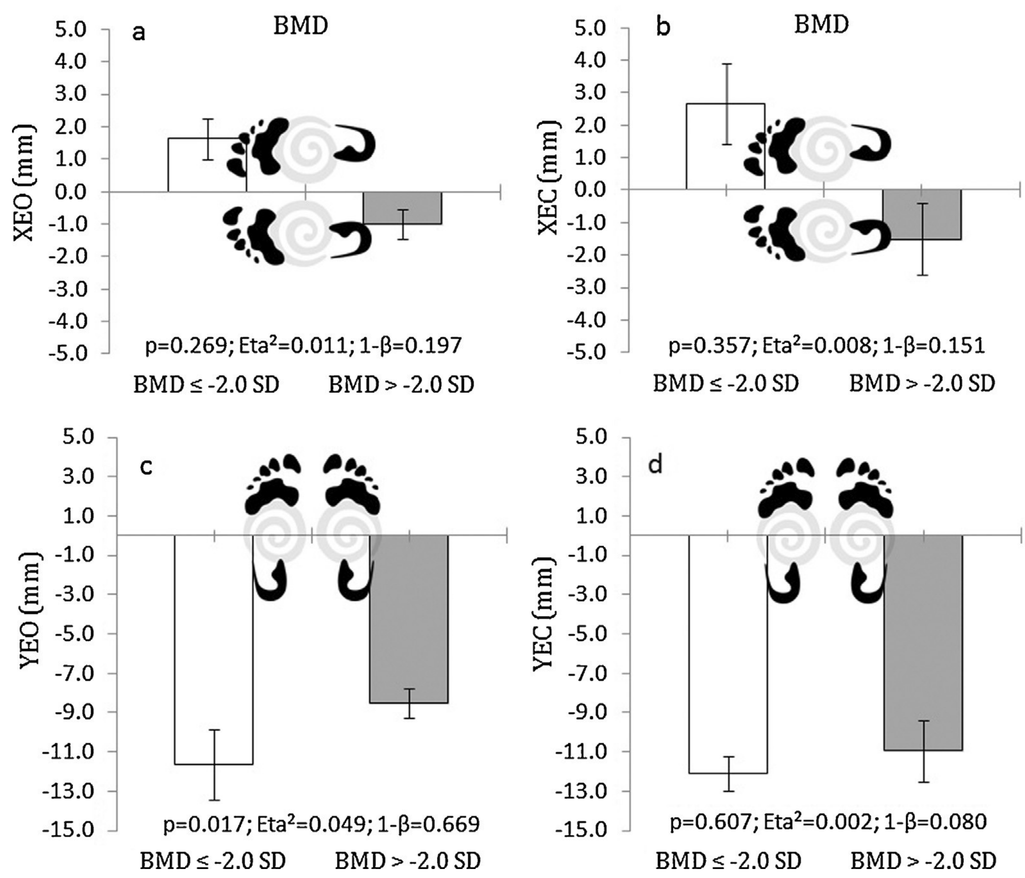

Fig. 3. Stabilometric analysis. Anteroposterior and mediolateral displacements of the CoP according to BMD groups. CoP: center of pressure. BMD: bone mineral density.

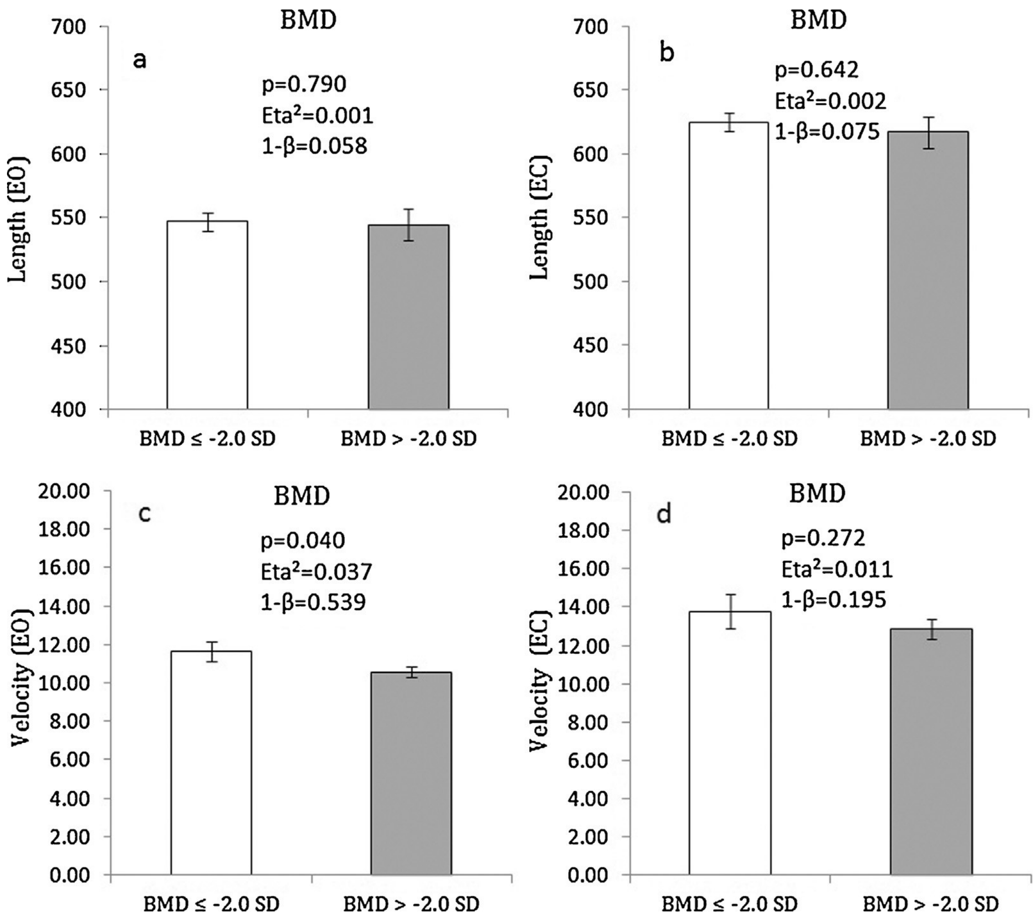

Fig. 4. Stabilometric analysis. Length and velocity of the CoP movements according to BMD groups. CoP: center of pressure. BMD: bone mineral density.

deformity (kyphosis), with a shift of the CoP and a poor alignment of the joints that may lead to impaired balance [17,36]. The association between postural instability, assessed by force platform, and low BMD is documented in the literature [17,18,37], and increased postural sway and imbalance have been reported to be important predictors of falls and fractures in individuals with osteoporosis [38]. Other authors, however, have reported that older adults with osteoporosis did not experience any less balance confidence, assessed by the short ABC-questionnaire [39], or worse postural control as measured with the timed up and go test (TUG) and the Berg balance scale (BBS) [40].

Posturography, considered to be the gold standard for postural balance evaluation, has been has been used to assess postural balance in postmenopausal women [22,41], and some of the most widely used parameters are sway length/velocity and the displacement of the COP mean location on the *X* and *Y* axes [42]. The stabilometric results yielded by our study showed that women with BMD below −2.0 SD had greater length and velocity values than those with BMD over −2.0 SD, although said values only reached significance for sway velocity, which is considered as the most precise measure for assessing postural balance [43], under the eyes-open condition. With regard to this, Burke et al. [44] observed that women with osteoporosis swayed at higher velocity than non-osteoporotic women in an eyes-open test, whereas other recent studies did not find significant differences in velocity sway according to BMD, under both eyes-open and eyes-closed conditions, in a population of age similar to that of our participants [22] and also in older women [45].

As for CoP movements, previous studies could not find any significant difference between women with and without osteoporosis in studies on a population of similar age to that of ours [21,22]. Our results showed that all the CoP dispersion parameters were greater for the group with BMD ≤ 2.0 SD, although statistical significance was only reached in the anteroposterior CoP shifts under eyes closed condition. These findings are consistent with those of some studies carried out on an elderly postmenopausal population, in which women with osteoporosis exhibited greater anteroposterior COP displacement [44,45]. This anteroposterior CoP displacement may be related to postural abnormalities such as kyphotic posture, that displaces the center of gravity in this axis [17] or to muscle control problem, mainly in ankle plantar flexor muscles, which play a significant role in postural corrections in the antero-posterior plane [46]. Further research with strength and biomechanical assessment could help to clarify this point.

Regarding the limitations of this work, in the first place the number of falls during the last year was retrospectively collected through questions in an interview, which may lead to a recall bias that might in turn distort the estimation of the number of falls the participants suffered. Secondly, this study was performed on postmenopausal women under 65, and therefore our results cannot be extended to older postmenopausal women. In the third place, the participants had access to the results of their densitometric analyses, which might have influenced their perception of their FoF and thus condition their stabilometric tests. Future studies on an older postmenopausal population should be conducted, employing a diary to collect falling experiences in a periodical way and having participants not know their BMD values in order to avoid any potential influence on their fear of falling and their postural stability.

5. Conclusions

Our study in a postmenopausal population aged 50–65 showed that, compared with women with BMD > 2.0, participants with BMD ≤ 2.0 had a significantly higher fear of falling, as well as greater sway velocity in the eyes-open test and greater anteroposterior displacements under the eyes-closed condition. A higher percentage of falls was reported by women with BMD ≤ 2.0, but differences were not significant. In the rest of the stabilometric analysis, no significant differences between groups were observed.

Contributors

F. Hita-Contreras: conception and design of the idea, acquisition of subjects and data, data interpretation and preparation of manuscript. E. Martínez-López: statistical analysis, data interpretation and critical revision of the manuscript. P. González-Matarín: acquisition of data, methods preparation and critical revision of the manuscript. N. Mendoza-Ladrón de Guevara: acquisition of subjects, methods preparation and critical revision of the manuscript. D. Cruz-Martín: methods preparation and critical revision of the manuscript. A. Ruiz-Ariza: methods preparation and critical revision of the manuscript. A. Martínez-Amat: conception and design of the idea, acquisition of subjects, data interpretation and critical revision of the manuscript. All authors approved the final version.

Competing interests

The authors declare no conflict of interest.

Funding

The authors have received no funding for this article.

Ethical approval

The work described in the present article has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans, and approved by the Ethic Committee of the University Hospital San Cecilio of Granada in May 18, 2010.

References

[1] Bączyk G, Opala T, Kleka P, Chuchracki M. Multifactorial analysis of risk factors for reduced bone mineral density among postmenopausal women. Arch Med Sci 2012;8(2):332–41.
[2] Kanis JA, McCloskey EV, Johansson H, et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int 2013;24(1):23–57.
[3] Barrett-Connor E, Weiss TW, McHorney CA, Miller PD, Siris ES. Predictors of falls among postmenopausal women: results from the National Osteoporosis Risk Assessment (NORA). Osteoporos Int 2009;20(5):715–22.
[4] Shiraki M, Kuroda T, Tanaka S. Established osteoporosis associated with high mortality after adjustment for age and co-morbidities in postmenopausal Japanese women. Intern Med 2011;50:397–404.
[5] Clarke BL, Khosla S. Female reproductive system and bone. Arch Biochem Biophys 2010;503(1):118–28.
[6] Poole KE, Compston JE. Osteoporosis and its management. BMJ 2006;333:1251–6.
[7] Arnold CM, Busch AJ, Schachter CL, Harrison L, Olszynski W. The relationship of intrinsic fall risk factors to a recent history of falling in older women with osteoporosis. J Orthop Sports Phys Ther 2005;35(7):452–60.
[8] Tinetti ME, Richman D, Powell L. Falls efficacy as a measure of fear of falling. J Gerontol 1990;45:239–43.
[9] Hita-Contreras F, Martínez-Amat A, Lomas-Vega R, et al. Predictive value of stabilometry and fear of falling on falls in postmenopausal women. Climacteric 2013;16(5):584–9.
[10] Scheffer AC, Schuurmans MJ, van DN, Van Der HT, de Rooij SE. Fear of falling: measurement strategy, prevalence, risk factors and consequences among older persons. Age Ageing 2008;37:19–24.
[11] Friedman SM, Munoz B, West SK, Rubin GS, Fried LP. Falls and fear of falling: which comes first? A longitudinal prediction model suggests strategies for primary and secondary prevention. J Am Geriatr Soc 2002;50(8): 1329–35.
[12] Bloem BR, Steijns JA, Smits-Engelsman BC. An update on falls. Curr Opin Neurol 2003;16:15–26.
[13] Rubin SM, Cummings SR. Results of bone densitometry affect women's decisions about taking measures to prevent fractures. Ann Intern Med 1992;116:990–5.
[14] Melzer I, Kurz I, Oddsson LI. A retrospective analysis of balance control parameters in elderly fallers and non-fallers. Clin Biomech 2010;25:984–8.
[15] Melzer I, Benjuya N, Kaplanski J. Postural stability in the elderly: a comparison between fallers and non-fallers. Age Ageing 2004;33(6):602–7.
[16] Cheng M, Wang S, Yang F, Wang P, Fuh J. Menopause and physical performance: a community-based cross-sectional study. Menopause 2009;16:892–6.
[17] Lynn SG, Sinaki M, Westerlind KC. Balance characteristics of persons with osteoporosis. Arch Phys Med Rehabil 1997;78(3):273–7.
[18] Kuczyński M, Ostrowska B. Understanding falls in osteoporosis: the viscoelastic modeling perspective. Gait Posture 2006;23(1):51–8.
[19] Abreu DC, Trevisan DC, Costa GC, Vasconcelos FM, Gomes MM, Carneiro AA. The association between osteoporosis and static balance in elderly women. Osteoporos Int 2010;21(9):1487–91.
[20] Ersoy Y, MacWalter RS, Durmus B, Altay ZE, Baysal O. Predictive effects of different clinical balance measures and the fear of falling on falls in postmenopausal women aged 50 years and over. Gerontology 2009;55(6):660–5.
[21] Cangussu LM, Nahas-Neto J, Petri Nahas EA, Rodrigues Barral AB, Buttros Dde A, Uemura G. Evaluation of postural balance in postmenopausal women and its relationship with bone mineral density – a cross sectional study. BMC Musculoskelet Disord 2012;13:2.
[22] Brech GC, Plapler PG, de Souza Meirelles E, Marcolino FM, Greve JM. Evaluation of the association between osteoporosis and postural balance in postmenopausal women. Gait Posture 2013;38(2):321–5.
[23] Lamb SE, Jørstad-Stein EC, Hauer K, Becker C. Prevention of Falls Network Europe and Outcomes Consensus Group Development of a common outcome data set for fall injury prevention trials: the Prevention of Falls Network Europe consensus. J Am Geriatr Soc 2005;53:1618–22.
[24] Lachman ME, Howland J, Tennstedt S, Jette A, Assmann S, Peterson EW. Fear of falling and activity restriction: the survey of activities and fear of falling in the elderly (safe). J Gerontol B Psychol Sci Soc Sci 1998;53:43–50.
[25] Elavsky S. Physical activity, menopause, and quality of life: the role of affect and self-worth across time. Menopause 2009;16:265–71.
[26] World Health Organization. Obesity: preventing and management of the global epidemic. Report of the WHO Consultation. World Health Organ Tech Rep Ser 2000;894:1–253.
[27] Kanis JA, Gluer CC. An update on the diagnosis and assessment of osteoporosis with densitometry. Committee of Scientific Advisors, International Osteoporosis Foundation. Osteoporos Int 2000;10:192–202.
[28] Nahas EAP, Kawakami MS, Nahas-Neto J, Buttros DA, Cangussu L, Rodrigues AB. Assessment of risk factors for low bone mineral density in Brazilian postmenopausal women. Climacteric 2011;14(2):220–7.
[29] Romero-Franco N, Martinez-Lopez E, Lomas-Vega R, et al. Short-term effects of proprioceptive training with unstable platform on athletes' stabilometry. J Strength Cond Res 2013;27:2189–97.
[30] Sukhee A, Huynliz K, Heeyoung S, Rhayun S. Factors influencing fear of falling in postmenopausal women. Korean J Women Health Nurs 2009;15: 344–52.
[31] Pua YH, Ong PH, Lim EC, Huang KS, Clark RA, Chandran M. Functional heterogeneity and outcomes in community-dwelling women with osteoporosis, with and without a history of falls. Gait Posture 2014;39(3):971–7.
[32] da Silva RB, Costa-Paiva L, Morais SS, Mezzalira R, Ferreira Nde O, Pinto-Neto AM. Predictors of falls in women with and without osteoporosis. J Orthop Sports Phys Ther 2010;40(9):582–8.
[33] Gold DT. The clinical impact of vertebral fractures: quality of life in women with osteoporosis. Bone 1996;18:185S–9S.
[34] Hübscher M, Vogt L, Schmidt K, Fink M, Banzer W. Perceived pain, fear of falling and physical function in women with osteoporosis. Gait Posture 2010;32(3):383–5.
[35] Park JH, Cho H, Shin JH, et al. Relationship among fear of falling, physical performance, and physical characteristics of the rural elderly. Am J Phys Med Rehabil 2014;93(5):379–86.
[36] Granito RN, Aveiro MC, Renno AC, Oishi J, Driusso P. Comparison of thoracic kyphosis degree, trunk muscle strength and joint position sense among healthy and osteoporotic elderly women: a cross-sectional preliminary study. Arch Gerontol Geriatr 2012;54(2):e199–202.
[37] Hsu WL, Chen CY, Tsauo JY, Yang RS. Balance control in elderly people with osteoporosis. J Formos Med Assoc 2014;113:334–9, pii: S0929-6646(14)00069-2.
[38] Lord SR, Sambrook P, Gilbert C, et al. Postural stability, falls and fractures in the elderly: results from the Dubbo Osteoporosis Epidemiology Study. Med J Aust 1994;160:684–5, 688–691.
[39] Smulders E, van Lankveld W, Laan R, Duysens J, Weerdesteyn V. Does osteoporosis predispose falls a study on obstacle avoidance and balance confidence. BMC Musculoskelet Disord 2011;12:1–8.
[40] de Abreu DC, Trevisan DC, Reis JG, da Costa GD, Gomes MM, Matos MS. Body balance evaluation in osteoporotic elderly women. Arch Osteoporos 2009;4(1–2):25–9.

[41] Hita-Contreras F, Martínez-Amat A, Lomas-Vega R, et al. Relationship of body mass index and body fat distribution with postural balance and risk of falls in Spanish postmenopausal women. Menopause 2013;20(2): 202–8.

[42] Manfredini D, Castroflorio T, Perinetti G, Guarda-Nardini L. Dental occlusion, body posture and temporomandibular disorders: where we are now and where we are heading for. J Oral Rehabil 2012;39(6):463–71.

[43] Hunter MC, Hoffman MA. Postural control: visual and cognitive manipulations. Gait Posture 2001;13(1):41–8.

[44] Burke TN, França FJ, Meneses SR, et al. Postural control among elderly women with and without osteoporosis: is there a difference? Sao Paulo Med J 2010;128(4):219–24.

[45] Silva RB, Costa-Paiva L, Oshima MM, Morais SS, Pinto-Neto AM. Frequency of falls and association with stabilometric parameters of balance in post-menopausal women with and without osteoporosis. Rev Bras Ginecol Obstet 2009;31(10):496–502.

[46] Schieppati M, Nardone A. Group II spindle afferent fibers in humans: their possible role in the reflex control of stance. Prog Brain Res 1999;123:461–72.