ORIGINAL ARTICLE

Postural control parameters in elderly female fallers and non-fallers diagnosed or not with knee osteoarthritis

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ABSTRACT

Objectives: To compare stabilometric parameters of elderly female fallers and non-fallers associated or not with knee osteoarthritis (OA). **Methods:** Fifty-six elderly female fallers and non-fallers diagnosed or not with unilateral or bilateral knee OA were divided into the following groups: FOA (n = 10), elderly female fallers with knee OA; FNOA (n = 11), elderly female fallers without knee OA; NFOA (n = 14), elderly female non-fallers with knee OA; and NFNOA (n = 21), elderly female non-fallers without knee OA. For analyzing semi-static balance on a force platform with the elderly females standing, the following parameters were assessed in four conditions: center of pressure (COP), anterior-posterior and mediolateral displacements (APD and MLD, respectively); and COP anterior-posterior and mediolateral displacement velocities (APV and MLV, respectively). The following conditions were assessed: 1) standing on a firm wooden surface with eyes open (WSEO); 2) standing on a firm wooden surface with eyes closed (WSEC); 3) standing on a foam surface with eyes open (FSEO); 4) standing on a foam surface with eyes closed (FSEC). **Results:** The elderly females with knee OA showed greater APD in all four conditions assessed ($P < 0.05$), while the elderly female fallers showed greater MLD ($P < 0.05$). No difference between the groups was observed for APV and MLV ($P > 0.05$). **Conclusions:** Knee OA per se increases APD of the COP, while the history of falls, regardless of the presence of knee OA, hinders postural control in the ML direction.

Keywords: accidental falls, postural balance, knee osteoarthritis.

INTRODUCTION

One of the consequences of population ageing is the increase in the incidence of chronic degenerative diseases,[1] of which osteoarthritis (OA) is the most prevalent joint disease among the elderly,[2] generating socioeconomic impact due to disabilities.[3]

Osteoarthritis accounts for a large part of the lower limb (LL) disabilities of the elderly, a population in which it predominates.[4] In the knees, OA can cause chronic disability among the elderly, limiting them in their routine activities and household chores, increasing, thus, their risk for falling. Changes in the joint cartilage caused by OA[4] have some consequences due to bone remodeling combined with cartilage loss. One of those consequences is joint instability,[5] which, combined with other OA characteristics, leads to a reduction in the range of motion and in joint proprioception,[6] a sense of

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unsafety or incapacity to perform joint movements, and all such factors contribute to impairment of the semi-static and dynamic balance.

The elderly also suffer with other consequences of the ageing process, such as changes in postural control, which leave them even more prone to falls.[7,8] Lack of safety in performing some activities justifies the extreme importance of identifying risk factors for falling.[9]

It is worth noting the importance of further studies to better understand the influence of OA on the history of falls, which increases health care costs and impairs the individuals' quality of life. There are several studies using force platform to assess balance.[6,9] Evidences show a greater sway of the center of pressure (COP) in individuals with knee OA; however, studies differentiating postural control of elderly female fallers with and without OA are scarce.

The detection of factors present in OA that might be associated with falls can aid health care professionals to program a more specific preventive intervention, because the risk of new falls increases after a fall. Thus, this study aimed at comparing stabilometric parameters of elderly female fallers and non-fallers, diagnosed or not with knee OA.

PATIENTS AND METHODS

This study included 56 elderly female fallers (non-accidental falls in the last six months) and non-fallers, aged 60–85 years, diagnosed or not with unilateral or bilateral knee OA. The radiological diagnosis of OA was based on the 2000 American College of Rheumatology Subcommittee on Osteoarthritis Guidelines.

Elderly females with the following pathologies were excluded: cardiorespiratory and neurological diseases; cognitive disorders; vestibulopathy; diabetes mellitus; history of bone fractures and/or lesions in LLs over the last six months; history of hip, knee or ankle surgery; BMI > 40 (morbid obesity); use of support devices, implants or prostheses in the LLs; knee injection of corticosteroids in the last three months; and use of drugs for the central nervous system (CNS). In addition, elderly females diagnosed with OA in the spinal column and in other joints of the LLs, except for the knees, were also excluded.

All volunteers provided written informed consent approved by the Ethics Committee in Research of the Centro de Saúde of the Medical School of Ribeirão Preto of the Universidade de São Paulo (CSE-FMRP-USP) (protocol 314 of 06/09/2009), confirming their participation. The patients' privacy was preserved.

The elderly females were distributed into two groups as follows: group F (n = 21), elderly female fallers; and group NF (n = 35), elderly female non-fallers. Later the groups were subdivided as follows: group FOA (n = 10), elderly female fallers with OA; group FNOA (n = 11), elderly female fallers without OA; group NFOA (n = 14), elderly female non-fallers with OA; and group NFNOA (n = 21), elderly female non-fallers without OA.

Prior to assessments, anthropometric data of the elderly females (weight, height and BMI) were obtained. Semi-static balance was assessed by use of a force platform (EMG System do Brasil), which assessed vertical force distribution in four points, providing balance analysis with quantification of the range and velocity of the anterior-posterior and mediolateral displacement (APD and MLD, respectively) of the COP. Data were digitized and analyzed by use of the EMG System do Brasil software.

During assessment, a previously agreed-on protocol was used to measure APD and MLD of all volunteers included in the study in the following conditions: 1) standing on a firm wooden surface with eyes open for 60 seconds (WSEO); 2) standing on a firm wooden surface with eyes closed for 60 seconds (WSEC); 3) standing on a 5-cm-thick foam surface (30 dm/cm^3) with eyes open for 60 seconds (FSEO); 4) standing on a 5-cm-thick foam surface with eyes closed for 60 seconds (FSEC).

During data collection, the volunteers remained barefoot on the force platform, feet apart to shoulder width, and arms along their body. They were instructed to look fixedly at a determined point within 1.5 m at eye level during data collection. Three collections were performed for each posture.

Data analysis

The SPSS for Windows software, version 16.0 (SPSS Inc., USA), was used for all statistical analyses, and the significance level of 0.05 was adopted.

The statistical analysis used models considering that the variables had normal distribution, tested by use of the Shapiro-Wilk test, and constant variance, tested by the Levene's test. When those assumptions were not observed, transformations in the variables were performed.

For comparing the anthropometric characteristics between the groups, three analyses of variance with two factors (two-way ANOVA) were used, the factors being disease and fall, and the dependent variables being age, weight, and height. Because there was a difference in weight when the factor was disease and a difference in weight and age when the factor was fall, those data were used as co-variables in the other analyses. For comparing balance between the groups, four two-way ANOVA were used as follows: as factors, fall and disease; as co-variables, age and weight; and as dependent variables, anterior-posterior (AP) body sway in the four conditions, AP body sway velocity in the four conditions, mediolateral (ML) body sway in the four conditions, and ML body sway velocity in the four conditions during semi-static balance.

RESULTS

Anthropometric data

There was a difference in age between groups when the factor was fall [F (1.52) = 5.42; P < 0.05], but not when the factor was disease [F (1.52) = 0.29; P > 0.05]. There was a difference in weight for both factors, fall [F (1.52) = 7.99; P < 0.05] and disease [F (1.52) = 18.37; P < 0.05]. However, there was no difference in height for the factor fall [F (1.52) = 0.06; P > 0.05] and for the factor disease [F (1.52) = 1.96; P > 0.05]. Group F had greater age and weight as compared with group NF. In addition, the elderly females with knee OA had greater weight as compared with the group without knee OA. Table 1 shows those values.

Semi-static balance

Anterior-posterior displacement of the COP (APD)

Multivariate analyses showed no difference for the factor fall, but for the factor disease [Wilk's λ = 0.73; F (4.47) = 4.37; P > 0.05]. No interaction between the factors fall and disease was observed [Wilk's λ = 0.88; F (4.47) = 1.53; P > 0.05], evidencing the predominance of the factor disease in changing AP balance, regardless of the history of fall. Univariate analyses showed the effect of disease in the following variables: WSEC [F (1.50) = 7.96; P < 0.05]; FSEO [F (1.50) = 12.75; P < 0.05]; and FSEC [F (1.50) = 8.83; P < 0.05]. Elderly females with OA showed a greater AP displacement as compared with the group without OA in three conditions (Figure 1).

Mediolateral displacement of the COP (MLD)

Multivariate analyses showed differences only for the factor fall [Wilk's λ = 0.78; F (4.47) = 3.25; P < 0.05]. No interaction between the factors fall and disease was identified [Wilk's λ = 0.95; F (4.47) = 0.63; P > 0.05], showing that the factor fall has a greater influence on the ML balance, regardless of the presence of OA. Thus, by using ANOVA, a difference was observed in the following variables: WSEO [F (1.50) = 4.37; P < 0.05]; FSEO [F (1.50) = 10.09; P < 0.05]; and FSEC [F (1.50) = 11.65; P < 0.05]. Group F showed greater MLD in the conditions WSEO, FSEO and FSEC as compared with group NF (Figure 2).

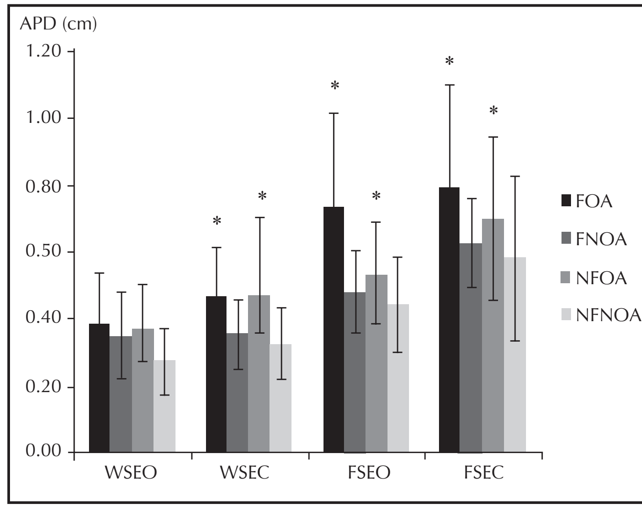

Figure 1
Anterior-posterior displacement (APD) of the center of pressure (COP) in each of the four conditions assessed for the following four groups: Group FOA: elderly female fallers with osteoarthritis; Group FNOA: elderly female fallers without osteoarthritis; Group NFOA: elderly female non-fallers with osteoarthritis; Group NFNOA: elderly female non-fallers without osteoarthritis. Values shown as mean ± SD.
The four conditions assessed were as follows: WSEO - standing on a firm wooden surface with eyes open; WSEC - standing on a firm wooden surface with eyes closed; FSEO - standing on a foam surface with eyes open; FSEC - standing on a foam surface with eyes closed.
* P < 0.05, with OA versus without OA.

Table 1
Anthropometric data of the study's volunteers

	Age (years)	Height (m)	Weight (kg)
Group FOA	69.30 ± 5.74	1.57 ± 0.04	78.44 ± 9.13
Group FNOA	72.72 ± 4.90	1.53 ± 0.06	65.00 ± 8.25
Group NFOA	68.43 ± 5.84	1.54 ± 0.05	68.29 ± 7.05
Group NFNOA	66.62 ± 5.13	1.54 ± 0.06	62.47 ± 808

Group FOA: elderly female fallers with osteoarthritis; Group FNOA: elderly female fallers without osteoarthritis; Group NFOA: elderly female non-fallers with osteoarthritis; Group NFNOA: elderly female non-fallers without osteoarthritis.

Velocity of the anterior-posterior displacement of the COP

No difference between the groups was observed regarding APD velocity in any condition.

Velocity of the mediolateral displacement of the COP

No difference between the groups was observed regarding MLD velocity in any condition.

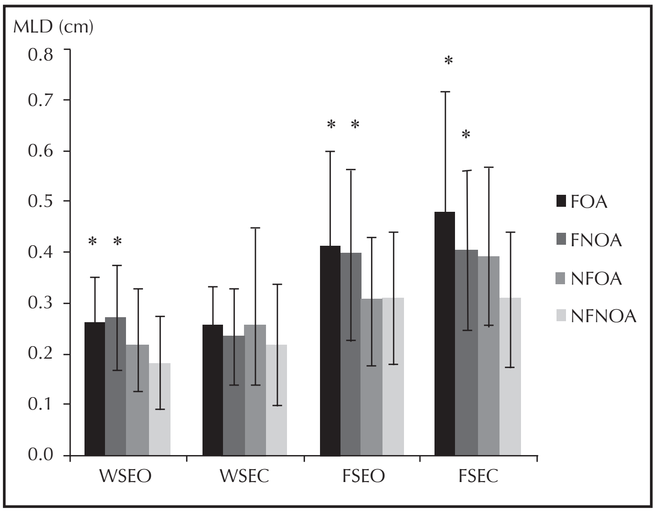

Figure 2
Mediolateral displacement (APD) of the center of pressure (COP) in each of the four conditions assessed for the following four groups: Group FOA: elderly female fallers with osteoarthritis; Group FNOA: elderly female fallers without osteoarthritis; Group NFOA: elderly female non-fallers with osteoarthritis; Group NFNOA: elderly female non-fallers without osteoarthritis. Values shown as mean ± SD.

The four conditions assessed were as follows: WSEO - standing on a firm wooden surface with eyes open; WSEC - standing on a firm wooden surface with eyes closed; FSEO - standing on a foam surface with eyes open; FSEC - standing on a foam surface with eyes closed.
* $P < 0.05$ fallers versus non-fallers.

DISCUSSION

Postural control requires an interaction between the sensory (information from the somatosensory, vestibular and visual systems) and neuromuscular systems, including the biomechanical relationships between body segments.[10] The integrated action of the sensory and motor systems allows precise input to the CNS about the body's position in space, using references from the support surface, the visual environment, and internal references, so that the CNS can establish the best strategy to maintain or recover balance, by using reactive strategies and anticipatory postural adjustments (pro-active and predictive responses).[11]

One of the major methods used to assess balance by use of COP is the force platform.[12] The movement of the COP of a quietly standing individual is obtained by use of stabilometry, which shows the COP displacement over time in the AP and ML directions. Some parameters derived from stabilometry are known to relate to the risk for falling.[12,13] The human body cannot maintain a totally still upright position, considering that spontaneous, narrow sways in the AP and ML directions are observed. Thus, currently the term semi-static*,* rather than static*,* balance is used.

Elderly non-fallers as compared with the younger population show a difference in their postural control pattern, evidenced by a wider postural sway. Studies have shown that in the sixth decade of life that increase in postural sway becomes more evident.[14,15] Era et al.[16] have reported that the increase in postural sway already happens in young adults, but becomes more intense from the age of 60 years onwards.

Based on those data, studies should be carried out comparing the balance of healthy elderly with that of individuals with a specific disease, to better understand the impact of diseases on postural control and to encourage the elaboration of a rehabilitation program for those patients.[17] A review study[18] has concluded that, under laboratory circumstances, the parameters assessed by using a force platform can provide valuable information to predict future or recurring falls among the elderly.

Both the advancing age and the presence of OA have implications on health, since both cause a reduction in the physiological function.[19] The occurrence of falls among elderly with OA can bring even greater medical, psychological and social complications to that population. Thus, preventing and reducing falls are of great importance for the health and well-being of the elderly, because falls can have a negative impact on the elderly quality of life, being associated with a greater chance of bone fractures, soft tissue injuries, cranioencephalic trauma, confinement, and post-fall syndrome.

Understanding the repercussion of knee OA on the balance of elderly females is extremely important, because it helps planning rehabilitation programs for that population. In addition, deficient postural control should be studied in dynamic conditions, and assessment tools that can be rapidly used in clinical practice and that are sufficiently sensitive to identify patients with bone, muscle and joint changes at risk for falling should be implemented. According to Horak,[20] the prevention of the risk for falling and the elaboration of an intervention program for individuals with impaired balance depend on the assessment of the integrity of the subjacent physiological systems and the adoption of compensatory strategies.

Thus, it is worth conducting more detailed studies on the disabling events of the elderly with knee OA, which might result in falls. In Brazil, studies on falls and their related factors in that elderly population with OA are still scarce.[21,22]

Some studies have shown that individuals with knee OA have impaired semi-static balance.[23] Hassan, Mockett and Doherty[6] have reported that individuals with knee OA, as compared with controls, have increased AP and ML sway in the quiet standing position with eyes closed. In another study, Hassan et al.[24] have reported that the static postural control was reduced in individuals with painless knee OA as compared with controls of matching ages. Our findings partially corroborate those, because the elderly females with OA have increased COP displacement in the AP, but not in the ML, direction, regardless of the history of falls.

However, regarding COP displacement in the ML direction, elderly female fallers showed a wider sway in all conditions, except for when on the firm surface with eyes closed. The results indicate that their increased ML instability is rather associated with the history of falls than with the presence of knee OA.

Some studies have reported lateral instability as a predictive factor of falls in the elderly. Of the major changes in the postural parameters assessed by use of the force platform, the amplitude of the MLD of the COP stands out.[18] Maki et al.[25] have suggested that the lateral stability control can be an important variable for the prevention of falls in the elderly. Our results corroborate those previous studies, because an increased MLD of the COP was observed in the elderly female fallers. Swanenburg et al.[26] have reported that the MLD range on the force platform in the single-task condition was a significant independent predictor of falls. The increased MLD observed might have been caused by weakness of the hip abductor muscles.[27]

There is no consensus in the literature about which COP displacement parameters are increased in the elderly population. Abrahamová and Hlavacka[15] have reported that the COP parameters increase from the sixth decade of life onwards, and such increase is more evident in APD velocity and range, and better demonstrated on an unstable surface with eyes closed. Du Pasquier et al.,[17] in a cross-sectional longitudinal study, have reported that the velocity of body sway in the AP direction is the factor that better shows the impaired ability to maintain the orthostatic posture with aging. Jeka et al.[28] have suggested that the ability to control the COP displacement velocity plays an important role in balance control. However, our results evidenced no difference in the APD and MLD velocities when comparing the groups.

Our results showed that the group with OA differed from the group without OA in the APD. Thus, elderly females with OA have a wider APD of the COP, which increases the risk of falls in that population. However, in our sample, the fact that the elderly females with OA had a history of falls did not increase the risk for falling. However, the history of falls interfered with the increase in the MLD, regardless of the presence of OA. Thus, specific approaches to balance rehabilitation of elderly female fallers and of those with knee OA are required.

The rehabilitation programs of elderly females with knee OA should comprise exercises to improve semi-static balance by training postural control strategies, such as ankle, hip and step strategies. However, elderly female fallers seem to require strengthening of their hip abductor muscles aiming at increasing ML stability. In this study, muscle strength was not assessed, which would illustrate the already reported association of a reduction in the strength of the hip abductor and adductor muscles with the increase in MLD. Further studies associating muscle strength assessment with balance might answer those questions.

The following limitations of our study are worth mentioning: the small sample size, a difficulty already reported by other studies using the force platform as an assessment tool of postural control in elderly females;[18] the lack of dynamic analyses of balance; and the lack of assessment of the LL muscle strength.

In conclusion, our results show that elderly females with knee OA have an increased COP displacement in the AP direction, while elderly female fallers have an increased COP displacement in the ML direction.

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