Postural Balance in Women with Osteoporosis and Effective Factors

Osteoporozlu Kadınlarda Postural Denge ve Etkileyen Faktörler

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Summary

Introduction: The most common cause of mortality and morbidity among osteoporotic individuals is bone fracture which in many cases is a direct result of falls. Individual factors contributing to the risk of fall are poor postural balance and lack of muscle strength. Our aims were to assess postural dynamic balance in osteoporotic women and to describe the effective factors on the balance performance.
Methods: Twenty osteoporotic women with kyphosis, 50 osteoporotic women without kyphosis, and 30 healthy women were included in the study. Anterior/Posterior (AP), Medial/Lateral (ML) and Overall (OA) stability indices were obtained using Biodex Stability System (Biodex Medical System, Shirley, NY). Subjects were tested both with eyes open and eyes closed. Quadriceps-hamstring muscles' strength were measured with isokinetic system at angular speeds of 60-180-300°/sec.
Results: OA, AP, ML stability indices in the group with osteoporosis were found to be statistically significantly higher in the open-eyed balance test. When a correlation analysis was performed on all osteoporotic patients, a negative correlation was detected between balance stability indices and knee flexion-extension strength at 60°/sec and knee flexion strength at 300°/sec. Multivariable regression analysis revealed knee extension strength at 60°/sec to be the most effective factor contributing to balance in osteoporotic patients.
Conclusion: Postural balance in osteoporotic women presenting is significantly worse than in the healthy women and the factor exerting the greatest influence on balance is quadriceps muscle strength. Therefore, particular importance must be given to balance and quadriceps strengthening exercises in order to prevent falls in osteoporotic patients. (Turkish Journal of Osteoporosis 2011;17:37-43)
Key words: Osteoporosis, postural balance, quadriceps strength

Özet

Amaç: Osteoporozlu hastalarda düşme sonucu oluşan kemik fraktürleri mortalite ve morbiditenin en sık nedenidir.Düşme riskiyle ilişkili faktörler arasında zayıf postural denge ve kas kuvvetsizliği de bulunmaktadır. Bu çalışmanın amacı osteoporotik kadın hastalarda postural dinamik dengeyi değerlendirmek ve denge üzerine etkili faktörleri araştırmaktır.
Gereç ve Yöntem: Çalışmaya osteoporozlu 50, osteoporoz ve kifozlu 20 ve sağlıklı 30 hasta alındı.Biodeks stabilite sistem ile antero-posterior(AP), mediolateral(ML) ve genel(OA) stabilite indeksleri değerlendirildi. Hastalar göz açık ve göz kapalı olarak test edildi. 60-180-300°/ sn açısal hızlarda quadriceps-hamstring kas güçlerinin ölçümleri izokinetik sistemle yapıldı.
Bulgular: Göz açık OA,AP,ML değerleri osteoporozlu hastalarda anlamlı olarak yüksek bulundu.Tüm osteoporoz hastaları arasında korelasyon analizi yapıldığında denge stabilite indeksleriyle 60 °/sn açısal hızdaki diz fleksiyon ve ekstansiyonu ve 300°/sn açısal hızdaki diz fleksiyonu kas kuvvetleri arasında negatif anlamlı bir ilişki saptandı.Multivariable regresyon analizinde 60 °/sn açısal hızdaki quadriceps kas gücünün osteoporoz hastalarında denge ile en fazla ilişkili faktör olduğu saptandı.
Sonuç: Sağlıklı kadınlara göre osteoporotik kadınlarda postural denge önemli derecede bozulmuştur ve dengeyi etkileyen en önemli faktör quadriceps kas gücüdür. Bu yüzden osteoporotik kadınlarda düşmeleri önlemek için denge ve quadriceps kuvvetlendirme egzersizlerine önem verilmelidir. (Türk Osteoporoz Dergisi 2011;17:37-43)
Anahtar kelimeler: Osteoporoz, postural denge, quadriceps kas gücü

Introduction

Osteoporosis is the most common metabolic bone disease and is characterized by increase in bone fragility resulting from an impairment in the microstructure of bone tissue and decrease in bone mass. Thirteen percent of men and 40% of women over the age of fifty are subjected to a whole life risk of fracture (1). These fractures can occur in almost any bone, although different sites

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have different impact on morbidity and mortality. Thus, most of the studies on osteoporosis deal with the prevention of fractures. Falls play a crucial role among the various causes of fracture. Investigating the underlying causes and taking preventive actions for those that are modifiable will decrease the risk of fracture (2). Individual factors contributing to the risk of fall are balance and gait problems, lack of muscle strength, sight problems, acute and chronic diseases and some medications (hypnotics, tranquilizers, diuretics, hypoglycemic agents) (3). Environmental factors include snow, ice, slippery surfaces, and insufficient light. Osteoporotic women have a higher risk of fracture when compared with women in the same age group. This has resulted not only from decreased density of bone mineral but also from the increased risk of fall (4). There is a strong correlation between poor postural balance and fall though many factors may affect the fall (5,6). Balance is controlled by sensory input, central processing, and neuromuscular responses. The sensory components include the vestibular, visual, and proprioceptive systems. An effective motor response requires an intact neuromuscular system and sufficient muscle strength to return the center of mass within the base of support when balance is disturbed. Control of balance is essential in all postures and situations, both static and dynamic. Falls and loss of balance most commonly occur during movement-related tasks such as walking and, less frequently, during static activities. It is therefore important that the evaluation of balance incorporate testing procedures that reflect the dynamic nature of such locomotor tasks, since static tests of balance are less efficient than dynamic tests in identifying individuals at risk of falls (7,8). The Biodex Stability System (BSS) is reliable for evaluating dynamic postural balance in healthy (9–11) and blind (12) subjects, and has been used to evaluate postural balance in recent years (9–11,13). Postural balance in osteoporotic patients is significantly worse than in healthy individuals. Thoracic hyperkyphosis is not only a disfiguring effect of osteoporosis but may also play a considerable role in gait disorder, instability, and risk of falls (14). In addition, back pain has a negative impact on both balance and functional mobility in osteoporotic women. A number of hypotheses may be proposed; individuals with back pain may reduce their level of physical activity and, as a result, become weak in muscles required for balance and functional mobility. Impairment of the musculoskeletal and/or the neuromuscular system may negatively affect both balance and functional mobility (15). Old age is another cause of poor balance in osteoporotic patients. The negative influence of age on balance and functional mobility has been investigated extensively (16,17). Bone fractures resulting from falls most likely occur in aging women (18). A number of studies have found that impairments in systems that help maintain stability are associated with an increased risk of falls among older people (19). A combination of low bone density and slower and less effective protective movements during falls may explain the greater number of fractures from falls in this group (20). Another crucial factor on falls is muscle strength. In the elderly, significant associations have been found between muscle strength in the lower limbs and falls (21). Knee extension strength has been considered as a significant determinant of performance on static and dynamic balance tests in 65-to 75-year-old women with osteoporosis (22). Based on the above-mentioned information, we aimed to investigate whether there is a difference in postural balance between osteoporotic patients and healthy individuals and to determine the factors that effect balance. We hypothesized that the postural balance is poorer in the osteoporotic patients than healthy subjects. We also expected increased toracic kyphosis and weak quadriceps muscle have a negative effect on balance. The risk of falls and resulting fractures may be decreased if the factors influencing balance can be determined.

Materials and Methods

Seventy osteoporotic women between the ages of 60–75 years and 30 healthy women with the same body mass index (BMI) and age were included in the study. Patients were evaluated in three groups. Group 1 included 50 osteoporotic women without kyphosis, group 2 included 20 osteoporotic women with kyphosis, and group 3 included 30 healthy women as the control group. Lumbar vertebrae and femoral neck bone mineral density (BMD) measurements of all patients using dual energy X-ray absorptiometry (DEXA) revealed a T score of -2,5 or less in at least one region. Individuals on medical therapy that could influence BMD and those presenting with malabsorption, endocrine diseases, chronic renal failure, arthritic inflammatory diseases such as rheumatoid arthritis, and diabetes mellitus, which may lead to secondary osteoporosis, were excluded. Moreover, patients with orthopedic disorders of lower extremity, history of sedative medication, severe cardiovascular disease, psychiatric and neurological diseases, or incurable hearing or sight disorders that may affect postural balance were not included. All participants' height and weight measurements were recorded and their body mass indexes (BMI) calculated. Hemogram and thyroid function tests were performed, and serum calcium, phosphorus, alkaline phosphatase, 25 (OH) vitamin D and parathyroid hormone (PTH) levels were measured. In addition, anteroposterior (AP) and lateral thoracolumbar vertebral radiographs were taken. The Cobb angle between T4 and T12 in lateral thoracolumbar radiographs of osteoporotic patients was measured to determine kyphosis. The angle between the lines taken vertical to the lines drawn over the T4 and under the T12 was calculated. Twenty patients with a Cobb angle of 40° or greater were included in the kyphotic group (23). To assess participants' balance status, this study used a commercially available balance device, the Biodex Stability System (BSS)(Biodex, Inc, Shirley, New York) (Figure 1) which consists of a movable balance platform that provides up to 20° of surface tilt in a 360° range of motion. The platform is interfaced with computer software (Biodex, Version 3.1, Biodex, Inc.) that enables the device to serve as an objective assessment of balance. The measurement of postural stability includes the overall (OA), anteroposterior (AP) and mediolateral (ML) stability scores. A high score in the OA index indicates poor balance. The OA stability score is believed to be the best indicator of overall ability of the patient to balance the platform (13). We assessed bilateral stance at level 8 (level 8 most stable, level 1 most unstable) with the BSS over a period of 20 seconds. Subjects were asked to step on the platform of the BSS and assume a comfortable position while maintaining slight flexion in the knees (15°), to look straight ahead, and to place arms across the chest. Foot position coordinates were constant throughout the test session. Subjects were tested without footwear at all times. Patients and controls were trained one minute for adaptation to the machine, following which three

practice trials were conducted to reduce any learning effects, and three test evaluations were performed. A mean score was calculated from the three test evaluations. Subjects were given a one-minute rest between tests. All subjects were evaluated both with eyes open and closed.

Concentric measurements of the quadriceps and hamstring muscle strength of the dominant leg were detected at angular speeds of 60–180–300°/sec in a movement range of 0-90° of knee, using Biodex Isokinetic Dynamometer (Biodex Medical System NY, Shirley). Prior to testing, each subject underwent a 5-min warming-up period of low-resistance ergometer cycling. Subjects were then seated in an adjustable chair and their thigh, hip, and chest were stabilized using straps. The axis of rotation of the knee joint was aligned with the axis of the dynamometer lever arm. The force pad was placed 3-4 cm superior to the medial malleolus with the feet in plantigrade

Figure 1. A patient in the balance test

position. The knee of the measured leg was positioned at 90º of flexion. Range of motion during testing was set using the goniometer through an arc from 90º knee angle to full extension. During the whole testing period, subjects were asked to produce knee extension as forcefully and quickly as possible through a complete range of motion. Verbal encouragement was given during every trial. Five, 10, and 15 attempts were carried out at the angular speeds of 60, 90, and 180º/sec, respectively. Prior to the test, every participant were subjected to three submaximal contractions at each angular speed to become familiar with the settings. The one with the highest peak torque (PT) value was used for further analyses. The trial proceeded from the lower speed to the higher speed. A rest period of 1 min was allowed between the trials. Not all torque measurements were gravity corrected. Peak torque to body weight ratio (PT/BW) was used for the evaluation.

All patients were given the Turkish Version of the Quality of Life Questionnaire of the European Foundation for Osteoporosis (QUALEFFO), its reliability and effectiveness in assessing the quality of life of osteoporotic patients were previously proven (24). QUALEFFO measures the domains of back pain, physical function, social function, general health perception, and mental function. This test has a range of 0–100 with 0 representing the best possible quality of life (25).

For statistical evaluation, SPSS 10.0 program was used (SPSS, Chicago, IL). Statistical significance level was accepted at $p < 0.05$. ANOVA was used to test differences between the groups in age and BMI; Kruskal-Wallis to determine differences between the patients and controls in balance; and ANOVA test at 60º/sec to study a possible difference in isokinetic muscle strength. Kruskal-Wallis test was used to test difference between patients and controls in isokinetic muscle strength at angular speeds of 180˚ and 300º/sec. Pearson correlation coefficients were calculated to evaluate the osteoporosis group for the influence of age, BMI, 25 (OH) vitamin D, knee flexor/extensor PT/BW, and QUALEFFO on postural control and the influence of age, BMI, 25 (OH) vitamin D, and QUALEFFO on muscle strength. A multiple linear regression analysis was performed to explore the relationship between balance performance and age, BMI, 25 (OH) vitamin D and knee flexor/extensor PT/BW.

Results

Although no differences were observed in age and BMI between the three groups there was difference between the three groups for QUALEFFO score (Table 1). The QUALEFFO score was the worst in the osteoporotic patiens without

Table 1- Demographic data of patients and controls			
Group	Age	BMI	QUALEFFO total score
Group 1	64.9±3 (58-73)	28.8±3 (22.0-37.0)	53.9±4 (43.2-62.8)
Group 2	64.5±3 (60-72)	29.1±4 (21.0-38.2)	51.2±4 (45.3-58.7)
Group 3	64.8±5 (60-81)	31.7±3 (21.8-40.0)	51.5±5 (39.6-65.4)
p value	0.938	0.64	0.026
[Mean ± SD (min-max)] Group 1: Osteoporosis without kyphosis Group 2: Osteoporosis with kyphosis Group 3: Control			

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kyphosis. In a test conducted to study balance values within an open-eyed setting, OA, AP, and ML stability indices were significantly higher in the osteoporosis group with kyphosis compared to the control group as well as to the osteoporosis group without kyphosis. Stability indices of the osteoporosis group without kyphosis were found to be higher than in the control group (Table 2). There was no difference between the three groups in OA and ML measurements performed with eyes closed. However, AP values were significantly higher in the osteoporosis group with kyphotic compared to the osteoporosis group without kyphosis and controls (Table 3).

PT/BW ratios were studied to assess the isokinetic muscle strength. Quadricep muscle strength in the kyphotic group measured at the angular speed of 60°/sec was significantly decreased compared to both osteoporosis group without kyphosis and control group, but hamstring muscle strength was only significantly worse than that of the osteoporosis group without kyphosis. No differences were observed when compared to the control group. PT/BW values of quadriceps muscle of the osteoporosis group without kyphosis measured at the angular speed of 60°/sec were found to be significantly lower than the values obtained for the control group. No differences were observed between the three groups for both flexion and extension strengths of knee at angular speeds of 180°/sec and 300°/sec (Table 4).

No correlation between stability indices and age, BMI, 25 (OH) vitamin D, total QUALEFFO score, and QUALEFFO's subgroups was observed. However, a negative correlation was shown between stability indices and muscle strength of knee extension and flexion at an angular speed of 60°/sec and of muscle strength of knee flexion at an angular speed of 300°/sec during testing performed with eyes open and eyes closed on osteoporotic patients with and without kyphosis (Table 5).

Table 2. Comparison of stability indices in balance test performed with eyes opened according to group

Group	OA	AP	ML
Group 1	3.75±1	2.73±1	2.75±1
Group 2	4.62±1	3.61±1	2.98±1
Group 3	3.64±1	2.72±1	2.52±1
p value	0.038	0.039	0.001

Table 3. Comparison of stability indices in balance test performed with eyes closed according to group

Group	OA	AP *	ML
Group 1	6.94±1	4.8±1	5.0±1
Group 2	7.51±1	5.77±1	4.7±1
Group 3	7.43±1	5.3±1	5.1±1
p	0.07	0.033	0.448

* Indicates a difference between the 1st and 2nd groups for AP at a p level of <0.05.

Table 4. Isokinetic quadriceps and hamstring muscle strength values according to group (PT/BW%)

	Group 1	Group 2	Group 3	p value
60°/sec Ext *	20.9±8	15.4±8	28.8±7	0.009
60°/sec Flex **	15.6±7	11.2±5	13.4±3	0.020
180°/sec Ext	13.1±6	12.7±6	14.3±5	0.304
180°/sec Flex	12.2±6	10.3±3	13.3±4	0.142
300°/sec Ext	12.8±5	12.3±5	13.6±5	0.621
300°/sec Flex	13.3±5	11.6±4	12.6±5	0.541

*Difference of p<0.01 determined between groups 1 and 2; a difference of p<0.05 determined between groups 1 and 3 as well as between groups 2 and 3 was observed for 60°/sec extension
**Difference of p<0.05 determined between groups 1 and 2 for 60°/sec flexion.

Table 5. Correlation analyses performed in osteoporotic patients (r (p value))

	PT/BW60E	PT/BW60F	PT/BW180E	PT/BW180F	PT/BW300E	PT/BW300F
OA	-0.44 (.00)	-0.30 (.01)	-0.16 (.18)	-0.18 (.13)	-0.16 (.18)	-0.25 (.03)
AP	-0.40 (.00)	-0.34 (.00)	-0.10 (.41)	-0.15 (.21)	-0.07 (.57)	-0.12 (.00)
ML	-0.42 (.00)	-0.34 (.00)	-0.17 (.16)	-0.12 (.32)	-0.18 (.14)	-0.24 (.04)
OA(K)	-0.29 (.01)	-0.18 (.03)	-0.09 (.49)	-0.09 (.45)	-0.19 (.11)	-0.25 (.03)
AP(K)	-0.30 (.01)	-0.24 (.04)	-0.07 (.57)	-0.08 (.49)	-0.17 (.17)	-0.19 (.01)
ML(K)	-0.49 (.68)	-0.01 (.92)	-0.02 (.89)	-0.00 (.97)	-0.06 (.59)	-0.16 (.02)

K: Kyphosis group

Table 6. Regression analyses (ß value)						
	Eyes open			**Eyes closed**		
	OA	**AP**	**ML**	**OA**	**AP**	**ML**
60˚/sec ext PT/BW	-0.075	-0.058	-0.050	-0.063	-0.054	-0.060

No correlation was shown between the PT/BW values measured at angular speeds of 60, 180, and 300º/sec and age, BMI, 25 (OH) vitamin D, total QUALEFFO and QUALEFFO's subgroups scores. Multivariable regression analysis performed to determine the most crucial factors affecting balance in osteoporotic patients with or without kyphosis established that PT/BW value of knee extension at 60°/sec was the most influential parameter on the stability indices of OA, AP, and ML (Table 6).

Discussion

Dynamic postural balance of osteoporotic women with and without kyphosis was shown to be more impaired than in healthy individuals in this study. Furthermore, balance of osteoporotic patients with kyphosis was worse than that of osteoporotic patients without kyphosis. We observed that the most crucial factor affecting the balance in osteoporotic patients was quadriceps muscle strength.

Falls have a significant impact on fracture formation, which is one of the most important causes of morbidity in osteoporosis. The probability of falls increases concomitantly with an increase in risk factors for falls. While the probability of fall is less than 7% in those displaying no risk factors or single risk factors, this rate increases to 78% in those displaying four or more risk factors (26). Impaired postural balance, which may occur due to various causes such as old age, back pain, and kyphotic postural anomalies, is an important factor in osteoporotic patients (27–29). In many studies, it was emphasized that kyphotic posture affects postural stability. From a biomechanical point of view, the spinal kyphosis causes a forward and downward shift of the center of mass (COM) of the trunk in the sagittal plane, which induces a forward and downward shift of the body COM with respect to the base of support. To maintain body balance, the patient has to correct for this shift. Extension of the hips, flexion of the knees, and plantar flexion of the ankles may counterbalance the forward shift of the body COM relative to the base of support (30). In addition, it was reported that postural changes make patients less active and lead to incapability in using the extremities and weak coordination (14). During the test performed with both eyes open and close, patients with kyphosis had significantly impaired balance compared to the controls and the osteoporosis group without kyphosis in our study. In another study conducted by Sinaki et al. (14) 12 osteoporotic patients with kyphosis and 13 healthy women were tested for balance by computerized dynamic posturography, and poorer balance was detected in osteoporotic patients with kyphosis. In the study of Antonelli-Incanzi, occiput wall distance was found to be associated with poor performance in test of balance (31). In the another study, it was also shown that osteoporotic patients without kyphosis have worse balance than healthy individuals (4,27). In a study carried out by Liu Ambrose et al. (4) balance in 21 osteoporotic patients was measured and compared to that of 21 healthy females.

Balance scores of the osteoporotic group were 11% worse than scores of healthy participants. They also demonstrated that back pain was more common among these osteoporotic women and had an important impact on balance (15). Lynn et al. (27) compared balance scores in 10 osteoporotic, 6 kyphotic and 5 healthy women and showed that balance in the kyphotic group was worse than in the other two groups and that the osteoporotic group displayed a poorer balance status than normal individuals. Inversely Greig et al. (32) showed that vertebral fracture not thoracic kypohsis is associated with impaired balance charecteristics in the osteoporosis population (32). We did not evaluate effect of vertebral fracture on postural balance in our study.

There is an apparent correlation between the risk of falls and muscle strength of lower extremities (19,21). Liu-Ambrose et al. (4) showed that quadriceps muscle strength was more decreased in osteoporotic patients than in healthy individuals. Moreover, in a study of Sinaki et al. (14) muscle strength of the lower extremities and back extensor was found to be significantly weaker in osteoporotic patients with kyphosis compared to the control group. Muscle strength of knee extension at low angular speed in all osteoporotic patients with or without kyphosis was also weaker than in the control group in our study. Carter et al. (22) showed that quadriceps muscle strength was determinative at a rate of 10–26% in both static and dynamic balance tests performed on osteoporotic patients. Wolfson et al. (33) also suggested that balance impairment might be correlated with both decreased sensorimotor functions and muscle strength of lower extremities. In healthy participants, knee extension strength has been associated with reaction time in addition to its role in contractility. Women with greater knee extension strength had the fastest neuronal processing or contractility either due to faster conducting neurons or larger muscle mass (30). Slowing of reaction time and muscle weakness were associated with increased sway and increased risk of falling (34). Based on the results obtained using correlation and multivariable regression analysis, our study showed that the most crucial factor affecting postural balance was quadriceps muscle strength in osteoporotic patients in both eyes open and closed positions.

Some studies have been performed in osteoporotic patients to determine whether there is a correlation between QUALEFFO and muscle strength and postural balance. Carter et al. (22) demonstrated a correlation between QUALEFFO and quadriceps muscle strength, while no correlation was observed between QUALEFFO and balance in osteoporotic women. We did not find any correlation between the total QUALEFFO score and postural balance and quadriceps muscle strength in our study. Although Sinaki et al. (14) showed relatively low muscle strength in osteoporotic patients with kyphosis compared to the control group, but the level of physical activity (h/week) was not considered as decreased. The interesting finding is the quality of life was not worse in the kyphotic group compared to the others in our study. QUALEFFO score was determined to

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be significantly higher in the osteoporotic group without kyphosis in our study. Scores in subgroups of social activities and mobility were also higher in the osteoporotic group without kyphosis. Postural deformities may cause important defects in daily living activities of osteoporotic patients. QUALEFFO scores of patients with postural deformities were found to be significantly higher than in healthy individuals in a study conducted by Miyakoshi et al. (35) with 157 women with postural deformity. They emphasized that spinal mobility has a strong impact on quality of life in these patients. We did not expect this finding in this study. It may be a result of the relatively limited number of kyphotic patients included in our study.

Serum levels of 25 (OH) vitamin D were associated with balance and quadriceps muscle strength in some studies (36-38). It has been shown that vitamin D treatment decreases the risk of falls by 22% when compared to calcium (Ca) and placebo, and has been suggested that it prevents falls by increasing muscle function and affecting the muscle cell growth while binding to specific nuclear receptors in muscle tissue (39). Balance values in women treated with vitamin D+Ca were increased within two months by 9% compared to those treated only with Ca (40). An increase of 4–11% in musculoskeletal function was determined in a similar study (41). However, no correlations were observed between the quadriceps muscle strength, balance and 25 (OH) vitamin D level of osteoporotic patients in our study. In a study conducted by Shaunak et al. (42) on 308 healthy women, no correlations were shown between 25 (OH) vitamin D levels and muscle strength of quadriceps. It was suggested that vitamin D decreases frequency of fall by increasing neuromuscular function and endurance rather than muscle strength (43).

The present study has some limitations. First of all our sample size was relatively small. We could not find any relationship between the QUALEFFO and poor balance in osteoporotic patients group and we were unable to explain why QUALEFFO score was not worse in the kyphotic group than others. It may be due to our relatively small sample size. Secondly, the current study was cross-sectional in nature, and thus relationship between poor balance and fall cannot be determined. In the study of Sambrook at al. (44) persons with extremely poor balance sustain fewer fractures than subjects with poor to good balance. This migth be because of the subjects with better balance were more likely to undertake activities that could result fall. Therefore, prospective studies are needed to clarify whether relation between the poor balance and fall and fracture in this population.

Based on all these findings, we conclude that postural balance and quadriceps muscle strength in osteoporotic patients with or without kyphosis are significantly worse than in the healthy population and that the most crucial factor acting on balance is quadriceps muscle strength. Therefore, we suggest that special attention must be paid to balance and quadriceps improving exercises within the current training programs to help to prevent falls in osteoporotic patients.

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