

# Balance training program is highly effective in improving functional status and reducing the risk of falls in elderly women with osteoporosis: a randomized controlled trial

M. M. Madureira · L. Takayama · A. L. Gallinaro ·  
V. F. Caparbo · R. A. Costa · R. M. R. Pereira

Received: 9 June 2006 / Accepted: 6 October 2006 / Published online: 7 November 2006  
© International Osteoporosis Foundation and National Osteoporosis Foundation 2006

## Abstract

**Introduction** The purpose of this study was to investigate the effect of a 12-month Balance Training Program on balance, mobility and falling frequency in women with osteoporosis.

**Methods** Sixty-six consecutive elderly women were selected from the Osteometabolic Disease Outpatient Clinic and randomized into 2 groups: the ‘Intervention’, submitted for balance training; and the ‘Control’, without intervention. Balance, mobility and falling frequency were evaluated before and at the end of the trial, using the Berg Balance Scale (BBS), the Clinical Test Sensory Interaction Balance (CTSIB) and the Timed “Up & Go” Test (TUGT). Intervention used techniques to improve balance consisting of a 1-hour session each week and a home-based exercise program.

**Results** Sixty women completed the study and were analyzed. The BBS difference was significant higher in the Intervention group compared to Control ( $5.5 \pm 5.67$  vs  $-0.5 \pm 4.88$  score,  $p < 0.001$ ). Similarly, the number of patients in the Intervention group presented improvement in two conditions of CTSIB compared to Control (eyes closed and unstable surface condition: 13 vs one patient,  $p < 0.001$  and eyes open, visual conflict and unstable surface condition: 12 vs one patient,  $p < 0.001$ ). Additionally, the

differences between the TUGT were reduced in the Intervention group compared to Control ( $-3.65 \pm 3.61$  vs  $2.27 \pm 7.18$  seconds,  $p < 0.001$ ). Notably, this improvement was paralleled by a reduction in the number of falls/patient in the Intervention group compared to Control ( $-0.77 \pm 1.76$  vs  $0.33 \pm 0.96$ ,  $p = 0.018$ ).

**Conclusion** This longitudinal prospective study demonstrated that an intervention using balance training is effective in improving functional and static balance, mobility and falling frequency in elderly women with osteoporosis.

**Keywords** Balance · Exercise program · Falls · Mobility · Osteoporosis

## Introduction

Osteoporosis is a debilitating, widespread disease, which affects approximately 55% of the population above 50 years old in the USA [1]. Falls among the elderly, especially for those with osteoporosis, are associated with high morbidity and mortality and can involve high-cost medical intervention [2]. In fact, falls are responsible for 90% of the growing increase in hip fractures [3] and are the sixth cause of death among patients aged over 65 [4].

Falls are multifactorial, and their causes are categorized as intrinsic (personal) and extrinsic (environmental) factors [5, 6]. Some examples of intrinsic factors include: altered balance, neurological diseases, sensory deterioration, musculoskeletal diseases, postural hypertension and the use of medication [7].

Research shows that altered balance is the greatest collaborator towards falls in the elderly [6, 8–12], with a

M. M. Madureira · L. Takayama · A. L. Gallinaro ·  
V. F. Caparbo · R. A. Costa · R. M. R. Pereira  
Division of Rheumatology (Bone Mineral Metabolism  
Laboratory), School of Medicine, University of São Paulo,  
São Paulo, Brazil

R. M. R. Pereira (✉)  
Faculdade de Medicina da Universidade de São Paulo,  
Av. Dr. Arnaldo, 455 - 3º andar - Reumatologia, sala 3107,  
São Paulo, SP 01246-000, Brazil  
e-mail: rosamariarp@yahoo.com

high correlation between balance deficit and the incidence of falls [13, 14].

For this reason, studies regarding the risk of falling in osteoporosis are of high priority in clinical intervention. Diminishing the incidence of falls is a health priority, which reflects on both the quality of life and health costs [2].

Moreover, evidence suggests that exercise reduces the risk of fractures, showing an effect on the maintenance of bone mass and, more importantly, improving postural stability, mobility and, consequently, diminishing the risk of falls [15]. Indeed, improving balance should be an objective in the prevention of falls [16].

However, knowledge regarding balance deficit and the probability of falls is limited and controversial [17]. The literature shows that exercise may or may not be efficient in the control of falls [18], and the impact of prevention programs with balance training in diminishing falling frequency has yet to be established, principally in women with osteoporosis.

Balance training has been investigated in healthy elderly individuals [3, 16, 19–21]; however, only one study regarding balance training in women with osteoporosis exists. Since patients with osteoporosis are at greater risk of fractures resulting from falls, further research in this group should be prioritized [22].

The purpose of the present study was to investigate the effect of a 12-month balance training program on functional and static balance, mobility and falling frequency in women with osteoporosis.

## Patients and methods

### Patient sample

Sixty-six elderly women aged over 65 years old were consecutively selected from patients of the Osteometabolic Disease Outpatient Clinic of the Rheumatology Division, University of São Paulo. Only patients with osteoporosis, classified according to the World Health Organization [23] were included; with a bone mineral density (BMD) T-score lower than  $-2.5$  standard deviation (SD), in the lumbar spine, femoral neck or total femur region.

The following women were excluded: those with secondary osteoporosis, visual deficiency, severe auditive deficiency, or vestibular alteration of important clinical status, such as women who used assisted walking devices or who were unable to walk independently more than 10 meters [24]; those who planned to be out of town for more than 4 weeks during the 12-month study; and women who presented absolute or relative contraindications for exercise training according to the American College of Sports Medicine [25].

The patients were randomized consecutively into two groups: the group submitted for the Balance Training Program (Intervention Group), consisting of 34 patients; and the Control group, consisting of 32 patients without intervention. The Control group only received treatment for osteoporosis and orientation to prevent falls and return regularly (3-monthly follow-ups) to the Osteometabolic Disease Outpatient Clinic. All patients read and signed a term of free informed consent that described the procedures which would be realized during the research.

Measured variables: interview and medical chart records

Personal, family and clinical data were evaluated through an interview and medical chart records, with emphasis on the history of fractures, number of falls in the preceding year, use of medication for osteoporosis, and use of medication that favored the risk of falling, such as hypnotics, hypotensors and antidepressants.

### Functional state evaluation

Static and dynamic balance and mobility were evaluated in all patients, before and at the end of the trial, by a physiotherapist who was blinded to the distinct group (Intervention, Control).

#### *Functional balance*

The Berg Balance Scale (BBS) is based on 14 items common to daily life activities used to evaluate functional balance [26]. The maximum score that can be achieved is 56, and each item possesses an ordinal scale of five alternatives which varies from 0 to 4 points.

The test is simple, easy to administer and accompanies the evolution of elderly patients. It only requires a ruler and a watch and takes approximately 15 minutes to execute [26]. A score lower than or equal to 45 is considered evidence of altered balance [27].

#### *Static balance*

Static balance was evaluated by the Clinical Test of Sensory Interaction for Balance (CTSIB), which consists of six sensory conditions (1: eyes open and firm surface, 2: eyes closed and firm surface, 3: eyes open, visual conflict and firm surface, 4: eyes open and unstable surface, 5: eyes closed and unstable surface, and 6: eyes open, visual conflict and unstable surface).

Static balance is considered to be altered when an individual cannot remain at least 30 seconds in each of the six conditions [28].

Improvement in the test was defined as the capacity to complete the test during the final evaluation when unable to complete the same in the initial evaluation.

#### Functional mobility

Functional mobility was evaluated by the Timed “Up & Go” Test (TUGT) [29], which registers the time an individual takes to get up out of a chair, walk 3 meters, turn around, walk back and sit down again.

Elderly individuals without balance deficit are capable of completing the test in less than 10 seconds.

#### Falls

The number of falls in the year prior to the study [30] was solicited and noted in the initial evaluation and at the end of the trial (final evaluation). During the year of the study, patients in both groups received a diary and were orientated to write down the days that they fell.

At the end of the study, the difference in the number of falls/patient (final evaluation - initial evaluation) was compared between the Intervention Group and Control.

#### Intervention

The Balance Training Program consisted of 1 hour of exercises realized once a week, with a total of 40 classes, supervised by an experienced physiotherapist. This program was realized in a club (Associação Atlética Acadêmica Oswaldo Cruz - AAAOC) belonging to the Clinics Hospital, School of Medicine, University of São Paulo, located near to the Hospital. The balance exercises described by Tinetti and Suzuki [3, 11] were used. The type and mild to moderate intensity of the exercises used in the present study were chosen so that they could also be performed by elderly patients at home [3]. A list of weekly attendance controlled the absences of each patient.

#### Basic warm-up and stretching exercises

Prior to training, the patients participated in 15 min of warm-up and stretching exercises, consisting of head rotation, shoulder rotation and stretching of the upper and lower limbs. Walking was performed for 15 min with the supervision of a physiotherapist, who associated exercises for the upper limbs throughout the walk.

#### Balance training

Balance was realized in dynamic and static positions for a period of 30 min. This consisted of walking in the tandem position (one foot in front of the other), walking on the tips

of the toes and on the heel, walking sideways, walking while raising the leg and the contra-lateral arm, standing on one leg, and standing in the tandem position, while gradually increasing the period of permanence in these last two static positions [3, 31].

#### Home-based exercises

The patients were instructed and encouraged to continue the same exercises at home at least three times a week for 30 min. A manual with instructions and illustrations for each exercise was distributed. The frequency of participation in the home-based exercises was noted each week by the physiotherapist.

#### Data analysis

Sixty-six consecutive patients were randomized in the present study. Data analysis was realized on 60 patients (30 Intervention Group and 30 Control), as six patients desisted (four Intervention Group and two Control). In the Intervention Group the reasons for desistance were: physical limitations as a result of falls ( $n=1$ ), foot pain ( $n=1$ ), personal reasons ( $n=2$ ); while in the Control group the reasons were: physical limitations as a result of falls ( $n=1$ ), personal reasons ( $n=1$ ).

The data were expressed as the mean and standard deviation (SD) for each variable and differences between the Intervention and Control groups were tested by the Student's *t*-test or Mann-Whitney test. The Chi-square test or Fisher's exact test was used to compare the number of patients in both groups (Intervention Group vs Control) for hypnotic and diuretic drug use, fracture history, CTSIB conditions (1–6) and improvement in CTSIB conditions. *P* values  $<0.05$  were considered significant.

#### Results

The basal characteristics of the patients of both groups were similar in relation to age, body mass index (BMI), fracture history, osteoporosis treatment, diuretics and hypnotics/antidepressants use and bone mineral density (BMD), with no statistically significant differences between the two groups (Table 1).

Similarly, in the first evaluation, no differences occurred when comparing the Intervention Group and the Control Group in reference to: Berg Balance Scale (BBS) score, the number of patients that could not complete the Clinical Test of Sensory Interaction for Balance (CTSIB) in the six sensory conditions, the Timed “Up & Go” Test (TUGT), and the number of falls/patients in the preceding year ( $p>0.05$ ) (Table 2).

**Table 1** Data at the onset of the study in relation to anthropometric parameters, fracture history, medication use and bone mineral density values (T-score) in the Intervention and Control groups

Variable	Intervention (n=30)	Control (n=30)	p-value
Age, years	74.57±4.82	73.40±4.61	0.342*
BMI, kg/m <sup>2</sup>	24.39±4.49	26.51±5.32	0.100*
Fracture history, n (%)	13 (43.3)	16 (53.3)	0.438***
Medication used for OP, n	2.37±1.50	2.30±0.88	0.498**
Hypnotics/ Antidepressants, n (%)	6 (20.0)	7 (23.3)	0.754***
Diuretics, n (%)	14 (46.7)	16 (53.3)	0.606***
Lumbar spine, T-score	-2.83±1.07	-2.62±1.12	0.470**
Femur neck, T-score	-2.70±0.75	-2.75±0.90	0.821**
Total femur, T-score	-2.10±1.26	-2.10±1.09	0.990**

Data expressed in means ± SD or percentage

BMI: body mass index, OP: Osteoporosis

\*Student's *t*-test

\*\*Mann-Whitney test

\*\*\*Chi-square test

### Adherence rate

A high level of adherence was observed. Sixty percent of the patients participated in all of the exercise sessions at the club and absences occurred with the following justifications: doctor's appointment, the realization of laboratory exams or for personal reasons. In relation to home-based exercise, 76.67% of the patients realized exercises at least

**Table 2** Data at the onset of the study for: Berg Balance Scale (BBS) score, number of patients that could not complete the Clinical Test of Sensory Interaction for Balance (CTSIB: condition 1: eyes open and firm surface; condition 2: eyes closed and firm surface; condition 3: eyes open, visual conflict and firm surface; condition 4: eyes open and unstable surface; condition 5: eyes closed and unstable surface; condition 6: eyes open, visual conflict and unstable surface), Timed "Up & Go" Test (TUGT), and number of falls/patient in the preceding year in Intervention Group and Control

	Intervention (n=30)	Control (n=30)	p value
BBS, score	48.80±4.10	48.13±5.36	0.900*
CTSIB condition 1, n (%)	0 (0.0)	1 (3.3)	1.000**
CTSIB condition 2, n (%)	2 (6.7)	1 (3.3)	1.000**
CTSIB condition 3, n (%)	2 (6.7)	2 (6.7)	1.000**
CTSIB condition 4, n (%)	4 (13.3)	4 (13.3)	1.000**
CTSIB condition 5, n (%)	15 (50.0)	12 (40.0)	0.604**
CTSIB condition 6, n (%)	12 (40.0)	9 (30.0)	0.589**
TUGT, seconds	14.31±4.03	13.86±3.43	0.610*
Falls/patient preceding year, n	1.20±1.88	0.87±0.86	0.745*

Data expressed in means ± SD or percentage.

\*Mann-Whitney test

\*\*Fisher's exact test

once a week, 40% of the patients exercised every day and 36.67% from one to four times a week.

### Comparison between the Intervention Group and Control

The difference in BBS score (final—initial evaluation) was greater in the group which suffered intervention (5.5±5.67 vs -0.5±4.88,  $p<0.001$ ) (Table 3).

Similarly, the percentage of patients in the Intervention group whose static balance improved in two sensory conditions (CTSIB, condition 5: eyes closed, unstable surface; and condition 6: eyes open, visual conflict, unstable surface) was statistically significant when compared to Control (CTSIB condition 5: 13 patients vs 1,  $p<0.001$ ; CTSIB condition 6: 12 patients vs 1,  $p<0.001$ ) (Table 3).

Equally, a significant difference in the functional mobility, as measured by the TUGT (final—initial evaluation) was observed in the Intervention Group compared to Control (-3.65±3.61 vs +2.27±7.18,  $p<0.001$ ) (Table 3).

Parallel to these improvements in functional and static evaluation, a reduction in the number of falls/patient (final—initial evaluation) was observed in the Intervention Group compared to Control (-0.77±1.76 vs +0.03±0.98,  $p=0.018$ ) (Table 3).

### Discussion

Few studies have been developed regarding balance training in patients with osteoporosis. The present longitudinal prospective study demonstrated that a program of balance training realized over a period of 12 months was effective in improving the functional and static balance, mobility and diminishing the number of falls in elderly women with osteoporosis.

**Table 3** Differences (final evaluation—initial evaluation) in: Balance Berg Scale (BBS) score, number of patients showing improvement in Clinical Test of Sensory Interaction for Balance (CTSIB condition 5: eyes closed and unstable surface; condition 6: eyes open, visual conflict and unstable surface), time of Timed "Up & Go" Test (TUGT), and number of falls/patient in the Intervention Group and Control

	Intervention (n=30)	Control (n=30)	p-value
Difference BBS, score	5.5±5.67	-0.5±4.88	<0.001*
CTSIB condition 5, n (%)	13 (43.3)	1 (3.3)	<0.001**
CTSIB condition 6, n (%)	12 (40.0)	1 (3.3)	0.001**
Difference TUGT, seconds	-3.65±3.61	+2.27±7.18	<0.001*
Difference of falls/patient, n	-0.77±1.76	+0.03±0.96	0.018*

Data expressed in means ± SD or percentage.

\*Mann-Whitney test

\*\*Chi-square test

In the present work, improvement in relation to functional balance was demonstrated by an increase in the BBS score in the final evaluation in the group submitted to the balance training program (Intervention Group). Similar results were shown in a study by Melzer et al. [32], where the patients who participated in the balance training obtained 64% improvement in 3 months. The authors showed that the group who underwent the balance training demonstrated better performance than the group submitted to muscular strength training.

Programs that emphasize balance training are more effective at improving balance than those that consist primarily of aerobic, muscular strength or flexibility exercises [33].

Although it is a complex issue to evaluate the effectiveness of different types of exercises [34], balance training has shown beneficial results, with diminished risks of falls [35].

Another positive result of the present study was the improvement in the two difficult conditions of the Clinical Test of Sensory Interaction for Balance (condition 5: eyes closed, unstable surface, and condition 6: eyes open, visual conflict, unstable surface) in almost half the patients. Carter et al. [24] obtained an improvement in static balance using muscular strength training rather than balance training, though only in 6.3% of the patients. Thus, the present findings suggest that balance training leads to more evident positive results in static balance than does muscular strength training.

In relation to functional mobility, improvement was demonstrated by a reduction in the TUGT time in the patients submitted to intervention. These results are relevant, since research shows that compromised mobility increases the risk of dependency three- to five-fold, in activities of daily life [36]. This is not surprising, considering that mobility is an important component of daily life activities, for example: going to the shopping mall, to the supermarket, to the doctor or the cinema. Increased dependency could lead to institutionalization and diminished quality of life. Good balance is considered fundamental for improving mobility and preventing falls [36].

In parallel to the improvement in functional evaluation, an important reduction in the frequency of falls was observed. Although the effect of exercise in the prevention of falls in the elderly is yet to be proved, some studies show that physical activity reduces the risk by 40% [37]. On the other hand, in a consensus on prevention of falls in the elderly, the only exercises recommended to prevent falls are those which specifically target balance training [38].

Many studies that show improvement in balance and mobility present similar characteristics in their exercises. This suggests that the content and intensity of the exercise program could be more important than other intervention

variables [39]. Moreover, differences in the administration of the exercise program, the professional experience of those who apply the exercises, the location in which the sessions are held and whether the exercise is conducted in group or realized individually, are all fundamental parameters which influence the success of the exercise program [39].

An important factor for the success of the exercise program is adherence. Contrary to the study by Forcan et al. [40], who stated that adherence to exercise in the elderly is weak, in the present study good adherence was observed, with more than half the patients present at all sessions. The current findings are similar to other studies which showed adherence up to 97.5% [17].

The success in adherence in the present study is probably due to the location where the exercises were performed (a pleasant, natural environment), to social interaction, and to the supervision of a physiotherapist. A secure environment, session supervision and the opportunity for social interaction reduce the feeling of isolation. A social support system is considered important in group activities, and helps sustain adherence and the effectiveness of the weekly exercise sessions and also the adherence to home-based exercises [35].

Similarly to our study, Robitaille et al. showed that an exercise program performed in groups improves the balance of the elderly in the community [41].

Another relevant factor was the use of a manual of instructions and illustrations for the realization of home-based exercises, which contributed to the continuity and adherence of the exercises performed. Each exercise was appropriately prescribed and illustrated by a physiotherapist, giving the patient adequate support. Descriptive and illustrated pamphlets have been used in some studies, complemented by a home-based exercise program, with positive results [3, 42].

The present positive results could also be related to the state of health of these patients, which was good in our patients. Buchner et al. [43] showed that exercise can have beneficial effects on health and on the risk of falls in certain subgroups of the elderly.

The physical and psychological benefits of the regularity of the sessions and the environment should never be ignored. Stimulating strategies and demonstrating ability in the transference from one exercise to another, consequently, maintaining enthusiasm during the exercises, can be practiced safely in groups [35].

Although our study did not use laboratory equipment [44] to substantiate the results obtained, we showed by reliable and reproducible scales and tests [26, 28, 29] that balance training performed once a week, supervised by a physiotherapist, and complemented by home-based exercises, is very effective in the improvement of functional and

static balance and mobility, and in the reduction of falls in elderly women with osteoporosis.

**Acknowledgements** Associação Atlética Acadêmica Oswaldo Cruz (AAAOC); Centro de Estudos em Reumatologia de São Paulo; CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior).

## References

- Kuczynski M, Ostrowska B (2006) Understanding falls in osteoporosis: the viscoelastic modeling perspective. *Gait Posture* 23:51–58
- Sinaki M, Brey RH, Hughes CA, Larson DR, Kaufman KR (2005) Balance disorder and increased risk of falls in osteoporosis and kyphosis: significance of kyphotic posture and muscle strength. *Osteoporos Int* 16:1004–1010
- Suzuki T, Kim H, Yoshida H, Ishizaki T (2004) Randomized controlled trial of exercise intervention for the prevention of falls in community-dwelling elderly Japanese women. *J Bone Miner Metab* 22:602–611
- Barraff LJ, Della PR, Williams N et al (1997) Practice guideline for the ED management of falls in community-dwelling elderly persons. *Ann Emerg Med* 30:480–492
- Ashley MJ, Gryfe CI, Amies A (1977) A longitudinal study of falls in an elderly population, II: some circumstances of falling. *Age Ageing* 6:211–220
- Silsupadol P, Siu KC, Shumway-Cook A, Woollacott MH (2006) Training balance under single and dual-task conditions in older adults with balance impairment. *Phys Ther* 86:269–281
- Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM (1999) Psychotropic medicine withdrawal and a home-based exercise program to prevent falls: a randomized controlled trial. *J Am Geriatr Soc* 47:850–853
- Overstall PW, Exton-Smith AN, Imms FJ, Johnson AL (1977) Falls in the elderly related postural imbalance. *Br Med J* 1:261–264
- Nelson RC, Amin MA (1990) Falls in elderly. *Emerg Med Clin North Am* 8:309–324
- Campbell AJ, Borrie MJ, Spears GF et al (1990) Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. *Age Ageing* 19:136–141
- Tinetti ME, Baker, DI, McAvay G et al (1994) A multifactorial intervention to reduce the risk of falling among elderly people living in the community. *N Engl J Med* 331:821–827
- Duncan PW, Studenski S, Chandler J, Prescott B (1992) Functional reach: predictive validity in a sample of elderly male veterans. *J Gerontol* 47:93–98
- Hindmarsh JJ, Estes EH Jr (1989) Falls in older persons. Causes and interventions. *Arch Intern Med* 149:2217–2222
- Horak FB, Shupert CL, Mirka A (1989) A components of dyscontrol in the elderly: A review. *Neurobiol Aging* 10:727–738
- Close JCT, Glucksman E (2000) Falls in elderly: What can be done? *Med J Aust* 173:176–177
- Steadman J, Donaldson N, Kalra L (2003) A randomized controlled trial of an enhanced balance training program to improve mobility and reduce falls in elderly patients. *J Am Geriatric Soc* 51:847–852
- Sihvonen S, Sipilä S, Taskinen S, Era P (2004) Fall incidence in frail older-women after individualized visual feedback-based balance training. *Gerontology* 50:411–416
- Nowalk MP, Prendergast JM, Bayles CM, D'amico FJ, Colvin GC (2001) A randomized trial of exercises programs among older individuals living in two long-term care facilities: The Falls-FREE Program. *J Am Geriatr Soc* 49:859–865
- Judge J, Whipple RH, Wolfson LI et al (1994) Effects of balance exercises on isokinetic strength in older persons. *J Am Geriatr Soc* 42:937–946
- Nitz JC, Choy NL (2004) The efficacy of a specific balance-strategy training programme for preventing falls among older people: a pilot randomised controlled trial. *Age Ageing* 33:52–58
- Seidler RD, Martin PE (1997) The effects of short term balance training on the postural control of older adults. *Gait Posture* 6:224–236
- Carter ND, Khan KM, Petit MA, Heinonen A, Waterman C, Donaldson MG, Janssen PA, Mallison A, Riddell L, Kruse K, Prior JC, Flicker L, McKay HA (2001) Results of a 10 week community based strength and balance training programme to reduce fall risk factors: a randomized controlled trial in 65–75 year old women with osteoporosis. *Br J Sports Med* 35:348–351
- WHO World Health Organization (1994) Assessment of osteoporotic fracture risk and its role in screening for menopausal osteoporosis; WHO Technical Report Series, Geneva
- Carter ND, Khan KM, McKay HA, Petit MA, Waterman C, Heinonen A et al (2002) Community-based exercise program reduces risk factors for falls in 65- to 75-year-old women with osteoporosis: randomized controlled trial. *CMAJ* 167:997–1004. Erratum in: *CMAJ* 2003 168:152
- American College of Sports Medicine (1995) Guidelines for Exercise Testing and Prescription, 5th Ed. Baltimore: Williams and Wilkins, pp. 1–373
- Miyamoto ST, Lombardi Junior I, Berg KO, Ramos LR, Natour J (2004) Brazilian version of the Berg balance scale. *Braz J Med Biol Res* 37:1411–1421
- Whitney SL, Poole JL, Cass SP (1998) A review of balance instruments for older adults. *Am J Occup Ther* 52:666–671
- Shumway-Cook A, Horak FB (1986) Assessing the influence of sensory interaction on balance, suggestion from the field. *Phys Ther* 66:1548–1550
- Podsiadlo D, Richardson S (1991) The Timed “Up & Go”: a test of basic functional mobility for frail elderly persons. *JAGS* 39:142–148
- Tinetti ME, Speechley M, Ginter SF (1988) Risk factors for falls among elderly persons living in the community. *N Engl J Med* 319:1701–1707
- Van Norman KA (1995) Exercise programming for older adults. *Human Kinetics, Champaign, IL, USA*, pp 41–66
- Melzer I, Benjuya N, Kaplanski J (2005) Effect of physical training on postural control of elderly. *Harefuah* 114:839–844
- Rogers ME, Fernandez JE, Bohlken RM (2001) Training to reduce postural sway and increase functional reach in the elderly. *J Occup Rehabil* 11:291–298
- Chang JT, Morton SC, Rubenstein LZ, Mojica WA, Maglione M, Suttrop MJ, Roth EA, Shekelle PG (2004) Interventions for the prevention of falls in older adults: systematic review and meta-analysis of randomised clinical trials. *BMJ* 328:680–683
- Skelton DA (2001) Effects of physical activity on postural stability *Age Ageing* 30:33–39
- Frank JS, Patla AE (2003) Balance and mobility challenges in older adults: Implications for preserving community mobility. *Am J Prev Med* 25:157–163
- Barnett A, Smith B, Lord SR, Williams M, Baumand A (2003) Community-based group exercise improves balance and reduces falls in at-risk older people: a randomised controlled trial. *Age Ageing* 32:407–414
- Feder G, Cryer C, Donovan S (1998) Guidelines for the prevention of falls in older people. Queen Mary and Westfield College, London
- Means KM, Rodell DE, O’Sullivan PS (2005) Balance, mobility, and falls among community-dwelling elderly persons: effects of a rehabilitation exercise program. *Am J Phys Med Rehabil* 84:238–250

40. Forcan R, Pumper B, Smyth N, Wirkkala H, Ciol MA, Shumway-Cook A (2006) Exercise adherence following physical therapy intervention in older adults with impaired balance. *Phys Ther* 86:401–410
41. Robitaille Y, Laforest S, Fournier M, Gauvin L, Parisien M, Corriveau H, Trickey F, Damestoy N (2005) Moving forward in fall prevention: an intervention to improve balance among older adults in real-world settings. *Am J Public Health* 95:2049–2056
42. King MB, Whipple RH, Gruman CA, Judge JO (2002) The performance enhancement project: improving physical performance in older persons. *Arch Phys Med Rehabil* 83:1060–1069
43. Buchner DM, Cress ME, de Lateur BJ, Esselman PC, Margherita AJ, Price R, Wagner EH (1997) The effect of strength and endurance training of gait, balance, fall risk, and health services use in community-living older adults. *J Gerontol A Biol Sci Med Sci* 52:218–224
44. Sinaki M, Brey RH, Hughes CA, Larson DR, Kaufman KR (2005) Significant reduction in risk of falls and back pain in osteoporotic-kyphotic women through a spinal proprioceptive extension exercise dynamic (SPEED) program. *Mayo Clinic Proceedings* 80:849–855