We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

Chapter 10

The Effectiveness of Progressive Load Training Associated to the Proprioceptive Training for Prevention of Falls in Women with Osteoporosis

Lucas Teixeira, Stella Peccin, Kelson Silva,
Tiago Teixeira, Aline Mizusaki Imoto,
Joelma Magalhães and Virgínia Trevisani

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/54554

1. Introduction

In most of the cases, osteoporosis is a related condition to aging. It can be seen in both genders, but it especially manifests in women after menopause due to estrogen production rate fall.

For understanding what happens, it is necessary to bear in mind that the bones are compounded of a matrix in which mineral complexes such as calcium are laid up. Another important feature is that they are in constant renewal process, since they are formed by cells called osteoclasts which are responsible for reabsorbing the aged areas and others, the osteoblasts, which is responsible for producing new bones. This permanent and constant process makes possible the bone reconstitution when fractures happen and it explains why around every ten years the human skeleton is entirely renewed. Along the time, however, the old cells absorption increases and the bone new cells formation decreases. The outcome is that the bones become more porous, losing resistance. Bone mass lighter loss features osteopenia. Greater losses are in the osteoporosis area.

If it is not early prevented, or if it is not treated, the bone mass loss is progressively increasing, in an asymptomatic fashion, without any manifestation, until a fracture occurrence. What features the osteoporotic fractures, is when they take place with a minimum trauma, what would not cause fractures in a normal bone. Therefore, they are also called fragility fractures.

The incidence of osteoporotic fractures is strictly related to the individual bone mass that depends on the speed of loss throughout life as well as the amount of bone tissue in the end of puberty and beginning of adulthood. The great variation in bone mass peak is explained not only by hereditary factors but also by gender, race, eating habits, several hormone influence, body composition of lean mass and body fat, intercurrent diseases, chronic use of medications and physical activity (Brandão & Vieira, 1999).

Like any other chronic disease, the ethiology of osteoporosis is multifactorial. Genetic factors contribute approximately with 46% to 62% of bone mineral density (BMD) whereas other causes include lifestyle, diet and physical exercise (Neto et al., 2002).

Osteoporosis clinical symptoms do not usually occur before a fracture occurrence. Osteoporosis is considered an asymptomatic disease. Indeed, during the disease progression, the bones become progressively more fragile without affecting the individuals. This characteristic of being a silent disease exposes the population to even a greater risk of suffering a fracture.

Osteoporosis is considered a "silent disease" until a fracture occurs. Approximately 1.5 million fractures per year are attributable to this disease. Only in the USA, these fractures result in 500.000 hospitalizations, 800.000 emergency room visits, 2.6 million physician visits. The treatment cost is high. In 2002, 12 billion dollars to 18 billion dollars were spent (Gass & Huges, 2006). In 1998, cost management of osteoporosis fractures in the UK recorded 942 million pounds per year (Szejnfeld et al., 2007). Osteoporosis has become one of the major public health problems. Nowadays, the impact of osteoporosis is compared to the impact caused by most important health problems, such as cardiovascular diseases and cancer (Froes et al., 2002).

It exposes the fallers to a high risk of fractures (Johnell et al., 2005; Siris et al., 2006). The first hip fracture is associated to 2.5-fold increased risk of subsequent fracture (Cólon-Emeric et al., 2003) with a high level of morbidity and mortality (Cathleen et al., 2006).

It is believed that about 25% of menopausal women in the USA will exhibit some kind of fracture as a consequence of osteoporosis. The most severe fractures are the fractures of femur and they are associated with higher medical expenses than all other osteoporotic fractures together (Moreira & Xaxier, 2001). The incidence of these fractures has doubled in the last 25 years and it is estimated that six million people in the world will suffer fracture of the proximal femur in 2050. Fractures resulted from the decrease of bone mineral loss are considered an orthopedic epidemic leading to an increase in costs for several countries and consequently representing a big social and economic problem (Ramalho et al., 2001).

There have been a significant number of evidences showing that the decrease in bone quality, from generation to generation, is caused by a change in life style, having as a main determinant the lack of physical activity. This evidence varies with the biology of the basic bone. However, epidemiological studies indicate that physical activity is the most important factor to maintain bone mass and prevent fractures (Mosekilde, 1995).

Almost all hip fractures (more than 90%) occur as a result of a fall and these fractures are related not only to the decreased bone mass, but also to other factors such as reduction of balance, muscle strength and power in the lower extremities (American College of Sports Medicine [ACSM], 1995; Parkkari et al. 1999). Therefore, aging and alterations in balance and muscle strength, as well as sensorial changes, predispose patients with osteoporosis to a higher risk of having fractures due to falls.

http://dx.doi.org/10.5772/54554

Falls are multifactorial (Cathleen et al., 2006), (Tinetti et al., 1989) and their intrinsic causes include altered balance, gait, muscle strength, visual acuity, cognition and the presence of chronic diseases (van Schoor et al., 2002).

The participation of environmental risk factors might reach up to 50% of the falls in elderly that live in the community. These factors include poor lighting, slippery surfaces, loose or folded rugs, high or narrow stairs, obstacles in the way (low furniture, small objects, wires), lack of rails in halls and bathrooms, extremely low or high shelves, inadequate shoes and clothes, poorly maintained streets with holes or irregularities and inappropriate orthosis.

A reduction of approximately 30% in the strength is found in individual ages ranging from 50 to 70. These changes are more common in women than in men, more prevalent in lower limbs than in upper limbs and a great amount of this reduction in strength is caused by a selective atrophy of Type IIB fibers (American College of Sports Medicine Position, 1998).

Evidences have shown that specific exercises might reduce the risk factors for falls and the number of falls in the elderly.

The purpose of our study was to evaluate the efficacy of the resistance training associated to a proprioceptive training in the prevention of falls and reduction of the respective risk factors in postmenopausal women with osteoporosis.

2. Physical exercise to prevent falls

Prevention in individuals older than 60 years has an important role in avoiding adverse consequences resulting from falls (Weatherall, 2004).

The work to prevent fractures related to osteoporosis should focus the prevention or increase of material and structural properties of the bone, the prevention of falls and improvement of total mass of lean tissue (American College of Sports Medicine, 1995).

The American College of Sports Medicine recommends that:

1. physical activity of transporting weight is essential to the normal development and maintenance of a health skeleton. Activities that focus the increase of muscle strength might also be beneficial, particularly for bones that do not support weight;
2. a sedentary woman might progressively increase her bone mass by becoming active, but the primary benefit of increasing the activity is to prevent a future bone reduction that resulting from the lack of activity;
3. exercise should not be recommended as a replacement to medications treatment;
4. the optimal program for an older woman might include activities that improve the strength, flexibility and coordination which might indirectly, but effectively decrease the incidence of osteoporotic fractures by reducing the probability of falls. Therefore, the treatment of osteoporosis should aim the prevention of falls and fractures and preservation or improvement of bone mineral density.

2.1. Exercises for postural control

Postural control is a result of the combination of several types of sensorial information, such as visual, vestibular and somatosensorial information, and passive and active properties of the nervous system and skeletomuscle system that composes the human postural control system (Figure 2), (Shumway-Cook et al., 2000).

The postural control system use three functions that are required to maintain balance: support, stabilization and balance. The body should contract the adequate muscles to sustain the body against gravity; the articular segments should be stabilized and the body should be stabilized in the body's support base (Rothwell, 1994). This way the treatment program which aims at falls prevention should contain strength and resistance increasing components for promoting the articular coaptation and to face the gravity, it also should prevent the posture reorganization aligning the body gravity center.

Currently, proprioception is defined as a set of afferent information provided by joints, muscles, tendons and other tissues that reaches the Central Nervous System (CNS) where it is processed, having an influence on reflex responses and voluntary motor control. Proprioception contributes to postural control, joint stability and several conscious sensations (Lephart & Fu, 2000).

Therefore the sensorial-motor training becomes indispensable for an appropriate falls prevention program, since it potentializes the propriocetive information captation and transmission providing to SNC information regarding the contraction speed, movement speed, articular position and angle, which are fundamental for a good motor control.

It is extremely important to understand that proprioception is only limited to the acquisition of the mechanical stimulus and its transduction in neural stimuli, not having any influence on the CNS processing and its motor response (Lephart & Fu, 2000).

Proprioception is part of a system denominated somatosensorial system. This includes all mechanical information provided by the mechanoreceptors. The feeling of pain is provided by the nociceptors and the thermal information provided by thermoreceptors (Guyton & Hall, 2006).

All propriocetive information are originated at the muscular and tendon receptors called muscular fusion and Golgi tendon organ and receptors located in ligaments, articular capsule, meniscus and cutaneous tissues (Guyton & Hall, 2006).

Four elements should be focused to reestablish the sensorimotor deficits: proprioception, stabilization, reactive neuromuscular control and functional motor patterns (Lephart & Henry, 1995).

The proprioceptive mechanism comprises both conscious and unconscious pathways. Therefore, the prescribed exercises need to include conscious exercises to stimulate the cognition as well as sudden and unexpected alterations of joint position that initiate reflex muscle contraction. These exercises should involve balance in an unstable surface while the individual perform functional activities. The purpose of the dynamic stabilization training is to improve the co-activation between the antagonist muscles (Hurd et al., 2006)

http://dx.doi.org/10.5772/54554

Exercises to stimulate proprioception and dynamic stabilization should be performed in closed-chain activities and with small movements, since the compression stimulates the articular receptors and the changes in the curve length-tension stimulate the muscle receptors. Limbs repositioning exercises should also be performed to stimulate the sense of joint position and neuromuscular control (Lephart & Henry, 1995).

The improvement of dynamic stiffness is another important aspect. It is suggested that muscle receptors increase its sensitivity through the increase of dynamic stiffness (Adler et al., 2008).

Exercises that involve eccentric training, like going down the stairs and landing after jumps, are the most efficient to increase anticipatory and reactive muscular stiffness (Bastian et al., 2006).

The reactive neuromuscular control is reached through exercises that create unexpected situations, such as perturbations in unstable surfaces in unipodal support and during gait. Apparently, this kind of training improves the preparatory and reactive muscle activation (Swanik et al., 2002).

The training protocol might include:

1. 5 – 10 minutes of warm-up, with stretching movements for upper and lower limbs, 03 repetitions for each movement being kept for 30 seconds, with 30-second intervals among the series. After stretching, movements of fast gait as previous warm-up were performed and in the end of the session, slow gait movements and stretching.

2. Proprioceptive exercises followed an evolution sequence based on the use of stable surfaces to unstable, walking straight forward progressing to changes in direction, from gait with no obstacles to gait with obstacles, alteration in the support base (from open to closed), exercises with eyes open to closed eyes, always respecting the functional capacity of each patient and progressively increasing the difficulty of each exercise. To aid the training, cones, balance boards, sticks, mats and trampolines were used. According to the patient's evolution, the exercises were combined creating the circuits.

2.2. Stretching

Stretching should be performed during the warm up and in the last phase. A great joint range of motion (ROM) increases the muscle, reduces the risk of lesion and increases the cartilage nutrition. Painful joints should not be stretched excessively to a point that will result in more pain; all movements should be made in order to get the maximum pain-free ROM. The use of heat before stretching reduces pain and increases the range. At least three sessions of stretching might be performed a week. In the beginning, three to five repetitions and a gradual increase up to 10 repetitions is the ideal. The muscle should be stretched during 10 to 30 seconds.

2.3. Muscle strengthening

Muscle strengthening should be acquired with weights or elastic bands which will give endurance to the movement. The training protocols should include the following principles:

- muscle contraction exercises should be made in a moderate speed;
- exercises should be chosen according to joint stability and degree of pain and edema;
- muscles should not be exercised to fatigue;
- exercise endurance should be submaximal;
- inflamed articular joints should be strengthen with isometric exercises and at first it should include few repetitions;
- pain or edema in a joint after an hour of exercise indicates excessive activity.

Isometric exercises are indicated for unstable or swollen joints. On the other hand, isometric contractions result in a low articular pressure and are well tolerated by older patients. It should start with contractions with an intensity of approximately 30% of maximal strength, slowly increasing to 80%. The contraction should not be kept for more than 6-10 seconds and the repetitions should be increased from 8 to 10, if tolerated by the patient. It should be performed twice a day during the inflammatory period and after the inflammation is over, it should be increased from 5 to 10 times a day.

Isotonic exercises should include from 8 to 10 exercises involving the major muscle groups (four exercises for the upper limbs and from four to six for the lower limbs). At first, patients should use weights with 40% of the individual's maximal load, increasing up to 80%. Generally, a series of four to six repetitions should be made, avoiding the muscle fatigue. At first, the frequency should be at most twice a week but in case of individuals with advanced age or significant fragility the exercises should be made only once a week. Between the sessions, there might be at least one full day of rest.

Changes in strength after resistance exercise training RET are assessed using a variety of methods, including isometric, isokinetic, one-repetition maximum (1-RM), and multiplerepetition (e.g., 3-RM) maximum-effort protocols. In general, strength increases after RET in older adults seem to be greater with measures of 1-RM or 3-RM performance compared with isometric or isokinetic measures. Older adults can substantially increase their strength after RET—with reported increases ranging from less than 25% to greater than 100% (American College of Sports Medicine, 2009).

3. Material and methods

The present research was approved by the Research Ethics Committee of the Federal University of São Paulo. The clinical trial was registered in the Australian New Zealand Clinical Trials Registry (ANZCTR).

Among the 758 bone densitometries tests made in the Image Diagnosis Service at the Ambulatório de Especialidades de Interlagos, São Paulo - Brazil, 284 were found positive for Osteoporosis, where 162 of these densitometries tests were from patients which ages were within the age group proposed by the present research and 80 of them were included in the study, since they met the required inclusion criteria (Fig. 1).

Patients were from 65 to 75 years old and only individuals with a postmenopausal osteoporosis, according to the OMS, with a bone mineral density (BMD) T-score of −2.5 standard deviation (SD), in the lumbar spine, femoral neck or total femur region (Lewiecki et al., 2004) were included.

The following women were excluded: those with secondary osteoporosis, visual deficiency with no possibilities of previous corrections; severe auditive deficiency; with vestibular alteration of important clinical status; as well as women who used assisted walking devices (orthesis or prosthesis); those who planned to be out of town for two consecutive weeks during the 18-week study and also women who presented absolute contraindications for physical exercise, according to the American College of Sports Medicine.

All patients selected according to the inclusion and exclusion criteria signed an informed consent (IC). The randomization was performed by a technical assistant not involved in the research using a computer program and the sequential numbers were kept in opaque, not translucent and sealed envelope being given to one of the two groups based on the Consort recommendations.

The volunteers were included in two groups: the first group (G1) comprised 40 patients who underwent 18-week proprioceptive and progressive muscular strength training associated to a drug treatment of Osteoporosis; and the second called G2 also included 40 patients that only underwent a conventional drug treatment.

3.1. Evaluation

The registration of patients was made during the medical evaluation in order to include or exclude the individuals in the research and their personal and clinical data were also registered.

All patients were evaluated by a physical therapist who was blinded to the group to which the patient belonged. The quality of life, functional skills and the risk and number of falls were evaluated.

The quality of life was evaluated using the Short Form Health Survey (SF-36), a questionnaire displayed in a scale from 0 to 100, where 0 means the worst quality of life and 100 points corresponds to the best quality of life, according to what is proposed by the survey (Ciconelli et al., 1999).

The Berg Balance Scale, a test where the maximum score that can be achieved is 56 and where each item has an ordinal scale of five alternatives which varied from 0 to 4 points, was used to evaluate the balance (Berg et al., 1996), Miyamoto et al., 2004).

The functional mobility was evaluated by the Timed "Up & Go" Test which measures the time an individual takes to get up of a chair, walks to a line on the floor 3 meters away as fast and safe as possible, turn around, walk back to the chair and sits down again allowing the buttocks and lumbar region to touch the seat surface (Podsiadlo et al., 1991, Shumway-Cook et al., 1997). The TUG was performed along with other balance and functional mobility tests (Bohannon et al., 2006) since it is a sensitive and specific measurement of the fall probability among elderly adults (Large et al., 2006, Kristensen et al., 2007).

The dynamic strength of the quadriceps muscle was evaluated by the One Repetition Maximum (1 RM) Test that measures the maximum weight a subject can lift with one repetition when making a standard weight lifting exercise. Three attempts were made to reach the plateau in the 1-RM score with 3-minute intervals between each attempt (Weier 1997, Hortobagyi et al., 1998).

The number of falls was evaluated by monitoring the immediate report of falls from patients of both groups during 24 weeks. The patients were also questioned if they experienced falls six months preceding the study.

3.2. Treatment protocol of Teixeira & Silva et al., 2010

The protocol consisted of a routine where: 1) the patients participated in a 5-10 minutes warm-up in a treadmill, static stretching exercises (global and segmentary) for the upper and lower limbs, lumbar, cervical and thoracic region with 3 repetitions for each muscle or muscular group, maintaining the stretching for 30 seconds between the 2 series of exercises. 2) The functional exercises (proprioception and balance) were performed in a routine that follows a progressive order beginning with stable surface and changing to unstable surfaces, gait training without obstacles and then performance of gait training with obstacles, exercises first with eyes opened and then eyes closed, first low speed exercises and according to the patient performance high speed exercises, bipedal training and then unipedal, also using resources such as balance, trampoline and proprioceptive boards always using the same progressive order (table 1). 3) Strengthening exercises included leg extensions with a load up to 80% of 1-RM, following a protocol of two weeks of adjustment wearing 1 to 2 kilos ankle weight, progressing for 50%, 60%, 70% up to 80% of 1-RM (American College of Sports Medicine, 2002).

Examples of exercises: ten repetitions with one-minute intervals for antero-posterior and latero-lateral gait; gait with obstacles (20 cm high); gait over mattress; going up and down the stairs; change in direction according to the sound stimulus; balance exercises lasting 30 seconds and with one-minute interval for unipodal and bipodal support on the floor with eyes open and/or closed; change in floor for a more unstable surface such as a trampoline and balance board; exercises with dissociation of waist and use of a stick (Table 1).

3.3. Data analysis

After evaluating 758 patients, 80 were randomized and only 65 concluded the study, being 33 patients from G1 and 32 from G2. Three patients included in the G1 group did not complete the study because they did not have appropriate means of transportation, two others due to financial conditions, another one moved to a different city and the last one abandoned the study due to personal reasons. Two patients from G2 group did not complete the study for personal reasons, three started exercising regularly in another place, one quit due to illness of a family member and two others because we could not contact them by phone in order to

http://dx.doi.org/10.5772/54554

schedule their re-evaluations, as illustrated in the chart based on the Consort recommendations (Moher et al., 2001) (Fig. 1).

Options of Exercises	Evolution of Exercises	Time or # of repetitions
Balance exercises (balance board, mini-trampoline. Dyna disc)	Eyes open or closed / stable or unstable	10 rep / 30s
Stability exercises	Unipodal or bipodal support / open or close base	10 rep / 30s
Anteroposterior and latero-lateral gait	With or without obstacle and Variation in speed	10 rep (3 m)
Mat exercises	Go up/down: 1 to 3 mats	10 rep / 3 series
Exercises on the stairs	Variation in speed	10 rep / 3 series
Exercises with sticks	With or without arm movements	10 rep / 3 series

Table 1. Examples of exercises

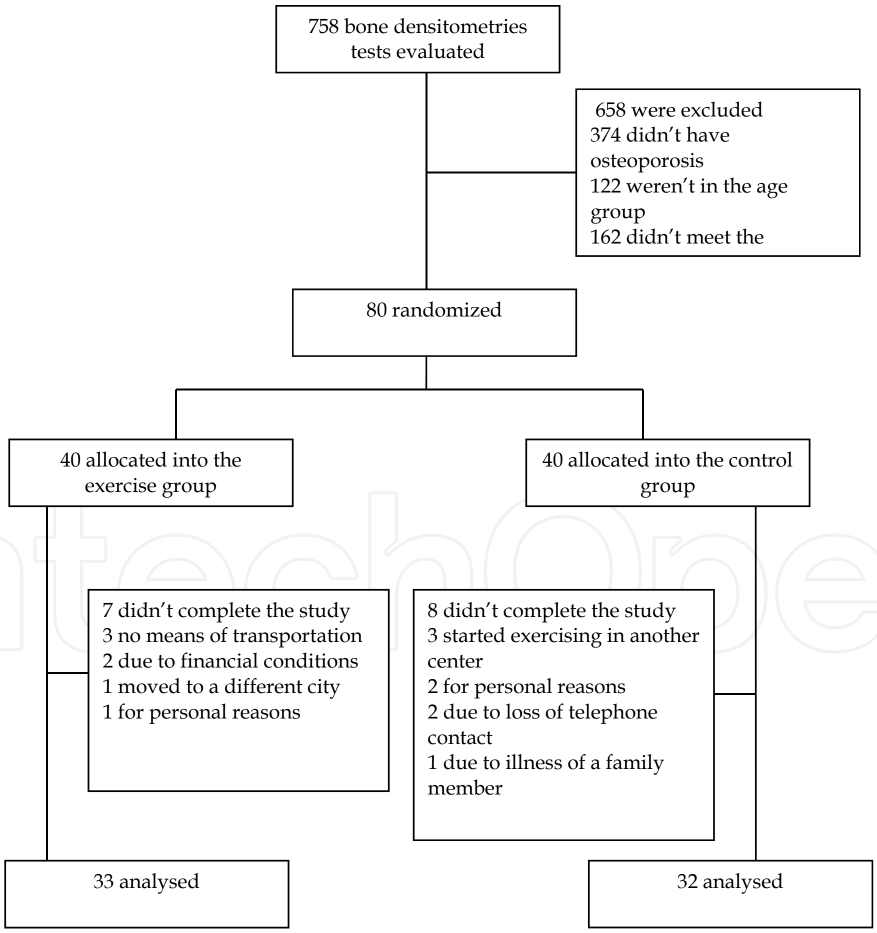

Figure 1. Organizational chart (based on Consort recommendations) including the inclusion and exclusion analysis, randomization, group allocation, losses and patients who concluded the study.

3.4. Statistical analysis

In order to verify the presumed normality in the data distribution, the Shapiro-Wilk test was used, as well as the Q-Q plot. Since the studied variable distribution could not be rounded up by the normal distribution the median and quartile 1 and 3 were calculated to describe the variables in the study.

The chi-square test was employed to evaluate the epidemiological data in the baseline.

The significance of the influence of the time the treatment was performed (pre and post-intervention) and influence of the groups (control and experimental) was evaluated by using the nonparametric hypothesis test (Robertson et al., 2005).

The statistical significance was set at $P \leq 0.05$. All the statistical process was performed with the statistical language R (version, 2.6.2; R Foundation for Statistical Computing, Vienna, Austria).

3.5. Results

The basal characteristics of the patients of both groups were similar in relation to age, bone mineral density, history of fractures, osteoporosis treatment, use of diuretics, hypnotics, and antidepressants, other rheumatic diseases and number of individuals that fell 6 months prior to the study.

According to data described in Table 2, it is possible to conclude that the scores for SF-36 in the intervention group were better in all eight sub-scales after the rehabilitation period compared to the admission time, as well as the control group. These changes were statistically ($p \leq 0.007$) and clinically significant (a change of at least 13.5 points in each sub-scale of the SF-36) for all sub-scales.

According to what was described in Table 3, there was a significant difference in the results of the Timed Up & Go Test in the pre and post- training ($p < 0.001$) for the experimental group. Furthermore, the post-training values for the experimental group were significantly greater than the ones shown by the control group ($p < 0.001$). In terms of maximum dynamic load, a significant increase between pre and post-training in the experimental group ($p < 0.001$) was observed. Besides that, the post-training values in the experimental group were significantly greater than the ones of the control group ($p < 0.001$).

Variables such as physical activity, rotational component and decreased base showed a significant increase when compared to the admission data and the control group ($p \leq 0.003$). The general score of the Berg Scale (TABLE 4) showed a significant increase in the experimental group ($p < 0.001$), where the post-training values were significantly greater in the experimental group compared to the control ($p < 0.001$). No significant differences were found in the items Transference and Static Tests. Although the changes in numbers are not huge they are consistent. A lot of people in the experimental group showed increased scores; therefore the possibility of a small score may not be great. No statistical reduction in the number of falls per patient was observed.

Variables	Moment	Control (N=32)	Intervention (N=33)	$\Delta_{\text{(intervention-control)}}$	p-value
Functional skills	t0	54,4(26,42)	63,95(22,56)	—	—
	t18	50,6(29,45)	82,44(17,3)	25,11[17,7;32,52]	< 0.0001
Physical aspects	t0	44,05(33,95)	36,05(34,63)	—	—
	t18	43,57(37,42)	92,44(17,71)	51,62[39,97;63,28]	< 0.0001
Pain	t0	38,88(20,63)	38,21(19,94)	—	—
	t18	44,93(21,51)	65,58(23,2)	20,98[12,29;29,68]	< 0.0001
General Health Status	t0	52(22,38)	51,09(17,72)	—	—
	t18	55,88(23,81)	73,67(17,54)	18,38[11,29;25,47]	< 0.0001
Vitality	t0	50,71(22,4)	58,26(20,26)	—	—
	t18	54,05(23,51)	74,88(15,49)	16,55[9,61;23,48]	< 0.0001
Social aspects	t0	63,62(29,4)	69,4(26,69)	—	—
	t18	68,05(28,51)	93,12(13,68)	23,06[14,32;31,81]	< 0.0001
Emotional aspects	t0	52,4(44,29)	55,79(40,38)	—	—
	t18	61,12(44,15)	85,28(28,49)	22,7[8,69;36,7]	< 0.0018
Mental health	t0	48,29(21,08)	64,3(20,52)	—	—
	t18	52,86(21,05)	78,84(17,41)	15,26[9,03;21,48]	< 0.0001

The data were expressed as the mean (standard deviation) or average [95% confidence interval].

Table 2. Pre and post-training values for SF-36 scores

Variables	Moment	Control (N=32)	Intervention (N=33)	$\Delta_{\text{(intervention-control)}}$	p-value
Maximum load (kg)	t0	7.6(2.27)	8.02(1.81)	—	—
Maximum load (kg)	t18	8.1(2.81)	14.81(3.14)	3.65[2.74;4.57]	< 0.0001
Time up and go (s)	t0	11.35(2.88)	10.74(2.23)	—	—
Time up and go (s)	t18	11.15(2.55)	6.9(1.11)	-3.96[-4.63;-3.29]	< 0.0001

The data were expressed as the mean (standard deviation) or average [95% confidence interval].

Table 3. Pre and Post-Training Values for the Time Up and Go Test (s), maximum load (Kg) and Berg Balance Scale (scores).

Variables	Moment	Control (N=32)	Intervention (N=33)	$\Delta_{(intervention\text{-}control)}$	p-value
Decreased base	t0	9.98(2.31)	10.05(1.4)	—	—
	t18	9.67(2.2)	11.28(1.44)	1.56[1.04;2.08]	< 0.0001
Static Tests	t0	11.88(0.33)	11.95(0.21)	—	—
	t18	11.71(0.99)	12(0)	0.19[-0.07;0.45]	0.1537
Rotational component	t0	11.21(1.14)	11.37(1.75)	—	—
	t18	11.17(099)	11.91(0.37)	0.7[0.43;0.97]	< 0.0001
Transference	t0	11.24(1.16)	11.53(1.05)	—	—
	t18	11.26(1.21)	11.81(0.93)	0.35[0.01;0.69]	0.0533
General score	t0	51.71(4.1)	52.07(3.63)	—	—
	t18	51.26(4.66)	55.12(1.73)	3.58[2.75;4.42]	< 0.0001

The data were expressed as the mean (standard deviation) or average [95% confidence interval].

Table 4. Table 4. Pre and Post-Training Values for the Berg Balance Scale (scores).

Based on the positive results of the protocol used for the physical status, an expressive reduction in the number of total falls (Figure 2) was observed. We could also observe a significant reduction between the pre and post-training in the experimental group ($p < 0.001$).

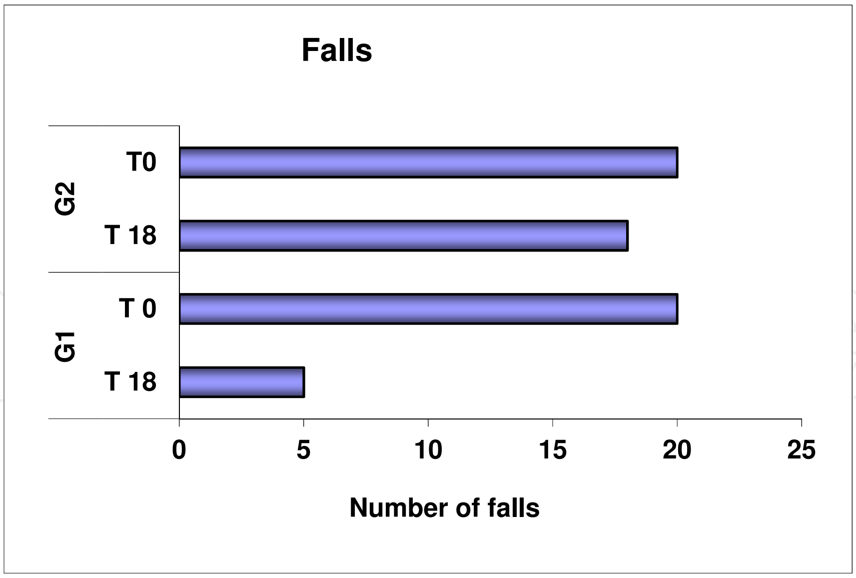

Figure 2. Number of falls 24 weeks preceding the treatment (Before) and 24 weeks after the treatment (After), in the Intervention (G1) and Control Groups (G2)

Besides that, the post-training values in the experimental group were significantly lower than the ones shown by the control group ($p < 0.001$), confirmed by the odds ratio (TABLE 5).

	Control (n=32)	Intervention (n=33)
T0	0,5625 ($^{18}/_{32}$)	0,6060 ($^{20}/_{33}$)
T18	0,6250 ($^{20}/_{32}$)	0,1515 ($^{5}/_{33}$)
Razão $^{T18}/_{T0}$	1,111	0,25
The data were expressed as ratio and odds ratio.		

Table 5. Comparison of odds ratio falling between the control and intervention groups.

4. Discussion

Evidences have shown that specific exercises might reduce the risk factors for falls and number of falls in older people (Table 6, 7).

Muscle Strength Training and Balance Training			
Autor	**Objective**	**Desing**	**Results**
Carter, et al, 2002	Exercise programs improve balance, strength and agility in elderly people and thus may prevent falls. However, specific exercise programs that might be widely used in the community and that might be "prescribed" by physicians, especially for patients with osteoporosis, have not been evaluated. We conducted a randomized controlled trial of such a program designed specifically for women with osteoporosis.	We identified women 65 to 75 years of age in whom osteoporosis had been diagnosed by dual-energy X-ray absorptiometry in our hospital between 1996 and 2000 and who were not engaged in regular weekly programs of moderate or hard exercise. Women who agreed to participate were randomly assigned to participate in a twice-weekly exercise class or to not participate in the class. We measured baseline data and, 20 weeks later, changes in static balance (by dynamic posturography), dynamic balance (by a timed figure-eight run) and knee extension strength (by dynamometry).	Of 93 women who began the trial, 80 completed it. Before adjustment for covariates, the intervention group tended to have greater, although nonsignificant, improvements in static balance (mean difference 4.8%, 95% confidence interval [CI] –1.3% to 11.0%), dynamic balance (mean difference 3.3%, 95% CI –1.7% to 8.4%) and knee extension strength (mean difference 7.8%, 95% CI – 5.4% to 21.0%).
Madureira et al; 2007	The purpose of this study was to investigate the effect of a 12-month Balance Training	Sixty-six consecutive elderly women were selected from the Osteometabolic Disease	Sixty women completed the study and were analyzed. The BBS difference was significant

Muscle Strength Training and Balance Training			
Autor	**Objective**	**Desing**	**Results**
	Program on balance, mobility and falling frequency in women with osteoporosis	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.	higher in the Intervention group compared to Control (5.5±5.67 vs differences between the TUGT were reduced in the Intervention group compared to Control (–3.65±3.61 vs 2.27±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 ± 1.76 vs 0.33 ± 0.96, p=0.018).
Chyu, et al, 2010	To evaluate the effects of tai chi exercise on risk factors for falls in postmenopausal women with osteopaenia through measurements of balance, gait, physical function and quality of life.	Sixty-one independently living elderly females aged 65 years and older with low bone. Subjects were recruited and randomly assigned to 24 weeks of tai chi (60 minutes/session, three sessions/week, n = 30) or a control group (n = 31). Computerized dynamic posturography, gait, 'timed up and go', five-chair sit-to-stand and quality of life assessed at baseline, 12 and 24 weeks.	After 24 weeks, subjects in the tai chi group demonstrated an increase in stride width (P = 0.05) and improvement in general health (P = 0.008), vitality (P = 0.02) and bodily pain (P = 0.03) compared with those in the control group.

Table 6. Studies that used different methods of muscle strength training and balance training

Muscle Strength Training and Balance Training			
Autor	**Objective**	**Desing**	**Results**
Smulders E et al; 2010	To evaluate the efficacy of the Nijmegen Falls Prevention Program (NFPP) for persons with osteoporosis and a fall	Persons with osteoporosis and a fall history (N=96; mean ± SD age, 71.0±4.7y; 90 women). Randomized in two groups. Primary outcome	The fall rate in the exercise group was 39% lower than for the control group (.72 vs 1.18 falls/person-year; risk ratio, .

Muscle Strength Training and Balance Training			
Autor	**Objective**	**Desing**	**Results**
	history in a randomized controlled trial.	measure was fall rate, measured by using monthly fall calendars for 1 year. Secondary outcomes were balance confidence (Activity-specific Balance Confidence Scale), quality of life (QOL), and activity level (LASA), assessed posttreatment subsequent to the program and after 1 year of follow-up.	61; 95% confidence interval, .40-.94). Balance confidence in the exercise group increased by 13.9% (P=.001). No group differences were observed in QOL and activity levels.
Burke TN et al; 2010	To assess the efficacy of an exercise program aiming to improve balance and muscular strength, for postural control and muscular strength of women with osteoporosis.	Sample consisted of 33 women with osteoporosis, randomized into one of two groups: intervention group, in which exercises for balance and improvement of muscular strength of the inferior members were performed for 8 wks (n = 17, age 72.8 +/- 3.6 yrs); control group, which was women not practicing exercises (n = 16, age 74.4 +/- 3.7 yrs).At baseline and after 8 wks of treatment, postural control was assessed using a force plate (Balance Master, Neurocom), and muscular strength during ankle dorsiflexion, knee extension, and flexion was assessed by dynamometry.	When compared with the control group, individuals in the intervention group significantly improved the center of pressure velocity ($P = 0.02$) in the modified clinical test of sensory interaction for balance test, center of pressure velocity ($P < 0.01$), and directional control ($P < 0.01$) in limits of stability test, isometric force during ankle dorsiflexion ($P = 0.01$), knee extension ($P < 0.01$), and knee flexion ($P < 0.01$).
Teixeira, et al, 2010	To evaluate the effect of a progressive muscular strength and proprioception training program on the muscle strength of the quadriceps, balance, quality of life and reduction in the risk of falls in postmenopausal women with osteoporosis.	One hundred sedentary postmenopausal women with osteoporosis, ages ranging from 55 to 75, were randomized into two groups: the intervention group comprised of 50 patients who underwent a 18-week of progressive load training for the quadriceps and proprioception training and the control group that included 50 patients of osteoporosis. The muscular strength, balance, functional	Eighty-five patients concluded the research. The program promoted a significant difference among the groups for SF-36 in the eight sub-scales ($p \leq 0.007$), Timed Up & Go Test ($p < 0.001$), 1-RM test ($p < 0.001$), Berg Balance Scale ($p < 0.001$) and also a decrease in the total number of falls in the intervention group compared to control ($p < 0.001$).

Muscle Strength Training and Balance Training			
Autor	Objective	Desing	Results
		mobility, quality of life were evaluated in the beginning and end of the research. The number of falls was evaluated 24 weeks post treatment.	
Wayne, et al, 2012	Tai Chi (TC) is a mind-body exercise that shows potential as an effective and safe intervention for preventing fall-related fractures in the elderly.	In a pragmatic randomized trial, 86 post-menopausal osteopenic women, aged 45-70, were recruited. Primary outcomes were changes between baseline and nine months of bone mineral density (BMD) of the proximal femur and lumbar spine (dual-energy X-ray absorptiometry) and serum markers of bone resorption and formation. Secondary outcomes included quality of life.	Changes in sway parameters were significantly improved by TC vs. UC (average sway velocity, $P = 0.027$; anterior-posterior sway range, $P = 0.014$). Clinical measures of balance and function showed non-significant trends in favor of TC.

Table 7. Studies that used different methods of muscle strength training and balance training

Because of the strong interaction between osteoporosis and falls, the selection of participants in protocols for the prevention of fractures should be based on factors related to bones and falls (Pfeifer et al., 2004).

The German Society of Sport Medicine and the American College of Sport Medicine also recommend that the ideal program for women with osteoporosis should include activities that improve strength, flexibility and coordination that might indirectly and more effectively decrease the incidence of osteoporotic fractures by the reduction in the probability of falls (Lange et al., 2005).

Few studies take into consideration the importance of the proprioceptive training as a fundamental and unseparable part of a muscular strengthening program. Mechanoreceptors located in the joints, tendons, muscles and neighbor tissue provide information to the Nervous System about the position and articular movements and about the forces generated in the muscles (Huntlei, 2003) (van der Esch, 2007).

The knee proprioception is essential for the modulation and accurate activation of the muscle contraction, once the functional skill and muscular balance are strongly affected by the proprioceptive inaccuracy and muscle weakness (van der Esch, 2007). Studies including patients with knee ligament lesions show that the proprioceptive training promotes additional sensorial information that contributes to the improvement in postural control (Bonfin, 2008).

http://dx.doi.org/10.5772/54554

This relationship becomes even more important when the muscle strengthening program aims to improve the functional balance and prevention of falls.

Despite the knowledge on muscular strength power and the proprioception for a good motor control, and consequently a lower unbalance and fall risk, previous studies to this one ignore the association importance of sensorial-motor training to strength training.

The significant results found in the present research might be explained by the concern in following the ACSM recommendations when prescribing exercises, respecting the basic concepts of prescription exercises.

Additionally, one should take into consideration that the skill to develop muscle strength decreases with aging (Hakkinen et al, 1998) explaining the importance of the gradual progression (Adams et al, 1999). With sedentary elderly people, a period of adaptation and low working load for two weeks should be applied for further implementation of a loading progression protocol (American College of Sports Medicine, 2002).

Data combined from three studies conducted by Gillespie et al., 2006 (Cochrane Library review) with a total of 556 women aged 80 years or older, who underwent to the same progressive muscular strengthening program, balance training and gait training indicate that this intervention decreased the number of individuals that fell during a year, having also reduced the number of injurious falls. Although the studies had methodological limitations, there is a determined consistency as for the decrease of falls in multiple interventions exercises (Gillespie et al., 2009). As for the physical exercise, we only know that it improves balance without a direct association with the decrease in the number of falls (Howe Tracey et al., 2009) and that although the decline in muscle strength is a risk factor for falls, the muscle strength training could not be associated to the reduced number of falls (Sherrington et al, 2009), (Gillespie, et al., 2009).

During strength training elderly people respond positively presenting exponential gains in muscular strength, on explosion as well in muscular resistance. This is explained due to muscular mass decreases in approximately 50% between twenty and ninety years old and the number of muscular fibers in an elder person is around 20% less than in an adult person, being clear the latent capability for recovery of a strength pattern nearly to an adult.

In this study, after a 18-week training, an average increase of 89.5% in the maximum dynamic strength of the quadriceps muscle (1RM) in the intervention group was observed, being within the values described by Humphries et al., 2000 which shows increases of 20 to 200% in the dynamic muscle strength of the quadriceps depending on the initial values and duration of the training. This increase in the knee extension force is significantly important because this force is an independent risk factor for falls and fractures caused by osteoporosis (Nguyen et al., 1993). The increase in the force occurs as a result of neural changes and muscle adjustments (Resende et al, 2006).

The body balance depends on information appropriate receiving through sensorial, cognitive components from the nervous system and from the musculoskeletal system in an integrated manner by the proprioception. The association of muscle strengthening and proprioceptive training was fundamental to the increase of functional mobility and skills, which can be related to the reduction of 36% in the time spent to the performance of the TUG. In this case, the lower the time spent to make the exercise, the better the balance (Resende et al, 2006).

Although the changes in the numbers were small, the improvement in the balance evaluated by the BBS was consistent, and they are in agreement with the results found by Madureira et al, 2007.

Bemben (2000) compared the effects of high and low-intensity training in 25 postmenopausal women (41 to 60 years old) using a high repetition (40% 1-RM, 16 repetitions) and high load (80 % 1-RM, 8 repetitions) protocols for six months showing increases from 30 to 40%, respectively in the dynamic strength in quadriceps.

In a randomized controlled trial of 10 weeks of strength, balance and stretching training in 53 postmenopausal women with osteoporosis, Malmros and colleagues (1998) showed that strength and muscle mass and also the static balance improved significantly.

In another randomized clinical trial, physiotherapy-directed exercise in 30 patients with osteoporosis significantly improved static balance measured by functional reach and increased quadriceps dynamic strength (Mitchell et al, 1998).

These two studies indicate that the exercises programs improved the profile of fall risk but showed limitations because of the small number of samples and short time of the interventions.

Hartard et al. (1996) studied the effects of muscle strength training in 16 postmenopausal women with osteopenia, where fifteen belonged to the control group. Although they used a small group, a proper load protocol for 6 months, twice a week at 70% 1RM was applied demonstrating a considerable increase in muscle strength ranging from 44 to 76%, with results similar to the ones found in the present investigation.

Kemmler et. al (2002) evaluated the dynamic force (1RM tests) in 137 postmenopausal women with osteopenia divided in two groups and observed a significant increase of 43% in the leg press in the intervention group training at 70% of 1-RM for fourteen months.

Carter et al. (2002) in a program that trains instructors to work with the community selected 93 postmenopausal women with osteoporosis who were randomized and underwent physical exercises of balance and muscle strength for twenty weeks. No improvement in the quality of life was found, which might be explained by the high quality of life at baseline. Researchers observed an improvement of 6.3% in the dynamic balance and an increase of 12.8% in the muscular strength.

On the other hand, this study contradicts other researches since it shows a significant improvement in the quality of life evaluated by the SF-36, where the values for the physical aspects and mental aspects were considerably higher than the ones found in the control group and the values in the baseline. These outcomes might be related to the systemic physiologic benefits provided by the exercises, which improves the capability of performing daily activities. The results can also be explained by the psychological effects the physical exercise provides, the socialization with other patients and the low levels of quality of life the patients had in the beginning of this study.

Madureira et. al (2006) conducted a randomized clinical trial that included 66 postmenopausal women with osteoporosis assigned to two groups. One of the groups underwent a 12-month of balance training once a week combined with oriented training at home showing significant results concerning balance, mobility and decrease in the number of falls.

Swanenburg et. al (2007) studied 24 women (65 years old or older) with osteoporosis or osteopeny who underwent three months of strength, balance and coordination training. After twelve months, they observed a reduction in the risk of fall (Berg Scale) and increase in the muscle strength of lower limbs. They also found a decrease in the number of falls in the intervention group (89%), showing a significant number although it was a pilot study.

Our figures concerning the reduction of number of falls are similar to the ones found in other studies, although an average of 40% (Barnett et al., 2003) is still not well-substantiated, which can be explained by the differences in the population and mainly in the interventions used in the different researches.

The programmed answers execution by the central nervous system is performed by the musculoskeletal system and the reflex answers, voluntary motor control, postural control and articular stability influence it, fundamental components for falls risk decrease. Therefore the proposed and performed program in this study took in consideration the effector system optimization importance and the neural components, thus, by associating the strength training to sensorial-motor training we obtained effective outcomes and even more vigorous than those that only use muscular strength or balance without taking in consideration the integrated action among the central nervous system, peripheral nervous system (through proprioceptors) and the effecting organs.

As we could observe, several studies have shown to be effective to increase the strength, balance and functional skills, decreasing the risk of falls. Only the research conducted by Madureira et al. 2007 and Swanenburg et al. 2007 direct related these outcomes with the number of falls. However, it is difficult to compare the studies because the training programs and the evaluation methods are different.

The possible limitations of the present study include the tests and functional scales used, that are validated but are not so accurate as the lab tests considered the gold pattern. On the other side, we used the BBS, TUG and 1-RM Test which are highly reproducible in the daily clinic practice, where the access to lab tests is not very often.

A high adherence rate to the exercises, the thorough evaluation made by a blinded physical therapist, the size of the sample and also the strict methodology used when prescribing the exercises might have contributed to the outcomes in this present study.

The purpose of this study was to implement a muscle and proprioceptive training program that would follow the recommendations stated by ACSM, promoting a program that would be strictly followed and prescribed, but easy to use and reproduce.

5. Conclusion

The association of progressive strength training for the quadriceps and the proprioceptive training is effective for the prevention of falls, increasing the muscle power, the static and dynamic balance and increasing the speed of the motor responses, therefore improving the performance of daily activities.

Acknowledgements

The authors would like to thank Federal University of São Paulo, University of Santo Amaro and Federal University of Amazonas for all the support given when developing this project.

Author details

Lucas Teixeira[1,3], Stella Peccin[1,4], Kelson Silva[1], Tiago Teixeira[2], Aline Mizusaki Imoto[1], Joelma Magalhães[5] and Virgínia Trevisani[1,2]

1 Department of Internal and Therapeutic Medicine – Federal University of São Paulo, Brazil

2 Department of Rheumatology - University of Santo Amaro, Brazil

3 Department of Physical Therapy - Federal University of Amazonas, Brazil

4 Department of Physical Therapy - Federal University of São Paulo, Brazil

5 Department of Physical Therapy - Uninorte Laureat University, Brazil

References

[1] Adams KL, Barnard KL, Swank AM, Mann E, Kushnick MR, Denny M (1999) Combined high-intensity strength and aerobic training in diverse phase 11 cardiac rehabilitation patient. J Cardiopulm Rehabil 19:209-215.

[2] Adler, SS.; Beckers, D. & Buck M. (2008). *PNF in practice: an illustrated guide*. 3rd ed. Berlin: Springer.

[3] American College of Sports Medicine (2002) Position Stand on Progression Models in Resistance Training for Healthy Adults. Med Sci Sports Exerc 34 (2):364-380.

[4] American College of Sports Medicine. (1995). *Guidelines for Exercise Testing and Prescription*. 5th Ed. Baltimore: Williams and Wilkins, pp. 1–373.

[5] American College of Sports Medicine. (1998). Position Exercise and physical activity for older adults. *Med Sci Sports Exerc*. 30: 992-1008.

[6] American College of Sports Medicine. (2002). Position Stand on Progression Models in Resistance Training for Healthy Adults. *Med Sci Sports Exerc*. 34 (2): 364-380.

[7] 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 randomized controlled trial. Age Aging 32:407-414.

[8] Bastian, AJ. (2006). Learning to predict the future: the cerebellum adapts feedforward movement control. *Curr Opin Neurobiol*. 16 (6): 645-9.

[9] Bemben DA, Fetters NI, Bemben MG, Nabavi N, Koh ET (2000) Musculoskeletal responses to high- and low-intensity resistance training in early postmenopausal women. Med Sci Sports Exerc 32:1949-1957.

[10] Berg KO, Norman KE (1996) Functional assessment of balance and gait. Clin Geriatr Med 12 (4): 705-723.

[11] Berg KO, Norman KE (1996) Functional assessment of balance and gait. Clin Geriatr Med 12 (4): 705-723.

[12] Bohannon RW (2006) Reference values for the timed up and go test: a descriptive meta-analysis. J Geriatr Phys Ther 29: 64–68.

[13] Bohannon RW (2006) Reference values for the timed up and go test: a descriptive meta-analysis. J Geriatr Phys Ther 29: 64–68.

[14] Brandão, CMA. & Vieira, JGH. (1999). Fatores envolvidos no pico de massa óssea. *Arq Bras Endocrinol Metabol.* 43(6):401-408.

[15] Brunner E, Langer F (2000) Nonparametric analysis of ordered categorical data in designs with longitudinal observations and small sample sizes. Biom J 42:663-675.

[16] Burke TN, França FJ, Ferreira de Meneses SR, Cardoso VI, Marques AP: Postural control in elderly persons with osteoporosis: Efficacy of an intervention program to improve balance and muscle strength: a randomized controlled trial. *Am J Phys Med Rehabil*;89(7):549-56, 2010.

[17] Carter ND, Kannus P, Khan KM (2001) Exercise in the prevention of falls in older people. Sports Med 31(6):427-438.

[18] Carter Nd, Kannus P, Khan Km (2002). Community-Based exercise program reduces risk factors for falls in 65- To 75-year-old women with osteoporosis: Randomized Controlled Trial. Cmaj; October 29, Vol. 167 No. 9; 997-1004.

[19] Cathleen, S.; Colón-Emeric, C. & Saag, KG. (2006). Osteoporotic fractures in older adults. *Best Pract Res Clin Rheumatol*. August; 20(4): 695–706.

[20] Cathleen, S.; Colón-Emeric, C. & Saag, KG. (2006). Osteoporotic fractures in older adults. *Best Pract Res Clin Rheumatol*. August; 20(4): 695–706.

[21] Chyu MC, James CR, Sawyer SF, Brismée JM, Xu KT, Poklikuha G, Dunn DM, Shen CL (2010). Effects of tai chi exercise on posturography, gait, physical function and quality of life in postmenopausal women with osteopaenia: a randomized clinical study. *Clin Rehabil;* 24(12):1080-90

[22] Ciconelli RM, Ferraz MB, Santos W, Meinão I, Quaresma MR (1999) Tradução para a língua portuguesa e validação do questionário genérico de avaliação de qualidade de vida SF-36 (Brasil SF-36). Rev Bras Reumatol 39: 143-150.

[23] Ciconelli RM, Ferraz MB, Santos W, Meinão I, Quaresma MR (1999) Tradução para a língua portuguesa e validação do questionário genérico de avaliação de qualidade de vida SF-36 (Brasil SF-36). Rev Bras Reumatol 39: 143-150.

[24] Cólon-Emeric, C.; Kuchibhatla, M.; Pieper, C.; Hawkes, W.; Fredman, L.; Magaziner, J.; Zimmerman, S. & Lyles, KW. (2003). The contribution of hip fracture to risk of subsequent fractures: data from two longitudinal studies. *Osteoporos Int.* 14 (11): 879–883.

[25] Froes, NDTC.; Pereira, ES. & Negrelli, WF. (2002). Fatores de risco da osteoporose: prevenção e detecção através do monitoramento clínico e genético. *Acta Ortop Bras.* 10 (1): 52-57.

[26] Gass, M. & Huges, BD. (2006). Preventing osteoporosis – related fractures: An overview. *Am J Med.* 119(4A): 3-11.

[27] Guyton, AC. & Hall, JE. (2006). *Textbook of medical physiology*. 11 ed. Philadelphia: WB Saunders.

[28] Häkkinen K, Kallinen M, Izquierdo M, Jokelainen K, Lassila H, Mälkiä E, Kraemer WJ, Newton RU, Alen M (1998) Changes in agonist-antagonist EMG. Muscle CSA. And force during strength training in middle-aged and older people. J Appl Physiol 84 (4):1341:1349.

[29] Hartard M, Haber P, Ilieva D, Preisinge E, Seidl G, Huber J (1996) Strength training as a model of therapeutic intervention: A Controlled Trial in Postmenopausal Women with Osteopenia. Am J Phys Med Rehabil 75(1):21-28.

[30] Hartard M, Haber P, Ilieva D, Preisinge E, Seidl G, Huber J (1996) Strength training as a model of therapeutic intervention: A Controlled Trial in Postmenopausal Women with Osteopenia. Am J Phys Med Rehabil 75(1):21-28.

[31] Hortobagyi,T, Katch FI, LaChance PF (1998) Interrelationships among various measures of upper body strength assessed by different contraction modes. Eur J Appl Physiol 58(7):749-755

[32] Hortobagyi,T, Katch FI, LaChance PF (1998) Interrelationships among various measures of upper body strength assessed by different contraction modes. Eur J Appl Physiol 58(7):749-755.

[33] Humphries B, Newton RU, Bronks R, Marshall S, McBride J, triplett-McBride T, Hakkinen K, Kraemer WJ,

[34] Humprhies N (2000) Effect of exercise intensity on bone density, strength, and calcium tumover in older women. Med Sci Sports Exerc 32:1043-1050.

[35] Hunter, DJ. & Sambrook, PN. (2000). Bone loss: Epidemiology of bone loss. *Arthritis Res.* 2(6): 441-445.

[36] Hurd, WJ.; Chmielewski, TL. & Snyder-Mackler L. (2006). Perturbation-enhanced neuromuscular training alters muscle activity in female athletes. *Knee Surg Sports Traumatol Arthrosc*. 14(1): 60-69.

[37] Hurley MV (2003) Muscle dysfunction and effective rehabilitation of knee osteoarthritis: what we know and what we need to find out. Arthritis & Rheum 49:444–52.

[38] Johnell, O.; Kanis, JA.; Oden, A.; Johansson, H.; De Laet, C.; Delmas, P.; Eisman, JA.; Fujiwara, S.; Kroger, H.; Mellstrom, D.; Meunier, PJ. Melton, LJ 3rd.; O'Neill, T.; Pols, H.; Reeve, J.; Silman, A. & Tenenhouse, A. (2005). Predictive value of BMD for hip and other fractures. *J Bone Miner Res.* 20 (7):1185–1194.

[39] Kemmler W, Engelke K, Lauber D, Weineck J, Hensen J, Kalendertitle WA (2002) Exercise effects on fitness and bone mineral density in early postmenopausal women: 1-year EFOPS: Med Sci Sports Exerc 34 (12):2115-23.

[40] Kristensen MT, Foss NB, Kehlet H (2007) Timed "up & go" test as a predictor of falls within 6 months after hip fracture surgery. Phys Ther 87: 24–30.

[41] Kristensen MT, Foss NB, Kehlet H (2007) Timed "up & go" test as a predictor of falls within 6 months after hip fracture surgery. Phys Ther 87: 24–30.

[42] Large J, Gan N, Basic D, Jennings N (2006) Using the timed up and go test to stratify elderly inpatients at risk of falls. Clin Rehabil 20: 421–428.

[43] Large J, Gan N, Basic D, Jennings N (2006) Using the timed up and go test to stratify elderly inpatients at risk of falls. Clin Rehabil 20: 421–428.

[44] Lephart SM, Fu FH, Borsa JP, Warner JP. (1994). *Proprioceptive of the shoulder joint in healthy, unstable, and surgically repaired shoulders*. J Shoulder Elbow Surg. 3: 371–380.

[45] Lewiecki EM, Kendler DL, Kiebzak, Schmeer P, Prince RL, Fuleihan (2004) Special report on the official positions of the International Society for Clinical Densitometry. Osteoporos Int 15: 779-784.

[46] Lewiecki EM, Kendler DL, Kiebzak, Schmeer P, Prince RL, Fuleihan (2004) Special report on the official positions of the International Society for Clinical Densitometry. Osteoporos Int 15: 779-784.

[47] Madureira MM, Takayama L, Gallinaro AL, Cparbo VF, Costa RA, Pereira RM (2007) 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. Osteoporos Int 18(4):419-425.

[48] Malmros B, Mortenson L, Jensen MB, Charles P (1998) Positive effects of physiotherapy on chronic pain and performance in osteoporosis. Osteoporos Int 8:215-21.

[49] Mitchell SL, Grant S, Atchison T (1988) Physiological effects of exercise on post-menopausal osteoporotic women. Physiotherapy 84:157-63.

[50] 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 (9): 1411-1421.

[51] 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 (9): 1411-1421.

[52] Moher D, Schulz KF, Altman D (2001) The CONSORT statement: revised recommendations for improving the quality of reports of parallel-group randomized trials. JAMA 285(15):1987-1991.

[53] Moher D, Schulz KF, Altman D (2001) The CONSORT statement: revised recommendations for improving the quality of reports of parallel-group randomized trials. JAMA 285(15):1987-1991.

[54] Moreira, C. & Xavier, JD. (2001). Doenças Ósteo-metabólicas. In: *Reumatologia, diagnóstico e tratamento*. Guanabara Koogan, 2ª ed, pp. 327-350.

[55] Mosekilde L. (1995). Osteoporosis and Exercise. *Bone.* 17(3): 193-195.

[56] Neto, AMP.; Soares, A.; Urbanetz, AA.; Souza, ACA.; Ferrari, AEM. & Amaral, B et al. (2002). Consenso Brasileiro de Osteoporose. *Rev Bras Reumatol.* 42(6):343-354.

[57] Nguyen T, Sambrook P, Kelly P, Jones G, Lord S, Freund J, Eisman J (1993) Prediction of osteoporotic fractures by postural instability and bone density. BMJ 307 (6912):1111-1115.

[58] Parkkari, J.; Kannus. P.; Palvanen, M.; Natri, A.; Vainio, J.; Aho, H.; Vuori, I. & Järvienen, M. (1999). Majority of Hip Fractures Occur as a Results of a Fall and Impact on the Greater Trochanter of the Femur: A Prospective Controlled Hip Fracture Study with 206 Consecutive Patients. *Calcif Tissue Int*. 65:1983-187.

[59] Podsiadlo D, Richardson S (1991) The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 39: 142–148.

[60] Podsiadlo D, Richardson S (1991) The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 39: 142–148.

[61] Ramalho, AC.; Castro, ML.; Hauache, O.; Vieira, JG.; Takala, E.; Calalli, F. & Tavares, F. (2001). Osteoporotic fractures of proximal femur: clinical and epidemiological features in a population of the city of São Paulo. *Sao Paulo Med J.* 119(2): 48-53.

[62] Resende SM, Rassi CM, Viana FP (2008) Effects of hydrotherapy in balance and prevention of falls among elderly. Arthritis & Rheum 12 (1):57-63.

[63] Shumway-Cook A, Baldwin M, Polissar NL, Gruber W (1997) Predicting the 21. probability for falls in community-dwelling older adults. Phys Ther 77(8) :812-819.

[64] Shumway-Cook A, Brauer S, Woollacott M (2000) Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther 80: 896 –903.

[65] Shumway-Cook, A. & Woollacott, M. (1995). *Motor Control Theory and Applications*. Williams and Wilkins: Baltimore.

[66] Shumway-Cook, A.; Brauer, S. & Woollacott, M. (2000). Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Phys Ther.* 80: 896 –903.

[67] Siris, ES.; Brenneman, SK.; Barrett-Connor, E.; Miller, PD.; Sajjan, S.; Berger, ML. & Chen, YT. (2006). The effect of age and bone mineral density on the absolute, excess, and relative risk of fracture in postmenopausal women aged 50–99: results from the National Osteoporosis Risk Assessment (NORA). *Osteoporos Int* . 17 (4): 565–574.

[68] Smulders E, Weerdesteyn V, Groen BE, Duysens J, Eijsbouts A, Laan R, van Lankveld W (2010). Efficacy of a short multidisciplinary falls prevention program for elderly persons with osteoporosis and a fall history: a randomized controlled trial. *Arch Phys Med Rehabil*; Nov; 91(11):1705-11

[69] Swanenburg J, de Bruin ED, Stauffacher M, Mulder T, Uebelhart D (2007) Effects of exercise and nutrition on postural balance and risk of falling in elderly people with decreased bone mineral density: randomized controlled trial pilot study. Clin Rehabil 21(6):523-34.

[70] Swanik, KA.; Lephart, SM.; Swanik, CB.; Lephart, SP.; Stone, DA. & Fu FH. (2002). The effects of shoulder plyometric training on proprioception and selected muscle performance characteristics. *J Shoulder Elbow Surg*. 11(6):579-86.

[71] Szejnfeld, VL.; Jennings, F.; Castro, CHM.; Pinheiro, MM. & Lopes, AC. (2007). Conhecimento dos Médicos Clínicos do Brasil sobre as Estratégias de Prevenção e Tratamento da Osteoporose. *Rev Bras Reumatol.* 47(4):251-257.

[72] Teixeira, LE.; Silva, KN.; Imoto, AM.; Teixeira, TJ.; Kayo, AH.; Montenegro-Rodrigues, R. & Trevisani, VFM. (2010). Progressive load training for the quadriceps muscle associated with proprioception exercises for the prevention of falls in

postmenopausal women with osteoporosis: a randomized controlled trial. *Osteoporosis International*; 21: 589-96.

[73] Tinetti, ME. & Speechley, M. (1989). Prevention of falls among the elderly. *N Engl J Med.* 320:1055–1059.

[74] van der Esch M, Steultjens M, Harlaar J, Knol D, Lems W, Dekker J (2007) Joint Proprioception, Muscle Strength, and Functional Ability in Patients With Osteoarthritis of the Knee. Arthritis & Rheum 57(5):787-793.

[75] Van der Esch, M.; Steultjens, M.; Harlaar, J.; Knol, D.; Lems, W. & Dekker, J. (2007). Joint Proprioception, Muscle Strength, and Functional Ability in Patients With Osteoarthritis of the Knee. *Arthritis & Rheum.* 57(5):787-793.

[76] Wayne PM, Kiel DP, Buring JE, Connors EM, Bonato P, Yeh GY, Cohen CJ, Mancinelli C, Davis RB (2012). Impact of Tai Chi exercise on multiple fracture-related risk factors in post-menopausal osteopenic women: a pilot pragmatic, randomized trial. *BMC Complement Altern Med*; 12:7

[77] Weatherall, M. (2004). Prevention of falls and falls-related fractures in community-dwelling older adults: a meta-analysis of estimates of effectivenessbased on recent guidelines. *Intern Med J.* 34:102-108.

[78] Weier, JP (1994) The effect of rest interval length on repeated maximal bench press. J Strength Cond Res 8: 58.

IntechOpen