EURA MEDICOPHYS 2005;41:315-37

SIMFER Rehabilitation treatment guidelines in postmenopausal and senile osteoporosis

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Although widely used and well established, physical therapy and rehabilitation for postmenopausal and senile osteoporosis still lacks evidence-based scientific support for the rationale of specific areas of therapy.

These guidelines derive from an extensive literature review of the subject. Wherever specific studies were lacking, expert opinion was sought to fill these gaps. The guidelines do not include the role of physical exercise in the premenopausal period.

Methodological criteria

Scientific evidence from Medline and Cochrane Library searches laid the basis for recommendations counter-marked with a capital letter. Information taken from international guidelines and foreign scientific societies has been integrated into the guidelines in sections of the rehabilitation and organization. Specifically, the National Osteoporosis Foundation Physicians' Guidelines (US) and the Physiotherapy Guidelines for the Management of Osteoporosis (UK) compiled by the Chartered Society of Physiotherapy provide an important reference for formulating orientation and organizational strategies typical to rehabilitation.

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The recommendations on rehabilitation methods and organizational strategies derive also from internal discussions and verifications within SIMFER, the Working Group and the Regional Chapters.

In Table I the strength of evidence classification is shown.

Population segments targeted by the guidelines are the following:

1. Healthy postmenopausal women.
2. Osteopenic postmenopausal women with bone mineral density (BMD T-score >-2.5).
3. Osteoporotic postmenopausal women without a history of bone fracture (BMD T-score <-2.5).
4. Postmenopausal women with an increased risk of falls.
5. Osteoporotic postmenopausal women with a history of bone fracture.

TABLE I.—*Strength of evidence classification.*

	Scientific proof	Available studies
A	Very strong	Meta-analysis or more than one randomized controlled trial (RCT) with coherent results
B	Strong	At least one RCT, with results consistent with those of other published studies
C	Fair	No RCT, but various controlled studies with coherent results
D	Insufficient	Only one controlled study non RCT or various studies with incoherent results
E1	Strong scientific consensus	General consent on the procedure or treatment
E2	Fair scientific consensus	Prevalent but not general consensus on the procedure or treatment
E3	Commission opinion	Commission opinion where general consensus is lacking

Objectives of rehabilitation in postmenopause and advanced age

In postmenopausal and elderly women, treatment, whether medical, physical or rehabilitative, should be directed at reducing the risk of bone fracture. The causes of bone fractures in the elderly woman, especially limb fractures, are due to two processes: the loss of bone integrity and the increased risk of falls. In patients with osteoporosis or increased risk of falling, rehabilitation should be initiated early or concomitantly with pharmacological treatment to optimize the patient's quality of life and health status and to reduce the risk of new or repeated bone fracture.[1] To this end, knowledge of skeletal (low BMD) or extraskeletal (falls) factors are of vital importance for preventing fractures in selected individuals.[2, 3]

General recommendations

Measurement of bone integrity

Studies use BMD as a systematic measurement of the effect of therapy, given the close correlation established between BMD and risk of fracture. A reduction of 0.11 g/cm^2 in BMD of the femoral neck is associated with a 2.6-fold increased risk of femoral fracture in women age 65 and older.[4] This indicator, therefore, forms the reference criterion for differentiating the risk of fracture in such patients.

Prospective studies have emphasized that the risk of fracture associated with osteoporosis increases from 1.5 to 3 times for each reduction of a standard deviation in BMD.[5] However, BMD is a controversial indicator [6] and has been criticized by several authors [7] since it represents only one of the many factors that describe bone resistance and does not characterize variations in bone quality. Turner *et al.*[5] demonstrated that bone strength should not be confused with BMD, although the two are correlated, because bone strength also depends on material and structural properties (*e.g.* trabecular orientation) of the bone. In an experiment on rats, a weight was applied to the right ulna and the resistance of the ulna was measured at experimental fracture; at sixteen-weeks follow-up examination the increase in BMD produced by the increased load and stress was modest (5.4%) but the resistance to fracture had increased by 64% in ultimate force, i.e. the greatest force of impact for fracture, and by 94% in the total amount of absorbed energy prior to fracture. The reason why such a small increase in bone density produced such a great increase in bone strength was related to the demonstration that the new bone was localized on the lateral and medial periosteal surfaces where the mechanical stress was greater. Hence, even small amounts of new bone growth may yield a large increase in bone strength, as long as the osteogenic stimulus is localized in a site where resistance is biomechanically required.

RECOMMENDATIONS

During the postmenopausal period women should have their spinal BMD measured to check the level of risk of fracture due to reduced BMD (E1).

In selected individuals at risk of fracture, BMD constitutes an instrumental measurement that should be periodically checked together with other systems to evaluate the results of rehabilitation in postmenopausal and elderly women (femoral BMD in women >65 years) and at intervals appropriate for the degree of risk determined (E1).

Importance of exercise in reducing bone loss

In a recently published Cochrane review [8] on the role of physical exercise in postmenopausal osteoporosis, the studies in the meta-analysis had such various limitations as small study sample size, wide variability in bone loss in controls, large range in measurement accuracy of BMD and heterogeneous age ranges of in study populations, with diverse trends in physiological loss of bone mass. For these reasons, the review, although a starting point for further study on the subject, was not conclusive.

What can be confirmed is that increased BMD is site-specific. For example, to the proximal femur when the exercise involves the hip, as in squat exercises (upright sitting position with back straight and knees bent), step, walking, press (horizontal press); to the lumbar spine when the exercise is performed in extension, loaded or nonloaded; to the wrists when the exercise involves the upper limbs. As concerns the hip, an exercise is efficacious on the trochanter when it uses the buttocks muscles; on the lesser trochanter (and intertrochanteric BMD values) when it involves the iliopsoas muscle; on Ward's triangle when an exercise involves the hip adductors and extensors, as underlined by Kerr *et al.*[9]

Specifically, Cussler *et al.*,[10] in a controlled clinical study on 144 subjects to determine the effect of exercises on bone density of the hip and the trochanter, found that trochanteric BMD is positively correlated with total weight lifted ($P<0.001$). The closest correlation between exercise type and trochanteric BMD in this study was found with squat exercises using weights (0.0023 g/cm^2; $P<0.001$) and with military press (lifting a bar from shoulder height to above the head, while keeping knees and back straight) (0.0012 g/cm2; $P<0.01$). BMD of the femoral neck and the lumbar spine was not statistically significantly correlated with total weight or weight lifted, whereas total body BMD was correlated with the amount of weight worn during walking (0.0006 g/cm^2; $P<0.01$). The authors concluded that there may be various explanations for the differences in efficacy of site-specific exercises, *e.g.* muscle insertion, different weights/stretching or type of muscle contraction, duration and nature of the exercise. Muscle strength may have a stronger impact on the trochanter than on the femoral neck. Although weight or stress is distributed to both parts, muscle insertion is on the trochanter, and the transmission of impact through the femoral neck is not efficacious enough to sufficiently stimulate new bone formation and growth of bone mass, especially in a segment chiefly consisting of cortical rather than trabecular bone.

As Frost points out, the increase in muscle strength and bone growth with muscle training has been demonstrated in animal [11] and human [9] studies; despite this, the amount of weight lifted still represents the only way to evaluate the total impact of this type of exercise in many studies.[12] However, weight alone does not sufficiently describe the distribution and location of the mechanical impact the exercise produces.

Kohrt *et al.* studied the effect of exercises involving joint-reaction or ground-reaction forces on BMD,[13] showing that only with the former was there an increase in femoral neck BMD, suggesting that calculation of weight alone is insufficient for determining which exercise type is more effective, and that the estimated ground-reaction force also needs to be included in the calculation.

RECOMMENDATIONS

The efficacy of physical exercise on BMD is site-specific (A); therefore, exercises should be chosen that can adequately act on various body segments of clinical interest.

Aerobic exercises

In the Cochrane review mentioned above, 9 studies examined the effect of aerobic exercise.[14-23] Of a total population of 561 subjects, 266 performed exercises and 295 were the controls. Of these studies, only 2 [16, 17] demonstrated high quality (scores ≥3). Except for 2 studies,[14, 15] in all others the controls continued their normal activities. Compliance with treatment, when reported, varied from 39% [15] to 83%.[16] The exercises involved the upper and lower limbs and the trunk, a mix of callisthenic exercises, stretching, muscle strength training and walking. Exercise intensity was measured by heart rate only in 2 studies [16, 22] or by maximum dynamic force, i.e. repetition maximum (RM), wherein the maximum number of times a weight can be correctly lifted before onset of fatigue,[21] or total body weight.[20] The effect of exercise was measured in different anatomic sites (lumbar spine, hip, wrist) and with different systems of measuring BMD (*e.g.* dual photon absorptiometry, quantitative computed tomography), making it difficult to compare the results of the various studies. Seven studies measured the effect of aerobic exercise on the spine in 186 active subjects and 189 controls,[17, 18, 21-23] 5 studies measured its effect on the hip in 161 active subjects and 174 controls,[17, 18, 21-23] and 2 studies measured its effect on the wrists [14, 19] in 80 active subjects and 106 controls. The results showed that aerobic exercise has a significant effect on BMD of the spine and the wrist but not on the hip.

RECOMMENDATIONS

Aerobic exercise is efficacious in reducing BMD loss in the spine and the wrist (A).

Machine-guided strength training exercises

Pruitt *et al.*[21] compared in a population of 26 healthy, non osteoporotic women aged 65 to 79 years the changes in hip BMD following a year of isotonic machine-guided training performed 3 times weekly. In one training group, muscle strength was 80% of 1 RM, and 40% in the other. Significant differences in strength between the training and the control groups emerged, but no significant differences in changes of BMD at 12 months were found.

Kerr *et al.*[9] published a methodologically well conducted study to determine whether BMD responded to load or number of weight lifts in a population of 56 healthy postmenopausal women. The program consisted of muscle training (strength and resistance training) of the upper and lower limbs, while the contralateral limbs of the same subjects were the controls. After 1 year, only the strength training group showed a significant increase in BMD of the wrist and the hip. The authors concluded that peak weight is more important than the number of repetitions in exercises for postmenopausal bone.

Nelson *et al.*[24] studied the effect on BMD of a program of machine-guided strength training performed twice a week for 1 year in a group of 40 women (age range, 50-70 years). The study showed a significant difference in changes in total body BMD at 1 year between the training and the control groups.

RECOMMENDATIONS

Machine-guided strength training is effective in reducing BMD loss, whereas resistance training is not (A).

Site-specific strength training

A randomized controlled study conducted by Revel *et al.*[25] demonstrated the efficacy of a specific exercise of site-specific strength training on bone density. The effect of isotonic iliopsoas *versus* deltoid strengthening was compared for 1 year by recording changes in lumbar BMD. Iliopsoas strength training was found to be effective, with a reduction in BMD loss in the treated postmenopausal women *versus* the controls ($P<0.01$). The treated subjects were then followed up for two more years during which they were divided into two groups in cross-over between treatment and control, confirming that previous results, wherein all subjects has a lesser loss of bone density, especially those who had continued for all three years of the study.[26]

Sinaki *et al.*[27-29] showed that back muscle strength in osteoporotic women is significantly lower than in healthy subjects and that strength training with a simple program of nonloading extension in the prone position may reduce the risk of vertebral fractures. The study evaluated the efficacy of these exercises in a population ranging in age from 58 to 75 years for two years and demonstrated a significant reduction in BMD loss in treated subjects and maintenance of a significant difference *versus* controls at 8 years of follow-up despite the expected reduction in BMD and muscle strength, given the absence of exercise.

RECOMMENDATIONS

Increase in muscle group strength is consistently correlated with a site-specific increase in BMD and is maintained in the short-to-mid-term (A).

Walking

The systematic Cochrane review reports 3 RCT studies on the effects of walking on BMD. The studies evaluated exercise intensity in different ways: treadmill walking at aerobic threshold level,[30] heart rate,[31] and a generic description of the perceived effect of exercise (brisk walking).[32] The total population in the 3 studies was 77 in the walking and 79 in the control groups.

Hatori *et al.*[30] investigated the effect of treadmill walking 3 times weekly for 7 months *versus* a non active control group in a small population of 33 subjects. The authors differentiated walking speed by instrumental measurement (ventilation/min); an effect was observed only in those subjects who walked at a quicker pace, whereas at lower speeds the effect was the same as in the controls. Unfortunately, the study had a low quality score and a short follow-up period.

A study conducted by Martin *et al.*[31] on treadmill walking at different speeds and evaluated by measuring heart rate showed at one year after training

2 to 3 times weekly a reduced postmenopausal loss of lumbar BMD only in women at less than 6 months since the onset of menopause.

Ebrahim,[32] in a study on 165 women with a history of femoral fractures, evaluated the effect on BMD of a walking program that included walking exercises 3 times weekly at increasing speed and duration over the course of the two-year study. The results showed that compared with controls the BMD loss in treated subjects was much less in the femoral neck and the lumbar spine ($P<0.05$). The cumulative risk of falls but not the rate of fractures, however, increased significantly in the treated subjects ($P<0.05$).

Large controlled studies permit a better definition of the effect of walking on BMD. Feskanich *et al.*[33] conducted a one-year prospective study on a population of 61 200 women and found a relationship between femoral fracture and activities of daily living (ADL), as measured using the metabolic equivalent threshold (MET), i.e. the level of metabolic energy needed to perform ADLs and walking. It was shown that the risk of hip fracture dropped by 6% for each increase of 3 MET/h/week of activity (equivalent to 1 h of walking per week at medium speed). Specifically, in the comparison between women who walked for a minimum of 1 h per week and those who walked for at least 4 h weekly, the latter had a lower risk of femoral fracture; this trend was noticeable also with an increased duration of walking ($P=0.2$).

The importance of walking speed has been variously studied.[33] Coupland *et al.*,[34] in a transversal study on 580 women, showed that the activities most closely correlated with bone density were stair climbing and walking speed, which produced a significant increase in trochanteric and total body BMD. Specifically, brisk walking increased trochanteric BMD by 8.4% compared with slow walking.

Krall *et al.*,[35] in a controlled clinical study on 232 women, showed that at 1 year into the study the women who walked over 12 km a week had higher lumbar and total body bone density than those who walked less than 1.5 km weekly.

Zylstra *et al.*[36] calculated that the annual increase was 0.8% in lumbar and 1.9% in femoral BMD for each hour walked per day.

An additional observation [37] is that bone response to mechanical load is highly stimulus specific; therefore, the exercise and the bones on which we chiefly want to work should be chosen carefully, since those exposed to greater risk of osteoporotic fracture are: the femoral neck, the vertebra and the distal radius. The exercise load should not exceed the fracture threshold, of course, but it should still be above the physiological load. Furthermore, the results of numerous laboratory studies indicate that desensitization and exercise adaptation can be avoided with brief, repeated exercises.[38]

Turner *et al.*[5] examined these notions and suggested that any high-impact exercise was efficacious in stimulating bone growth, wherein the exercise represents an important dynamic stimulus conditioning repeated ground reaction. Using the Osteogenic Index formula, they calculated the osteogenic potential of an exercise based on the estimated intrinsic bone impact, subdivided in weekly rehabilitation sessions and repeated exercises. As regards walking, these calculations permitted a description of the intensity of administering the exercise, defining the impact (ground reaction depends on the subject's body weight and walking speed) and the pace (number of steps) for a series of brief session repeated over the course of a day.

RECOMMENDATIONS

Brisk walking and stair climbing are correlated with a lower loss of BMD (A).

The exercise should have a high impact, i.e. able to condition an important ground reaction, be repeated for brief cycles and repeated several times daily (C).

Exercises to reduce the risk of falls

About 40% of persons age 65 and older fall every year.[39] General inactivity and altered neuromuscular function are two noted risk factors contributing to falls and femoral fractures.[40, 41] Evidence for this comes from a prospective cohort study [42] on 9 704 women >65 years in which high levels of physical activity were associated with a reduced risk of femoral fracture but not wrist fracture. Similarly, fewer femoral fractures were found in women who undertook at least 2 h of intense physical activity weekly.

Published studies have identified several risk factors contributing to falls: hyposthenia, loss of co-ordination, hyperkyphosis, increased postural sway, slow walking, reduced body function.[43-45]

However, a recent Cochrane review [39] of 13 RCT on exercise and physiotherapy to prevent falls in the elderly showed that outcomes of various fall prevention interventions did not prove efficacious. On the contrary, the results of studies on 566 women >80 years treated with individualized exercise programs with graded strength training, balance and walking showed they were efficacious in relation to the number of subjects who had experienced a fall over the course of 1 year.[46-48] Studies investigating the effect of exercise alone on institutionalized subjects were not found to be efficacious in preventing falls.[39]

Jensen *et al.*[49] showed that an exercise program with individualized strategies that comprised education, safety modifications to the home, individualized exercise regimens, assistive devices, medications, ortheses and problem-solving conferences on fall management was successful in preventing falls and fall injuries in subjects >65 years.

Programs should be individualized on the basis of fall risk factors and by evaluating the different types of interventions that address both intrinsic and extrinsic risk factors.

Recommendations

Inactivity and deterioration of neuromuscular function are two risk factors that contribute to falls (A). Exercise programs are efficacious in the elderly only if individualized and targeted at problems that have been identified and are monitored over time: hyposthenia, balance disturbances, agility, and neuromuscular disorders, vision deficit, internal disease and current pharmacological therapies (A).

The role of exercise in improving balance and agility to prevent falls

A recent review [50] investigated the role of balance and agility exercises in preventing falls in subjects age and older. The review defined agility as “a quick, active smooth motion” and balance as “body stability”. Balance activities included exercises that modified body stability (*e.g.* standing on one or both feet), whereas those for agility were activities that modified dynamic stability (dancing, brisk walking while dribbling a ball, obstacle race).

The review selected 13 randomized controlled studies.

Balance exercises

The literature review confirms that exercise may reduce the rate of falls in the elderly,[39, 51-53] particularly when the regimens comprise balance exercises.[51, 52, 54] Two studies [55, 56] report the effect of Tai Chi on the frequency of falls in men and women age 70 and older. The one study,[55] which compared the efficacy of Tai Chi practiced for 15 weeks *versus* computerized balance training or an educational program showed that both types of exercise regimens were significantly more effective than education alone, without differentiating between Tai Chi and specific training. In the other study,[56] no difference in fall frequency was found between subjects who practiced Tai Chi for 48 weeks and those who followed a more general exercise regimen.

A recent systematic literature review [57] concluded that there may be some evidence that Tai chi is efficacious in fall prevention.

Recommendations

Exercises to improve balance, including Tai chi, are efficacious in patient groups at greater risk of falling (A).

Agility exercises

Two studies investigated the efficacy of this type of training. Liu-Ambrose *et al.*,[58] in a study on 104 women (age range, 75-85 years) with osteopenia, combined agility and strength training for 25 weeks and showed that there was a significant reduction in the risk of falling compared with only stretching and relaxing exercises.

Shigematsu *et al.*,[59] using aerobic activities (dancing) as a form of agility exercise, showed that compared with the controls, improved performance of active subjects was found on static and dynamic stability testing: standing on one leg with eyes closed, functional reach (maximum distance a subject can reach by stretching arms straight out with elbows extended while standing upright and maintaining stance) and walking around two obstacles. Davis *et al.*[50] concluded that, although there was no conclusive evidence that agility training reduced falls, this type of exercise may be as efficacious as strength training in fall prevention and may therefore be advisable for this purpose in subjects unable to perform strength training.

Recommendations

Agility exercises are recommended to reduce the risk of falls in the elderly; they represent a useful alternative also for those patients unable to perform other types of muscle strengthening exercise (A).

Balance and agility exercises combined with other types of training

A study by Steadman [60] showed that the combination of complex functional exercises specifically designed for improving balance does not further reduce the risk of falls in patients with postural instability compared with the positive effect of standard physiotherapy on patients with mobility disorders. Balance exercises combined with other strength training regimens have different levels of efficacy. Four studies [46, 48, 61, 62] showed a significant reduction in fall frequency, whereas two studies [63, 64] showed no differences *versus* controls. In studies where balance and agility training were a part of a larger exercise program, only one study [65] demonstrated a reduction in the rate of falls, whereas three studies [66-68] showed no effect.

RECOMMENDATIONS

Treatment programs on nonhomogeneous populations and nonindividualized rehabilitation programs showed no efficacy (A).

Agility and balance exercises combined with more complex programs are useful when inserted in an individualized nonstandardized rehabilitation project (E1).

Postural control exercises

The problem of correcting thoracic hyperkyphosis secondary to osteoporosis was studied by Lynn *et al.*[43] not only because the disorder causes pain but also because it increases the risk of falls. Subjects with hyperkyphosis often use hip rather than physiologically more efficacious ankle compensation strategies during sudden changes in balance. These reactions were improved with proprioceptive dynamic posture training in osteoporotic women with hyperkyphosis.[69]

Pain may derive from osteoporotic vertebral collapse and postural deformities such as scoliosis and hyperkyphosis.

Back muscle strength training is significantly correlated with a reduction in spinal fracture and kyphosis;[29] in severe hyperkyphosis posturing, however, it may cause tenderness due to compression of the lower ribs on the iliac crest, leading to reduced pulmonary function.[70-72]

A review of a study by Pfeifer *et al.*[1] showed that based on published data back extensor muscle strength training reduces hyperkyphosis, spinal fractures and back and chest pain.[29, 73]

Malmros *et al.*[74] demonstrated that reduction of dorsal hyperkyphosis by strengthening the dorsal extensor muscles and postural rehabilitation improves static and dynamic posture and may reduce pain, increase mobility, reduce depression and improve the patient's quality of life.

Since repositioning the body's center of gravity reduces body sway [69] and increased body sway is closely correlated with the risk of fracture and falls,[44] changes in the body's center of gravity with postural rehabilitation for dorsal hyperkyphosis may be associated with a lower rate of falls and limb fractures.[75]

RECOMMENDATIONS

Postural rehabilitation and dorsal extensor muscle strength training are vital in preventing and correcting spinal deformities, particularly hyperkyphosis (A).

Postural rehabilitation and exercise are useful for relieving musculoskeletal pain (A) and for promoting thoracic expansion, with subsequent increased vital capacity and subjective well-being (C).

Postural rehabilitation also permits restoration of the body's center of gravity to a position that may enhance balance and thus prevent falls (B).

Spinal bracing

Spinal braces are devices designed to support, relax and correct the lumbar spine. Epidemiologic data from 1987 showed that over 250 000 braces for back problems were prescribed yearly in the US. No newer data for the US or Italy are available.[76] Nor are there evidence-based clinical studies (prospective, controlled, randomized) proving the efficacy of bracing in patients with spinal disorders referable to osteoporosis,[76] despite the elevated incidence of spinal fractures associated with the disease.[77, 78] The many types of braces on the market [79, 80] can be roughly grouped into 3 large categories: rigid, semirigid and dynamic.

Rigid braces in osteoporotic elderly patients

This category of braces comprises those with three-point or five-point cruciform anterior spinal hyperextension orthoses with a metal frame, lumbar strap and back pad.[81] Also included in this category are cruciform braces and Taylor braces. Compared with the former, they share 2 characteristics: they give less support and have a lumbar strap that wraps around and presses on the abdomen.[81]

WORKING PRINCIPLES AND DESIGN FEATURES

These braces ensure maximum spinal support and are the only ones suited for treating recent osteoporotic vertebral fractures.[82, 83] Made of aluminum, they are well tolerated because the pelvic or pubic support structure does not compress the abdomen or the rib cage.[82, 83] Elderly patients with intense pain from recent osteoporotic vertebral fracture accept braces because they offer benefits that are rapidly perceived on wearing.[83, 84] As back pain subsides, however, patients are less willing to continue wearing the brace.

INDICATIONS

Recent osteoporotic spinal fractures,[81] regardless of the extent or degree of pain [83, 84] they cause. This type of braces is the only one that can prevent exacerbation of spinal compression because of the efficacious support they provide.[82, 83] Patients should be weaned off braces as early as possible (within 45-60 days) and adequately supported with kinesiotherapy.[81] Cruciform braces (Taylor braces) may be indicated in the treatment of subacute fractures or in subjects with back pain associated with moderate hyperkyphosis.[81]

LIMITATIONS

Brace rigidity [85, 86] accounts for the many limitations that significantly reduce compliance with wearing them.[70, 87] They are poorly tolerated in frail older persons or those with severe hyperkyphosis who are less adaptable. Bracing leads to muscular hypotrophy [78] which should be counteracted with appropriate brace kinesiotherapy.

RECOMMENDATIONS

These braces are indicated for treating vertebral collapse and recent osteoporotic vertebral fractures (A).

They should be worn only for short periods (45-60 days) (E1).

Semirigid braces may be used instead of rigid braces in elderly frail patients (E1).

Brace wearing should be combined with adequate kinesiotherapy (E1).

Semirigid and dynamic (elastic) braces in the elderly with osteoporosis

These types of braces have been a part of medical treatment since its beginnings. The many models commonly available differ in design and structure. Scientific evidence that delineates specific indications and modes of use for a specific brace type is lacking.

WORKING PRINCIPLES

Some data support the use of braces for back pain in adults but not in the elderly with osteoporosis.[88-90] A recent meta-analysis of controlled studies [88, 90-92] provided evidence for the advantages of braces in restricting range of spinal motion, without causing such side effects as reduced paravertebral muscle strength. This effect may be beneficial, although its real utility, particularly in the workplace environment, remains debated. It has been shown that muscle force is unchanged (electromyographically documented).[88] It cannot be guaranteed that spinal muscle load is diminished by brace wearing, even when the antalgic effect is excluded. Nor is it possible to deny the widely held but never substantiated belief in an effect from prolonged brace wearing, i.e. rapid loss of muscle strength and subsequent spinal dysfunction.[88] Despite some theories in its favor, it cannot be stated with absolute certainty that increased abdominal pressure [93, 94] from brace wearing reduces mechanical load (compression) on the spine [95] and reduces biomechanical stress.[88, 96] The psychological effect of safe and secure motion has no scientific basis.[88] Moreover, it has been established that braces reduce intradiscal lumbar pressure by about 30%.[97] However, no scientific studies have proven or disproved the possibility of reducing back pain by wearing a spinal brace.

CONSTRUCTION CHARACTERISTICS

Semirigid braces are made of thick fabric, either single or double woven, with or without elastic inserts and paravertebral posterior bars that vary in number and thickness.[98] The front may be flat or rounded and has a double side closure, i.e. a central closure with hooks or Velcro fasteners. Bar width is usually 15 mm or 20 mm, and thickness varies from 0.80 mm to 1 mm. Bar contour, or adaptation of the bars to the patient's body, should be carried out manually by the orthotist. The bars may vary in resistance depending on the material they are made from (plastic or aluminum). In the elderly, braces with rear shoulder straps are used.

Dynamic (elastic) braces for the elderly with osteoporosis are made of elastic fabric. The bars are 15 mm or 20 mm wide and 0.40 mm to 0.60 mm thick and conform to the patient's body without the need for manual contouring. The brace may have bands or horizontal elastic pulls that facilitate donning the brace. The bands can be overlapped to adjust front height to conform to the anatomy of an obese patient or in cases of comorbidities. More advanced models such as the SpinoMed [99] have an adjustable elastic posterior support bar to which an anterior abdominal support and a shoulder support are connected. Contrasting results have been reported about the inhibitory/stimulatory action on trunk muscles.[99, 100]

Indications

Semirigid and dynamic lumbar braces partially restrict spinal motion.[88, 90, 91, 92] They are a temporary device for patients with back pain in osteoporosis. Brace wearing should be combined with rehabilitation treatment ultimately aimed at weaning from the brace.[89]

Semirigid lumbar braces are indicated in elderly patients with osteoporosis, in moderate to severe osteoporotic back pain, in secondary hyperkyphosis, osteoporotic vertebral collapse, and reduced ability to sustain the spinal column.[101, 102] Forced bed rest is not recommended.[102] Combined brace and pharmacological treatment promotes satisfactory management of acute phase or flare-ups of lumbar back pain, facilitating the patient and the rehabilitation therapist in performing rehabilitation exercises and in the ensuing treatment phase (education and ergonomics).[103]

Dynamic braces may be prescribed for the elderly patient with osteoporosis when postural stimulation is desired.[101, 102] The primary indication is curved back and chronic spinal pain, which should direct the use of the dynamic brace toward pain relief, and recovery of postural sensorimotor and proprioceptive function.[102] Concomitant with brace wearing should be a rehabilitation program designed to wean the patient off the brace.[102] The literature contains studies demonstrating the ability of SpinoMed [99] to reduce pain, enhance spinal mobility and reduce hyperkyphosis. The authors demonstrated the device's possibilities in terms of augmented extensor back muscle strength which was directly correlated with increased electromyographic muscle action (biofeedback effect).[99] Similar findings were reported by previous studies that evaluated electromyographic action during brace-on.[100] The authors also demonstrated that the stronger extensor muscles may promote an improvement in hyperkyphosis, with increased height and postural control and reduced disequilibrium, with a consequent reduction in falls and non-vertebral fractures.[69, 75, 99]

Limitations

Semirigid lumbar braces are poorly tolerated in elderly patients with a prominent abdomen. Conformity with patient anatomy is slightly better with elastic braces.

Recommendations

In the treatment of pain induced by spinal deformities and soft tissue weaknesses (E1).

Inclusion of bracing in a motor function rehabilitation program (C), with gradual weaning (E1).

Braces may also be used to correct posture in hyperkyphosis and to stimulate a proprioceptive effect (C).

The rehabilitation program should be continued to prevent falls and to strengthen muscle segments (E1).

General recommendations for the use of spinal braces

1. Early phases of osteoporotic vertebral fracture.

— Acute phase: rigid brace, with early weaning and functional recovery (A).

— Subacute and chronic phases: functional recovery integrated with semirigid, dynamic brace.

2. General treatment objectives.

— Apply corrective force (rigid braces) to abnormal curvature such as hyperkyphosis in osteoporosis (E1).

— Promote spinal stability and posture control when soft tissues (myoligamentous complex) no longer ensure trunk stability (rigid, semirigid, dynamic braces).

— Reduce pain by limiting spinal motion (rigid, semirigid, dynamic braces) (A).

3. Specific treatment objectives in outcome phase.

— Ensure spontaneous motion, without neglecting the need for full freedom of use of limbs to allow a normal social activity (E1).

— Promote correct posture recovery: teach the patient how to use the dynamic brace as an active posture guide rather than adapt to the brace or depend on it for passive guidance (E1).

— Attempt a positive integration of bracing with a specific spinal rehabilitation program (E1).

— Promote early pain recovery (A).

— Offer maximum wearability and adaptability, combined with cosmetically unobtrusive bracing (E1).

Protective hip ortheses

Coxofemoral ortheses, or hip braces, are technical devices worn on the hip and femur surface to protect the coxofemoral area.

Types and fabbrication design

Coxofemoral ortheses may be divided into:

— rigid braces made of plastic, metal or fiberglass;

— dynamic braces made of elastic microfiber fabric.

Rigid ortheses consist of a thoracolumbar corset and a femoral support, connected with a rigid, vertical articulated bar. Dynamic braces consist of two horizontal bands, the one wrapping around the abdomen and the other around the thigh, connected to a vertical mobile bar. Both types of braces have padding that can be attached to the vertical piece with Velcro to protect against accidental falls.

Indications

Published data [104, 105] agree that hip protectors against the risk of femoral fracture are useful particularly in elderly institutionalized patients at high risk for fracture with coexisting manifested central neurological deficit in balance and coordination.

Rigid braces are poorly tolerated by most patients, whereas dynamic braces are better accepted.[104] Rigid braces are also poorly tolerated by osteoporotic individuals who are still active and less inclined to accept wearing a hip protector because of the limitation it imposes on function.[105, 106]

Cost-benefit analyses have not shown a clear advantage of hip protectors compared with the natural history of the disease.[107, 108]

Recommendations

Hip protectors reduce the incidence of femoral fractures in elderly institutionalized individuals with central neurological deficit and high risk of femoral fracture (A).

The device should not be used in osteoporotic individuals who are still active and at a low-to-moderate risk of fracture (A).

No evidence is available about their utility in patients with osteoporosis and coxalgia secondary to coxarthrosis (E1).

Risk classification and definition of rehabilitation objectives and strategies

A logical classification of rehabilitation interventions is based on the characteristics of the population to which they are directed.

Such criteria include age, age at menopause, BMD, level of habitual physical activity, and risk of falls. Based on these patient characteristics, treatment may be classified as:

a) early treatment.

Rehabilitation program for healthy postmenopausal women or those with osteopenia (BMD with a T-score >-2.5). This program may slow the accelerated loss of bone density during the initial postmenopausal period in individuals not presenting signs of frailty. Although published studies on heterogeneous populations did not distinguish between these presenting characteristics, it is assumed that selective strength training for the spine and resistance training for the hip may be included in a basic exercise regimen.

b) late treatment.

Rehabilitation program for postmenopausal osteoporotic women with a history of fractures (BMD T-score <-2.5) and those with a higher risk of falls. The program should be complementary to pharmacological therapy and dietary modification. In subjects with spinal pain and manifest difficulty in postural control, bracing treatment may be preferably associated with a semirigid or a dynamic brace.

Subjects at risk of falls

Diminished BMD is no longer held to be the only factor in risk for fractures. BMD alone is insufficient for predicting fracture; in fact, BMD values overlap widely in subjects with and without a history of fracture.[109-111] Falls represent the major risk factor for fractures, especially limb fractures.[109-112] In defining an individual's risk for fracture, the risk of falls and low BMD act independently of one another and cumulatively.[40]

The risk of falls increases with age; most seniors have at least one serious fall per year.[113] Fortunately, only 5-10% of these falls lead to a fracture [113] for various reasons depending on the type of fall and the defense reactions the individual uses [110, 111, 114] and BMD. This was confirmed in a study by Geusens [115] that demonstrated an increasing risk of fracture in women who fell and had a low BMD compared with those with a history of falls but a normal BMD. The combination of low BMD and history of falls increases the risk of fracture.

A study by Tinetti [113] showed a lack of efficacy of various fall prevention programs with respect to the number of fractures; however, this most likely resulted from not having distinguished between subjects with low and those with normal BMD. Yet selecting populations based on risk of falls appears to be an indispensable criterion for increasing the efficacy of a rehabilitation program.

Barnett,[65] using an exercise regimen in men and women age 65 and older and with at least one risk factor for falls, showed that agility and balance training was effective in preventing falls. The same type of program was not found to be effective in reducing the incidence of falls in another study [66] on subjects aged between 60 and 85 years without risk factors for falls.

The most effective program appears to be a regimen of home exercising for balance and strength training.[46, 48, 61] This type of rehabilitation has been shown to be efficacious in all 3 study populations >75 years, but it is not yet known whether the program is also effective in subjects with or without risk of falls.

RECOMMENDATIONS

Rehabilitation programs should be personalized and directed at a patient's specific risk factors (A).

An increased risk of falls does not necessarily increase the risk of fracture. The same may be said for low BMD. However, both factors, particularly when combined, warrant rehabilitation. Rehabilitation should not be standardized but rather customized to the patient's unique needs (A) as should its primary objectives.

The problem of compliance in rehabilitation

Although less studied, compliance is a decisive factor in determining the success of a rehabilitation program for degenerative conditions.

Compliance in exercise programs to reduce bone mineral density loss

Published data report that bone loss in postmenopausal women is about 1-4% per year,[116-118] with an annual loss of 1.5% in spinal and 1.1-1.4% in femoral neck bone over the first 4 to 5 years. Thereafter, the rate of loss is slower,[119, 120] making the early postmenopausal period the most critical in terms of rate and extent of bone loss.[31]

The ideal bone remodeling time is estimated to be 4-6 months; therefore, treatment to prevent bone loss should last for at least 2-3 months since it is within this period that its effect on bone density can be evaluated in a period of equilibrium.[121]

Programs to augment BMD and muscle strength should be comprise: high-intensity regimens with on and off treatment cycles that maintain their efficacy also in the longterm; low-intensity regimens, or daily activities that may be performed in a manner and for a duration that are efficacious for maintaining BMD and keeping compliance high so that they can be proposed as a permanent exercise program.

Karlsson,[122] in a review of the efficacy of exercise in preventing fractures cited studies that describe the decline in BMD in retired US football players, given that 30-50 years after retirement from professional sports the players presented no difference in BMD *versus* the normal population (*i.e.* the players had no added benefit).

Sinaki *et al.*[29] demonstrated that 8 years after a two-year program of spinal extension exercises the risk of vertebral compression fractures was 2.7 times higher in the control group *versus* the study group. Spinal lumbar BMD had diminished significantly in both groups, but the difference in loss between them was statistically significant (P<0.001). Similarly, spinal extensor muscle strength remained higher in the study sample *versus* the controls (P<0.01). Based on these results, the author concluded that short periods of concentrated intense exercise were sufficient and that a longterm program produced greater benefit at lower cost.

Other studies in the Cochrane review did not include a follow-up that was long enough to postulate a hypothesis for a lasting training effect over time.

RECOMMENDATIONS

The duration of a program of intense strength training, whether in a health club or with devices, may be limited to a few months a year so long as the regimen is intense, of proven efficacy in short-term follow-up and is repeated over the course of the patient's life (B).

Compliance in rehabilitation programs to improve balance and agility

A rehabilitation program should be easy to follow also for elderly subjects. Robertson *et al.*[48] found that evaluation of compliance at 1-2 years is the best time to evaluate a program's acceptability level. Compliance with at home strength training and balance exercises varied between 42% and 63% in subjects who practiced at least 3 times weekly, while compliance with exercise performed at least twice a week ranged between 25% and 72%.[46, 48, 61, 63] At the end of 2 years, only 44% of subjects still in the second year of the study continued their program 3 times a week.[47]

Day *et al.*,[62] in a study examining a program with 1 session weekly plus a daily home exercise regimen, found a lower compliance rate among subjects assigned home exercises. Neither the Robertson nor the Campbell study made use of incentives (*e.g.* home visits) to encourage continued participation, even though such visits might have been useful.

Wolf *et al.*[55] in their study on compliance asked participants to notify their coordinator about absences; 2 missed sessions were permitted. Moreover, absent participants were followed up by a visiting nurse who encouraged them to continue with their exercises at home. Only 6.5% (13 of 200) subjects were excluded from the study because of pathologic conditions or a spouse's illness.

Lord *et al.*[66] reported that 75 of 100 participants recruited for an exercise program participated in at least 26 sessions and were available for control tests at 12 months. The reasons cited for dropping out of the study were serious (death, stroke) or less serious (dizziness, arthrosis). The number of sessions subjects attended was significantly correlated with the degree of improvement in the time reaction test and in lower limb muscle strength.

Although compliance is not reported in all studies, these data indicate how crucial this factor is in the acceptability of exercise programs.

Recommendations

Compliance with prolonged low-intensity exercise programs at health clubs or at home may be sufficient when motivation to continue is renewed and clinical monitoring is adequate (A).

To maintain sufficient compliance, an exercise program should produce functional improvement and subjective well-being that can be verified in the short-term by the individual himself (E1).

Recording adverse effects

Despite the common notion that exercise is good, attention needs to be directed at possible adverse events. In a particularly vulnerable population like that of subjects at risk for fracture or falls, this factor demands special attention.

Adverse events should be recorded in all studies and programs. Generally, such events include bone, joint and muscle pain, along with falls during exercising, orthostatic hypotension, *angina pectoris* and dyspnea.

Campbell *et al.*[46] emphasized that strength training and balance exercise may potentially increase the risk of falls in the early stages, especially when subjects begin exercises they are unfamiliar with (muscle strength and balance). One risk indicator is the time to first fall. Of the 4 studies that examined home exercise programs with strengthen training and balance exercises, the treatment group did not have a faster time to first fall.[46, 48, 61, 63] Robertson *et al.* reported that 3 participants had experienced adverse effects with the exercise program studied: 1 due to exercise-related pain, 2 due to myalgia, and 1 due to hypotension while walking outside.[61]

Only 2 studies selected for this review documented adverse events. In the agility training group there were 3 cases of muscle pain, 4 of dyspnea, 2 false steps (1 participant), and 6 falls (4 participants).[58] Hauer *et al.*[67] reported no clinical problems related to the program.

Recommendations

Before beginning any type of physical activity an osteoporotic woman may be unaccustomed to, whatever her age, contraindications to the proposed exercise type should be considered (internal, musculoskeletal, and neurological diseases and functional limitations) (A).

The intensity of the exercise program should also be graded, especially in exercises promoting strength and balance, or in subjects unaccustomed to physical activity (E1).

Final recommendations

General principles for the physiatrist

In addition to evaluating medical conditions, diagnostic test results, nutritional status and concurrent medications, a patient's physical, functional, psychological and social status need to be considered before designing a rehabilitation project.

Plan a training program that includes safe performance of motion and ADL, lifting, transfer and walking.

When performed safely, walking and ADL are practical ways to maintain general function and bone mass in the elderly and in women of any age with low BMD. For muscles and bones, additional training is advised that comprises graded resistance training and exercises with gradually increased weight-lifting, all planned around the patient's functional capabilities.

Deficits revealed at physiatric evaluation should be compensated with assistive devices for walking and transfer or collection. All rehabilitation methods should be progressively applied to correct, when possible, such deficits, *e.g.* improvement in balance and quadriceps strength to permit a woman to get out of a chair unassisted.

Based on the patient's initial conditions, a complete exercise program should be designed to comprise aerobic exercises with weight lifting, posture training, progressive strength and resistance training, stretching for soft tissues, joint mobilization, balance training. The exercises may improve function, bone mass, muscle strength, balance and reduce the risk of falls.

During the rehabilitation program, continuation with medical therapy and appropriate diet should be monitored.

Avoid prolonged immobilization and recommend only partial best rest (with short intervals of sitting upright and walking) and only when needed or for the shortest periods possible.

In patients with acute spinal fracture or chronic pain following multiple vertebral collapse, the use of a corset may help relieve pain by reducing spinal load on the fracture and help keep the spinal column better aligned.

Correct pain management is fundamental in the rehabilitation of spinal fractures. This may be achieved with physical therapy, pharmacological treatment and behavioral techniques, directing attention to the risk of side effects such as disorientation and sedation, which, in turn, may lead to falls.

Evaluate the patient, his or her concurrent therapies (considering possible interactions), and the home environment for major risk factors of falls.

TABLE II.—*Risk factors for osteoporotic fractures.*

History of low-impact fractures
Low bone mineral density (BMD)
History of fractures among first degree relatives
Caucasian race
Advanced age
Female sex
Dementia
Recurrent falls
Lack of physical activity
Frail clinical conditions
Heavy smoker
Low body weight (<55 kg)
Estrogen deficit
Low calcium intake
High alcohol intake
Poor eyesight even with corrective devices

TABLE III.—*Principal risks of falls.*

Environmental factors
Poor lighting
Pathway obstacles
Rugs
Lack of handrails in the bathroom
Slippery ground outside the home
Medical factors
Age
Female sex
Visual deficits
Urgent urinary incontinence
History of falls
Orthostatic hypotension
Unsure transfer and mobility
Medical therapy (analgesics, antiepileptics, psychotropics)
Depression
Cognitive deficits
Anxiety and agitation
Malnutrition
Neuromuscular factors
Poor balance
Muscular hypotension
Kyphosis
Proprioceptive deficit
Psychological factors
Fear of falling

Protective hips ortheses may reduce femoral fractures in older women at high risk of falls (history of falls, balance deficit, reduced eyesight).

Table II shows risk factors for osteoporotic fractures.

In Table III principal risk of falls are shown.

General recommendations for an exercise program

Aerobics and resistance training promote the reduction of bone density loss. The former are exercises in which bone and muscle work against the force of gravity, and body weight is sustained by support from the lower limbs, *e.g.* jogging, walking, stair climbing, dancing, playing ball. Swimming and bicycling do not belong to this category. The latter are strength training exercises that increase muscle mass and strengthen bone, *e.g.* weight lifting, health club machines.

Many activities of daily living and most sports activities combine these 2 types of exercises, so that an active lifestyle helps strengthen muscles and maintain BMD. However, frail women with a history of falls, who fall frequently or have severe osteoporosis will merit caution in designing a rehabilitation program. Motion such as rotation, flexion, and high impact may be harmful. In planning a rehabilitation program it is wise to remember the following principles of physical conditioning in osteoporosis:

1. Specificity: specific exercises for a specific patient, specific for one or more objectives (BMD, muscle strength, agility, cardiopulmonary function), specific to anatomic sites.

2. Overload: a progressive increase in duration, intensity and frequency of exercises; added weight should surpass the stress threshold without injuring soft tissues or bone.

3. Reversibility: the positive effect of exercise will be lost if the program is discontinued.

4. Initial values: people with the lowest initial functional capacity will gain the highest improvement, while those with average or above average bone mass will have the least.

5. Diminishing returns: a biological ceiling effect on the physiological improvement from exercise; the closer a person comes to this ceiling, the greater the effort to make smaller gains.

Recommendations for at risk populations

Healthy postmenopausal and osteopenic postmenopausal women

Rehabilitation objectives:

— to maintain or increase BMD in osteopenia and slow the rapid rate of bone loss in the early postmenopausal period;

— to increase strength, balance and improve aerobic capacity;

— to improve posture and proprioceptive afferents of the spine and lower limbs;

— to inform patients about healthy lifestyle, risk factors of falls (E1).

Aerobic exercises with weight lifting or strength training are recognized therapeutic interventions that are helpful in reducing the rapid loss of bone density in menopause (A).

Stress mechanisms impact on bone density (A).

There is evidence that high-impact exercises have the greatest potential effect on bone density in women (A).

High-impact exercises are advised for patients who regularly practice physical activities (E1).

Low-impact exercises are advised for patients who do not regularly practice physical activities (E1).

Low-to-medium impact exercises (*e.g.* aerobics, jogging) should be appropriately designed for patients who are unaccustomed to exercising and those age 50 and older (E1).

Effective exercise regimens need to be progressive in terms of impact and intensity as aerobic capacity and muscle strength increase (E1).

There is agreement, however, that above normal mechanical stress is the only way to promote bone growth (A).

Useful programs are those that integrate high impact and low-to-medium impact exercises (E1).

High impact exercises are not advised in patients with joint disorders or have trouble learning and repeating an exercise, or are incontinent (E1).

Cognitive serial control exercises and proprioceptive biofeedback exercises are advised to improve postural and motion control (E1).

Precautions

Prolonged periods of high-impact activities may cause musculoskeletal injury. Exercises should be graded carefully, maintaining a repertory of low-to-medium impact exercises alternated with high impact exercises that patients can safely perform (E1).

Postmenopausal women with osteoporosis but without a history of fractures

Rehabilitation objectives are:
— to diminish loss of bone density;
— to prevent fractures and falls;
— to increase muscle strength, balance and aerobic capacity;
— to improve posture and proprioceptive afferents of the spine and lower limbs;
— to educate the patient about healthy lifestyle and risk factors for falls (E1).

Rehabilitation programs should comprise aerobic and strength training exercises (A).

Peak weight is more important than the number of repetitions to slow the loss of BMD during the early postmenopausal period (A).

Exercises should be planned in combination with other therapies to reduce the loss of bone density in postmenopausal women at risk for developing osteoporosis (E1).

Several recommendations for women with osteoporosis are also valid for this group: the importance of exercise impact, graded intensity and impact (A).

Strength training should be site-specific, selecting the bone the exercise is targeted at: hip muscles, dorsal flexors, flexoextensor muscles of the fingers, etc. (A).

Similarly, weight-lifting exercises should be directed at loading the bone segments most affected by the complications of osteoporosis, i.e. hip, spine and wrist in subjects at risk for fracture (A).

As an activity with high compliance, brisk walking for at least 1 h a day 3 times a week should be encouraged (E2).

Cognitive serial control exercises and proprioceptive biofeedback exercises are advised to improve control of posture and motion (E1).

Precautions

Activities to be avoided are:
— high-impact exercises;
— chest bends;
— trunk rotation with weights;
— weight lifting (E1).

Women with increased risk of falls and postmenopausal osteoporotic women with a history of fracture

Rehabilitation treatment objectives:
— to prevent falls and fractures;
— to improve balance and coordination;
— to increase muscle strength, flexibility and aerobic capacity;
— to improve posture and proprioceptive afferents of the spine and lower limbs;
— to reduce pain;
— to inform patients about healthy lifestyle and risk factors for falls (E1).

The objectives in this patient group are chiefly to reduce the risk of falls and fractures and to counteract the loss of bone density. Moreover, studies on this group have emphasized the importance of improving muscle strength (A).

1. Exercise selection

Since tolerance to exercise in these women may be very low, training should begin with the lowest impact exercises (*e.g.* sitting) (E1).

Training should begin with low intensity low impact exercises (E1).

To strengthen muscles, exercises should begin with nonloaded short bars. Exercising in warm water permits movement with less pain. While there is no evidence suggesting that hydrokinesiotherapy is effective on bone, it may be useful because it promotes a sense of well-being, increases aerobic capacity, muscle strength and pain control (C).

Cognitive serial control exercises and proprioceptive biofeedback exercises are advised to improve control of posture and motion (E1).

Precautions

Fractures pose the greatest risk for this group (A).

High impact exercises are not recommended, nor should torsion or flexion be performed as they may cause vertebral collapse (A).

Low impact exercises that work against gravity or body weight are suggested (E1).

All exercises should be graded in intensity and impact (E1).

In subjects with back pain and manifest difficulty in postural control, bracing treatment (preferably semi-rigid or dynamic braces) may be associated.

Individual stress tolerance should be carefully observed (C).

2. Fall prevention

Diagnosis of osteoporosis should be associated with the identification of intrinsic factors that can increase the risk of falls (visual disturbance, joint disorders, particularly those of the lower limbs, hyposthenia, coordination, balance, concurrent pharmacological therapies, etc.) and extrinsic factors (environmental, daily planning etc.) (E1).

All such factors should be demonstrable to the patient and a remedy sought for them (E1).

The international literature contains studies on the effect of Tai Chi, demonstrating its efficacy in lowering the risk of falls. In Italy Tai Chi is not widely practiced, but programs that improve balance, muscle strength and coordination are recommended. Several Tai Chi techniques should be included in group exercises, particularly in women with balance disturbances and those unable to perform higher impact exercises (E1).

In this group it is important to evaluate the need of assistive devices to improve stability and balance and to prevent fractures, *e.g.* walking aids and protective hip braces (E1).

Strength training and balance exercises should also be suggested (E1).

Activities that promote coordination and balance even in frail persons, *e.g.* simple one-legged stance exercises repeated several times daily, should be encouraged (E2).

Where possible, high compliance activities such as brisk walking for 1 h a day at least 3 times a week should be promoted (E2).

Particularly frail individuals at high risk for falls, especially if institutionalized, should be advised to wear hip protectors (E1).

3. Posture and flexibility

Dorsal hyperkyphosis is often present in osteoporosis and is associated with vertebral collapse and pain. Postural education and self-correction are important for reducing pain and respiratory disturbances. As high compliance activities, brisk walking for 1 h a day at least 3 times a week should be encouraged (E1).

Exercises that strengthen trunk extensor muscles are very important for preventing worsening of deformities and bone loss (A).

These exercises may be performed in the prone position, with a pillow under the abdomen, and with or without a small weight (E1). They may also be performed in other positions, *e.g.* sitting, if the prone position is not tolerated (E2).

Exercises to increase chest expansion, rhomboid muscle strengthen, and balance should also be encouraged (C).

Patients should be rehabilitated to walk, using a walking aid when necessary (E1).

Stretching to improve musculotendinous extension should be a part of any rehabilitation program for the major muscle groups of the upper and lower limbs (E1).

The frequency, intensity and duration of prescribed exercises should be kept in mind so as to optimize the rehabilitation outcome (E1).

Exercises should also be repeated, as discontinuation leads to loss of benefit (A).

High impact exercises improve bone density; however, such exercises should be implemented with due caution (intensity, duration, frequency) in relation to the patient's bone density, balance and coordination for them to be both efficacious and safe (E1).

In subjects with back pain and manifest difficulty in postural control, bracing treatment (preferably semirigid or dynamic braces) may be added.

4. Pain management

In this patient group, pain is a prominent symptom and so requires attention in therapeutic intervention. Although only half of spinal fractures actually cause pain, patients are often referred to rehabilitation treatment for pain following spinal fracture. Other causes of pain are spinal deformities, joint and soft tissue stress.

Pain management is accomplished with medications, taking account of possible gastrointestinal and central nervous system side effects, physical therapy and bracing treatment (E1).

As a physical means, transepidermal neurostimulation (TENS) is a known antalgic therapy to treat chronic pain. It acts chiefly by stimulating the gate control system and so may be useful in treating pain from vertebral collapse (E1).

In addition, heat may be a useful aid in reducing muscle contractures and relieving pain (E1).

In subjects with back pain, rigid bracing may be added in the acute phase (recent spinal fracture), preferably with a semirigid or dynamic brace in the outcome phase.

Patient evaluation

After a diagnosis of osteopenia and osteoporosis has been established by BMD measurement, the physiatrist will perform an evaluation of rehabilitation. This will permit a definition of the project and specific rehabilitation programs (areas of motor function, transfer, walking, relational communication and social reentry), including any extraskeletal problems the patient may have.

The project should include efficacy indicators of adequate treatment. The evaluation methods listed below comprise systems and simple, inexpensive tools that can be easily implemented in most rehabilitation settings in Italy.

EVALUATION OF ANTHROPOMETRIC CHARACTERISTICS: height and body weight

CHEST EXPANSION.—It is measured at the xyphoid process with the patient standing and hands on the neck, at maximum expiration and maximum inspiration. Variation is deducted from the difference between the circumference of maximum inspiration and maximum expiration with the ruler held at the nose.

SPINAL DEFORMITY.—Recording of kyphosis (distance from wall to neck with the patient standing against the wall) and scoliosis (height of hump on bending forward).

FLEXIBILITY.—Vertebral (Schober test) and large joints (articular goniometry).

MUSCLE STRENGTH.—Dorsal extensors in isometric conditions (prone, pillow under the abdomen, maintaining the back extended for at least 20 s). Analysis of 1 RM (repetition maximum: maximum resistance a person can overcome after 1 repetition of an exercise) with isotonic devices in relation to the muscle group in question (Caution: do not use weights that are too heavy or bars that are too long). Grip strength with Jamar-type dynamometry.

WALKING AND GENERAL MOBILITY.—Walking test based on speed at which a short distance is walked (*e.g.* 20 m or 100 m) or mid-term resistance (distance walked in 2 min or 6 min of continuous walking). Timed up and Go test: the time a patient needs to get up from a chair, walk 3 meters, turn, walk back and sit down.

AEROBIC CAPACITY.—Treadmill or cycloergometer (60% of maximum heart rate).

BALANCE.—One-legged stance: the length of time a patient can stand between parallel bars on one foot without support. Preliminary trials are permitted. Sensitized Romberg test: how long the patient is able to stand steady with feet approximated (the toes of one foot touching the heel of the foot in front of it) and eyes open and then closed. Functional reach: the maximum distance a subject can reach in front by stretching the arms out with elbows extended, while standing steady on a platform. The Berg Balance Scale is one of the most commonly used tools to evaluate balance (Appendix 1).

FUNCTIONAL EVALUATION.—Timed sit to stand: the subject is asked to stand up from a sitting position and then sit down again as quickly as possible 10 times without using a support and without shoes. Physical performance test (PPT): a series of 7-9 functional tests that includes tasks of putting on and taking off a jacket, picking up small objects from the floor, rotating 360°, and climbing 1 or more sets of stairs.

PAIN.—Verbal or numeric evaluation of pain and visual analogue scales. The Short-Form McGill Pain Questionnaire (SF-MPQ) (Appendix 2). Monitoring of medications, analysis of verbal and nonverbal behavior, pain diary. Brief Pain Inventory or Pain Disability Index (Appendix 3). Analysis of affective disorders (depression, anxiety, etc.).

The evaluation results should be analyzed individually for each patient and collectively within the rehabilitation project to measure the progress and efficacy of the program and the possible need for modification.

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APPENDIX

Appendix 1

Berg Balance Scale

1. Sitting to standing

Instructions: Please stand up. Try not to use your hands for support.

4 ❒ able to stand without using hands and stabilize independently
3 ❒ able to stand independently using hands
2 ❒ able to stand using hands after several tries
1 ❒ needs minimal aid to stand or to stabilize
0 ❒ needs moderate or maximal assist to stand

2. Standing unsupported

Instructions: Please stand for 2 min without holding.

4 ❒ able to stand safely 2 min
3 ❒ able to stand 2 min with supervision
2 ❒ able to stand 30 s unsupported
1 ❒ needs several tries to stand 30 s unsupported
0 ❒ unable to stand 30 s unassisted

If a subject is able to stand 2 min unsupported, score full points for sitting unsupported. Proceed to item #4.

3. Sitting with back unsupported but feet supported on floor or on a stool

Instructions: Please sit with arms folded for 2 min.

4 ❒ able to sit safely and securely 2 min
3 ❒ able to sit 2 min under supervision
2 ❒ able to sit 30 s
1 ❒ able to sit 10 s
0 ❒ unable to sit without support 10 s

4. Standing to sitting

Instructions: Please sit down.

4 ❒ sits safely with minimal use of hands
3 ❒ controls descent by using hands
2 ❒ uses back of legs against chair to control descent
1 ❒ sits independently but has uncontrolled descent
0 ❒ needs assistance to sit

5. Transfers

Instructions: Arrange chairs for a pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use 2 chairs (1 with and 1 without armrests) or a bed and a chair.

4 ❒ able to transfer safely with minor use of hands
3 ❒ able to transfer safely definite need of hands
2 ❒ able to transfer with verbal cueing and/or supervision
1 ❒ needs 1 person to assist
0 ❒ needs 2 people to assist or supervise to be safe

6. Standing unsupported with eyes closed

Instructions: Please close your eyes and stand still for 10 s.

4 ❒ able to stand 10 s safely
3 ❒ able to stand 10 s with supervision
2 ❒ able to stand 3 s
1 ❒ unable to keep eyes closed 3 s but stays steady
0 ❒ needs help to keep from falling

7. Standing unsupported with feet together

Instructions: Place your feet together and stand without holding.

4 ❒ able to place feet together independently and stand 1 min safely
3 ❒ able to place feet together independently and stand for 1 min with supervision
2 ❒ able to place feet together independently and to hold for 30 s
1 ❒ needs help to attain position but able to stand 15 s feet together
0 ❒ needs help to attain position and unable to hold for 15 s

8. Reaching forward with outstretched arm while staNDING

Instructions: Lift arm to 90°. Stretch out your fingers and reach forward as far as you can. Examiner places a ruler at end of fingertips when arm is at 90°. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the finger reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.

4 ❒ can reach forward confidently >25 cm
3 ❒ can reach forward >12.5 cm safely
2 ❒ can reach forward >5 cm safely
1 ❒ reaches forward but needs supervision
0 ❒ loses balance while trying or requires external support

9. Pick up object from the floor from a standing position

Instructions: Pick up the shoe/slipper which is placed in front of your feet.

4 ❒ able to pick up slipper safely and easily
3 ❒ able to pick up slipper but needs supervision
2 ❒ unable to pick up but reaches 2-5cm from slipper and keeps balance independently
1 ❒ unable to pick up and needs supervision while trying
0 ❒ unable to try or needs assistance to keep from losing balance or falling

10. Turning to look behind over left and right shoulders while standing

Instructions: Turn to look directly behind you over toward left shoulder. Repeat to the right. Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.

4 ❒ looks behind from both sides and weight shifts well

3 ❒ looks behind one side only other side shows less weight shift
2 ❒ turns sideways only but maintains balance
1 ❒ needs supervision when turning
0 ❒ needs assist to keep from losing balance or falling

11. Turn 360°
Instructions: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.
4 ❒ able to turn 360° safely in 4 s or less
3 ❒ able to turn 360° safely one side only in 4 s or less
2 ❒ able to turn 360° safely but slowly
1 ❒ needs close supervision or verbal cueing
0 ❒ needs assistance while turning

12. Placing alternate foot on step or stool while standing unsupported
Instructions: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool 4 times.
4 ❒ able to stand independently and safely and complete 8 steps in 20 s
3 ❒ able to stand independently and complete 8 steps >20 s
2 ❒ able to complete 4 steps without aid with supervision
1 ❒ able to complete >2 steps needs minimal assist
0 ❒ needs assistance to keep from falling/unable to try

13. Standing unsupported one foot in front
Instructions: (demonstrate to subject)
Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width).
4 ❒ able to place foot tandem independently and hold 30 s
3 ❒ able to place foot ahead of other independently and hold 30 s
2 ❒ able to take small step independently and hold 30 s
1 ❒ needs help to step but can hold 15 s
0 ❒ loses balance while stepping or standing

14. Standing on one leg
Instructions: stand on one leg as long as you can without holding.
4 ❒ able to lift leg independently and hold >10 s
3 ❒ able to lift leg independently and hold 5-10 s
2 ❒ able to lift leg independently and hold ?3 s
1 ❒ tries to lift leg unable to hold 3 s but remains standing independently
0 ❒ unable to try or needs assistance to prevent fall

❒ Total score

Appendix 2

The Short-Form McGill Pain Questionnaire

The examiner reads the instructions aloud to the patient and then reads the adjectives listed, repeating them if necessary.

"Several of the words I will read describe your present pain. Tell me which words describe it best and the degree to which you feel that type of pain. Leave blank any words that do not apply to you".

	None	Mild	Moderate	Severe
Throbbing	0	1	2	3
Shooting	0	1	2	3
Stabbing	0	1	2	3
Sharp	0	1	2	3
Cramping	0	1	2	3
Gnawing	0	1	2	3
Hot-burning	0	1	2	3
Aching	0	1	2	3
Heavy	0	1	2	3
Tender	0	1	2	3
Splitting	0	1	2	3
Tiring-exhausting	0	1	2	3
Sickening	0	1	2	3
Fearful	0	1	2	3
Punishing-cruel	0	1	2	3

Total score

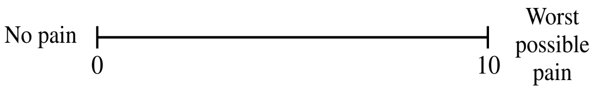
Present Pain Intensity Index (PPI)

For each category, the words below describe the worst possible pain. Mark which word best describes your pain.

1) No pain
2) Mild
3) Discomforting
4) Distressing
5) Horrible
6) Excruciating

Visual analogue scale

Tick along the scale the degree of your pain (0-100)



Appendix 3. Pain Disability Index

For each category, please circle the number which describes the levels of disability you typically experience. A score of 0 means no disability at all and a score of 10 means that all the activities in which you would normally be involved have been totally disrupted or prevented by your pain.

1. Family/home responsibilities. Activities related to the home or family, including chores and duties performed around the house (e.g. yard work) and errands or favors for other family members (e.g. driving the children to school).

No disability 0 1 2 3 4 5 6 7 8 9 10 Total disability

2. Recreation. Hobbies, sports and similar leisure time activities.

No disability 0 1 2 3 4 5 6 7 8 9 10 Total disability

3. Social activity. Participation with friends and acquaintances other than family members, including parties, theatre, concerts, dining out, and other social functions.

No disability 0 1 2 3 4 5 6 7 8 9 10 Total disability

4. Occupation. Activities that are a part of or directly related to one's job, including non-paying jobs such as that of a homemaker or volunteer work.

No disability 0 1 2 3 4 5 6 7 8 9 10 Total disability

5. Sexual activity. This category refers to the frequency and quality of one's sex life.

No disability 0 1 2 3 4 5 6 7 8 9 10 Total disability

6. Self-care. Activities of daily maintenance and independent daily living (taking a shower, driving, getting dressed, etc.)

No disability 0 1 2 3 4 5 6 7 8 9 10 Total disability

7. Life-support activities. Basic life-support behaviors such as eating, sleeping and breathing.

No disability 0 1 2 3 4 5 6 7 8 9 10 Total disability