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# Review
## Musculoskeletal Rehabilitation in Osteoporosis: A Review*

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**ABSTRACT: Measures of musculoskeletal rehabilitation play an integral part in the management of patients with increased fracture risk because of osteoporosis or extraskeletal risk factors. This article delineates current scientific evidence concerning nonpharmacologic approaches that are used in conjunction with pharmacotherapy for prevention and management of osteoporosis.**

Fractures caused by osteoporotic fragility may be prevented with multidisciplinary intervention programs, including education, environmental modifications, aids, and implementation of individually tailored exercise programs, which are proved to reduce falls and fall-related injuries. In addition, strengthening of the paraspinal muscles may not only maintain BMD but also reduce the risk of vertebral fractures. Given the strong interaction between osteoporosis and falls, selection of patients for prevention of fracture should be based on bone-related factors and on risk factors for falls. Rehabilitation after vertebral fracture includes proprioceptive dynamic posture training, which decreases kyphotic posturing through recruitment of back extensors and thus reduces pain, improves mobility, and leads to a better quality of life. A newly developed orthosis increases back extensor strength and decreases body sway as a risk factor for falls and fall-related fractures. Hip fractures may be prevented by hip protectors, and exercise programs can improve strength and mobility in patients with hip fracture. So far, there is no conclusive evidence that coordinated multidisciplinary inpatient rehabilitation is more effective than conventional hospital care with no rehabilitation professionals involved for older patients with hip fracture. Further studies are needed to evaluate the effect of combined bone- and fall-directed strategies in patients with osteoporosis and an increased propensity to falls.
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**Key words: clinical trials, exercise, bone, muscle, osteoporosis**

## INTRODUCTION

MOST ANTIFRACTURE STRATEGIES have focused on increasing the biomechanical competence of bone by reducing bone turnover. The efficacy of these interventions to reduce the risk of fracture has been consistently documented in well-defined patients with confirmed osteoporosis (low BMD or prevalent vertebral fracture). Fractures in the elderly—particularly fractures of the appendicular skeleton—result from two processes: a loss of skeletal integrity and an increased risk of falls. However, little attention has been given to the targeting of extraskeletal factors to prevent fractures in selected individuals. In the management of patients with increased risk of fracture because of osteoporosis or extraskeletal risk factors, measures of musculoskeletal rehabilitation should be considered as a prelude to, or even in conjunction with, pharmacotherapy to optimize musculoskeletal health, improve quality of life, and reduce the risk of fracture and fracture recurrence. Given the importance of muscle function to bone quality and to the risk of falls and fall-related injuries, this article emphasizes the role of elements of muscle function, such as strength and coordination, in the prevention of fracture and postfracture rehabilitation in patients with osteoporosis. Therefore, representative data related to musculoskeletal rehabilitation of osteoporosis were gathered based on a comprehensive MedLine search and review of the Cochrane Library.

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## PREVENTION OF OSTEOPOROTIC FRACTURES: ROLE OF EXERCISE AND MUSCLE STRENGTH

In addition to low bone mass, falling is a major factor contributing to the occurrence of symptomatic fractures in older people.[1] Approximately 40% of persons 65 years or older fall every year.[2] Inactivity and impaired neuromuscular function are well-known risk factors for falling and hip fractures.[3,4] In a prospective cohort study among 9704 white women ≥65 years of age, high-level physical activity was associated with a reduced risk for hip fracture but not wrist and vertebral fractures.[5] Graded reductions in the risk of hip fracture were found in women who performed moderate-to-vigorous activities for at least 2 h/week or who reported more hours of heavy chores per week. In contrast, the more hours a woman spent sitting per day, the higher her risk of hip fracture: women who sat for at least 9 h/day had a 43% higher risk than those who sat for <6 h/day. Although the dose–response relation with physical activity was established for hip fractures, it was less apparent for wrist and vertebral fractures.

A recently published review described the results of 13 randomized controlled trials of physical exercise or physical therapy to prevent falls in elderly people.[2] Pooled data from six studies evaluating the effect of untargeted group interventions showed no significant evidence of effectiveness based on the number of persons who fell. One of the six studies even reported a significant increase in falls in the briskly walking group, who had an excess risk of 15/100 person-years (95% CI, 1.4–29/100 person-years). In contrast, participants exposed to tai chi intervention had a lower rate of falling than controls (risk ratio, 0.51; 95% CI, 0.36–0.73).[6] Tai chi exercises were performed on a weekly basis for 15 weeks with supervision by an instructor. In addition, subjects were requested to try tai chi forms bid for 15 minutes.

Pooled data from three studies with a total of 566 community-dwelling women ≥80 years using the same individually tailored program of progressive muscle strengthening, balance retraining, and a walking plan indicated that this intervention reduced the number of individuals sustaining a fall over a 1-year period (pooled relative risk [RR], 0.80; 95% CI, 0.66–0.98).[7–9] The number of injurious falls also was reduced (pooled RR, 0.67; 95% CI, 0.51–0.89). Trials that investigated other than the above-described exercise interventions or the effect of exercising alone for elderly nursing home residents showed no evidence of effectiveness in preventing falls.[2]

However, in a recently published trial, Jensen et al.[10] reported that a multidisciplinary program of both general and resident-specific tailored strategies reduced falls and fall-related injuries in persons ≥65 years of age living in residential-care facilities. The strategies comprised educating staff, modifying the environment, implementing individual exercise programs, supplying and repairing aids, reviewing drug regimens, providing free hip protectors, and having problem-solving conferences after falls.[10] However, fracture endpoint trials based on strategies to prevent falls have not been reported.

Previous studies have shown that BMD in postmenopausal women was maintained or increased with progressive resistance training.[11–14] Back strength is significantly lower in persons with osteoporosis than in healthy persons.[15] As reported by Sinaki et al.,[16] strengthening of the paraspinal muscles can reduce the risk of vertebral fractures. They found that progressive, resistive back strengthening reduced the risk for vertebral fractures in women 58–75 years old.

## SELECTION OF PATIENTS FOR FRACTURE PREVENTION ACCORDING TO RISK OF FALLING AND BONE-RELATED RISK FACTORS

Currently, prevention of osteoporotic fractures is based mostly on drug therapies that have been proved to lower the risk of fractures in well-defined patients with low bone density or a prevalent vertebral fracture. Patient selection for drug treatment relies, therefore, almost exclusively on bone-related risk factors for fracture. Although low bone mass is considered a major risk factor for fractures, it alone is generally not sufficient to predict fractures.[17–19] There is a large overlap in BMD between patients with and without fractures.[20] Falling seems to be a major risk factor for fractures, especially appendicular fractures.[17–19,21] For predicting hip fracture, risk factors for falls and low BMD act as independent and additive risk factors.[3]

The risk for falling increases with age; thus, a large proportion of elderly have one or more falls per year.[22] However, only 5–10% of falls result in a fracture,[22] for several reasons. First, the orientation of the fall and the effectiveness of protective responses influence fracture risk in the elderly.[18,19,23] Second, interaction has been documented between osteoporosis and falls in the occurrence of fractures. In a French prospective cohort study of risk factors for hip fracture (the EPIDOS study), falls and risk factors for falls (low physical activity or disturbed body balance) were related to the occurrence of humerus fractures in patients with osteoporosis but not in subjects with normal BMD.[21] In line with these findings, a retrospective study of postmenopausal women by Geusens et al.[1] showed an increased risk for fractures during the preceding year in women who reported a fall during that period and had low BMD, but not in women with a history of falling and normal BMD nor in women who reported no falls irrespective of their BMD (Table 1). These results suggest that the risk for clinical, mainly appendicular, fractures is increased only in women with a combination of low BMD and incident falls. These findings also could explain why even women with osteopenia may have an increased risk of fracture, if they fall.

Studies of fall prevention have shown varying results, but none have shown a decrease in the number of fractures.[22] This apparent lack of antifracture efficacy might reflect the fact that these studies were not performed in patients selected based on low BMD. As shown by Kannus et al.,[24] hip protectors may decrease the risk for hip fractures in frail elderly subjects who are wearing the device when falling. In their study, selection of patients was not based on low BMD but on advanced age (>80 years) in combination with

Table 1. Association Among Osteopenia, Osteoporosis, History of Falls, and Fracture in the Preceding Year in Postmenopausal Women

| *BMD* | *No. of women* | *Adjusted risk** | *95% CI* |
|---|---|---|---|
| No recent fall | | | |
| Normal† | 1145 | 1.0 | — |
| Osteopenia‡ | 705 | 2.8 | 0.9–8.9 |
| Osteoporosis§ | 289 | 2.8 | 0.6–12.8 |
| Recent fall | | | |
| Normal† | 208 | 1.1 | 0.1–9.6 |
| Osteopenia‡ | 189 | 21.0 | 7.1–62.3 |
| Osteoporosis§ | 113 | 24.8 | 6.9–88.6 |

* Adjusted for age and body mass index, both included in logistic model as continuous variable.

† T score $> -1.0$.

‡ T score between $-1.0$ and $-2.5$.

§ T score $< -2.5$.

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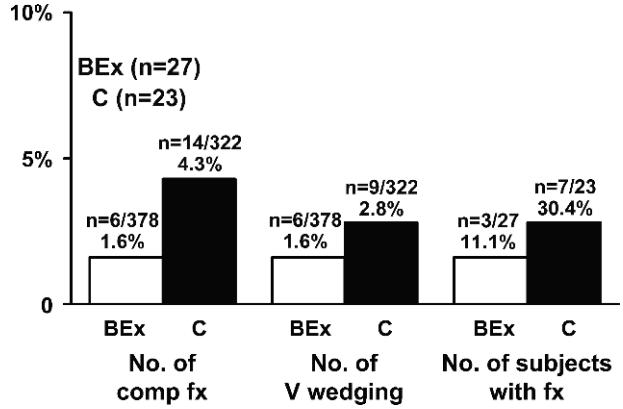


**FIG. 1.** Effect of back muscle strengthening on the rate of vertebral fractures in postmenopausal women. A total of 378 vertebrae was examined in the back exercise group, and a total of 322 vertebrae was examined in the control group (14 vertebrae, $T_4$–$L_5$, were examined in each patient). BEx, back exercise group; C, control group; comp fx, compression fracture; fx, fractures; V, vertebral. (Reproduced with permission from the International Osteoporosis Foundation and National Osteoporosis Foundation.[30])

frailty—both factors that are related to an increased risk for low BMD[25] and falls.[22] However, in the Fracture Intervention Trial,[26] postmenopausal women with low BMD or prevalent vertebral fracture were studied without selection based on the risk of falls. In these women, alendronate decreased the risk of vertebral and nonvertebral fractures. In the same study, however, alendronate had no effect in another cohort of women with normal baseline BMD,[26] a suggestion that bone-directed therapy is effective for reducing fracture risk only in patients with documented osteoporosis. Findings have been similar with risedronate, the first bisphosphonate to be studied with prevention of hip fracture as a primary endpoint(s).[27] Risedronate decreased the risk of hip fracture in women with established osteoporosis but not in women mainly selected based on risk factors for falls but without proven low BMD. Thus, bisphosphonates seem to reduce the risk of fracture only in women who have low BMD or prevalent vertebral fractures. It remains to be clarified whether measures to prevent falls—in combination with drug therapy—might further reduce the risk of fracture.

Considered together, these observations provide evidence for an interaction between osteoporosis and falls in the occurrence of clinical fractures. An increased number of falls may have contributed to the age-standardized increase in the incidence of appendicular fractures during the past decades.[28,29] An increased risk for falls is likely to be the main risk factor for fracture occurrence in subjects whose bone mass is not decreased to the level of osteoporosis. In addition to measuring BMD, risk evaluation for falls might, therefore, enhance the identification of patients at the highest risk for fractures. Further studies are needed to evaluate the effect of combined bone- and fall-directed strategies in patients with osteoporosis and an increased propensity to falls. Future research should address the antifracture efficacy of a combined strategy consisting of bone-forming agents and fall prevention measures.

## REHABILITATION AFTER VERTEBRAL FRACTURE

### *Exercise*

Back strengthening exercises can reduce thoracic hyperkyphosis, vertebral fracture (Fig. 1), loss of height, and pain of the anterior rib cage, which are the most disfiguring consequences of osteoporosis.[16,30] Improvement of back strength reduces the kyphotic posture that can occur with osteoporosis and aging.[31] Development of hyperkyphotic posture not only can predispose to postural back pain but also can increase the risk of falls. In subjects with hyperkyphosis, compensatory use of hip strategies rather than ankle strategies occurs during incidents of momentary challenges of balance.[32] In a controlled trial, use of a proprioceptive dynamic posture training (PDPT) program improved balance in osteoporotic subjects with kyphosis.[33]

Chronic pain may be caused by vertebral fractures per se or may be a result of postural deformities, such as hyperkyphotic or scoliotic changes in the spine, with inappropriate stretching of ligaments. Strong back muscles are significantly correlated with a decreased risk of vertebral fractures and kyphosis.[16] Hyperkyphosis is a common disfiguration after vertebral fracture. In patients with severe kyphosis, pressure of the lower part of the rib cage over the pelvic rim causes considerable flank pain and tenderness and compromises breathing.[34] With healthy posture, there is sufficient space between the lower ribs and the iliac crest, and no contact occurs, even on lateral bending of the trunk. In severe osteoporosis with compression fractures, substantial dorsal kyphosis, and loss of height, iliocostal contact occurs. This contact can result in iliocostal friction syndrome and flank pain.[35,36] Therefore, helping the patient to decrease kyphotic posturing through recruitment of back extensors for provision of better dynamic-static posturing can reduce pain, increase mobility, reduce depression, and im-

prove the patient's quality of life.[37] Sacral insufficiency fractures necessitate sedative physical therapy, reduction of weight bearing with use of gait aids, and orthoses.[38]

*Spinal orthoses*

Traditionally, spinal orthoses have been used in the management of thoracolumbar injuries treated with or without surgical stabilization. The vast majority of orthoses, however, are used in persons with back pain.[39] In the United States alone, >250,000 corsets are prescribed each year.[40] Until recently, however, most of these orthoses had never been tested under standardized conditions.[41] Kaplan et al.[41] found that rigid bracing is not necessary for managing postural osteoporotic back pain, and indeed, a weighted kypho-orthosis was more effective for patient compliance and pain relief. Moreover, the use of rigid thoracolumbar braces in osteoporosis is limited by factors such as short stature (<147 cm), atrophy of trunk muscles, hiatal or inguinal hernia, moderate to severe obesity, scoliosis caused by osteoporosis and compression fractures, and restricted respiration, leading to low compliance.[34,42]

Most recently, Pfeifer et al.[43] reported the effectiveness of orthoses for stabilizing osteoporotic vertebral fractures. In that study, the use of one particular, newly developed orthosis was associated with a significant increase in trunk muscle strength, most likely because of increased muscular activity while wearing the orthosis. This finding is consistent with those by Lantz and Schultz,[44] who described increased electrical activity of back muscles when a lumbosacral orthosis is worn, and support the concept of so-called biofeedback as an underlying principle of efficacy. Stronger back muscles may decrease the angle of kyphosis and thus improve body height.[31] This result may be associated with better posture and a correction of the center of gravity, which then results in less body sway.[33] Because body sway is a well-documented risk factor for falls and fall-related fractures,[45] this change of the center of gravity may be accompanied by a lower rate of falls and nonvertebral fractures.[46] This assumption is further supported by the findings of Sinaki and Lynn,[33] who described a reduction in the risk of falls through PDPT in osteoporotic women with kyphotic posturing. Given the widespread use of orthoses in various diseases, there is an urgent need for controlled clinical trials to further elucidate functions and applications of these technical devices.

*Vertebroplasty (kyphoplasty)*

Another technique that recently has been advocated for the management of vertebral fractures is percutaneous transpedicular polymethylmethacrylate vertebroplasty (PTPV). This procedure consists of an injection of acrylic cement (such as polymethylmethacrylate) into a partially collapsed vertebral body. The objective is to relieve back pain related to vertebral fracture and augment the vertebral mechanical stability.[47,48] In patients with osteoporotic fractures who underwent vertebroplasty, Jensen et al.[47] found that the use of narcotics and analgesics decreased in 63% of cases, increased in 7%, and remained the same in 30%. Ambulation and mobility improved in one-half of the patients, became worse in 1%, and did not change in 48%.[47] Current data about these types of procedures are hampered by lack of randomized placebo-controlled trials that have adequate duration of follow-up. Complications that may occur with this procedure include pressure on spinal cord or nerve roots, pain and weakness, pulmonary embolism (if cement enters the blood, it may travel to the lungs), rib fracture after lying on the stomach for a prolonged period during the procedure, infection, and bleeding. In addition, putting methylmethacrylate into fractured vertebrae may cause the adjacent vertebra to fracture more easily. PTPV can provide pain relief in a high percentage of patients with refractory pain caused by spinal compression fractures.[49] However, vertebroplasty does not substitute for rehabilitative measures that are needed after fracture.

## REHABILITATION AFTER HIP FRACTURE

By any measure, hip fracture is the most devastating complication of osteoporosis. The mortality rate in patients with hip fracture is 12–20% higher than in persons of similar age and sex who have not had a fracture.[50] Of those who survive the operative intervention for an osteoporotic hip fracture, less than one-third are restored to their prefracture functional state, and both those with and those without restored status require some form of ambulatory support or even institutionalized care.[51] Therefore, it is imperative that we continue to refine our treatment approaches, with the goal of improving the outcome.

*Measures to prevent falls*

Reduced muscle strength, lack of coordination, hyperkyphosis, increased postural sway, slow walking velocity, and poor functional performance have been identified as important risk factors for falls.[32,45,52] In elderly individuals at risk, there is strong evidence that PDPT and exercise programs can improve fall-related risk factors and can reduce the incidence of falls.[33,53,54] Multitargeted interventions—including exercise programs designed to improve strength or balance, education programs on home safety and fall prevention, medication adjustments, and environmental modification—may be even more effective for reducing the risk of falling.[2] However, although treatment, including exercise, for elderly people reduces the risk of falls, none of the studies individually or collectively in any meta-analysis had an effect on the occurrence of fall-related osteoporotic fracture. That issue will have to await a clinical trial specifically designed for that purpose and may be particularly relevant to the design and implementation of strategies to prevent falls in patients with hip fracture.

Most hip fractures result from a fall, and thus, all patients who sustain a hip fracture should be assessed for the presence of risk factors for falls. Subsequently, different interventions that target multiple identified (intrinsic and extrinsic) risk factors of individual patients should be considered. There is now strong evidence that exercise programs can improve strength and mobility in patients with hip fracture.[55] However, further research is needed to ascertain whether the extent of improvement in these risk factors is sufficient to prevent falls and further fractures in this high-risk group of older people.

*Hip protectors*

Hip fractures may be prevented by the use of an external hip protector, a shell of polypropylene or polyethylene to absorb part of the energy from the impact of a fall, and more importantly, shunt the energy toward the soft tissues around the hip. Various studies,[24,56–59] including a pilot trial by Lauritzen et al.,[58] showed a lower incidence of hip fractures in nursing-home residents assigned to wear hip protectors. In other studies, including a well-designed trial by van Schoor et al.,[60] wearing a protective device was not effective for preventing hip fracture. Diversion of the impact away from the greater trochanter did not result in an increase in non-hip fractures. The available evidence suggests that most of the subjects who did sustain a hip fracture were not wearing the protector at the time of the event. This observation both magnifies the potential size of the effect of the intervention and points to compliance as a problem.[60] Methods to improve the compliance should be developed, and their effectiveness tested. Further studies also should examine whether the presence of a hip protector changes the activity level of the person, and subsequently, the risk for falls.

*Rehabilitation*

Intensive physical training is effective for improving strength and functional performance in older people, even among those who are frail and residing in a nursing home.[61,62] In a recent randomized intervention study by Hauer et al.,[63] a 3-month progressive resistance and functional training program increased strength and functional performance during rehabilitation after hip fracture.

Most studies of the effect of rehabilitation on functional recovery after hip fracture have involved acute or subacute rehabilitation facilities, targeting patients on wards and in postdismissal settings. The methods used in these studies differed considerably in aims, interventions, and outcomes, producing inconsistent and conflicting results.[64–69] According to a recent meta-analysis,[70] there is no conclusive evidence that coordinated multidisciplinary inpatient rehabilitation is more effective than conventional hospital care (no rehabilitation professionals involved) for older patients with hip fracture.

Because many community-living older persons who fracture a hip eventually return home, much of postfracture rehabilitation occurs at home; thus, little is known about effective ambulatory strategies for the rehabilitation of geriatric patients after hip operation. In a recent randomized controlled trial by Tinetti et al.,[71] a home-based systematic multicomponent rehabilitation strategy was no more effective for promoting recovery than usual home-based rehabilitation.

*Antiresorptive treatment*

Secondary prevention of hip fractures should be an integral part of the management of individuals who sustain hip fractures. One option is the prescription of medications that lower the risk of hip fracture. Such therapies that are currently available include calcium and vitamin D supplementation,[72] alendronate,[26] and risedronate.[27] The bisphosphonates and calcium reduce the risk of hip fracture by improving bone mass and bone quality, and vitamin D supplementation affects the risk of falling not only by increasing bone mass but also by improving muscle function.[73,74] However, the rate of use of these therapies among patients with hip fractures is low. Despite the fact that proven, efficacious drugs are now available for the treatment of osteoporosis, osteoporosis continues to be underdiagnosed and undertreated in the elderly, even after hip fracture.[75,76]

One of the many reasons why clinicians do not consistently initiate treatment for osteoporosis even after a hip fracture might be the fact that all of these drugs have been tested for primary prevention of hip fractures. No studies have yet evaluated either pharmacologic or nonpharmacologic measures aimed at secondary prevention of hip fractures. For example, it remains to be shown whether calcium supplementation after a hip fracture can reduce the subsequent loss of bone mineral from the contralateral hip, and in turn, diminish the risk of another hip fracture. However, data from patients with hip fracture have shown a significant relationship between calcium intake and bone loss from the proximal femur.[77] Prospective randomized trials to assess interventions targeted at this critical time period are certainly warranted.

## CONCLUSION

Patients who have both low BMD and a propensity to fall would benefit most from specific exercise programs as well as the use of hip protectors in some instances. Low BMD and the propensity to falls both contribute to osteoporotic fractures, particularly in the elderly. According to a recently published review,[2] professionally prescribed home-based balance retraining, muscle strengthening, and walking, as well as tai-chi group exercise and a multidisciplinary, multifactorial risk factor screening and intervention program, are likely to be beneficial for preventing falls in elderly people.

Rehabilitation after vertebral fractures caused by osteoporosis consists of improvement of muscle strength (particularly of the lower extremities) to decrease the risk of falls and fractures, back strengthening exercises to improve posture and decrease hyperkyphosis, and sedative physical therapy to decrease postural deficit-related pain. In addition, implementing a PDPT program can improve balance and may decrease hyperkyphosis.

Among other factors, a loss of musculoskeletal integrity after hip fracture is likely to have a major impact on the outcome of rehabilitation and on the risk of fracture recurrence. However, it remains to be clarified whether targeted interventions (pharmacologic or nonpharmacologic) might be able to modify this process by enhancing bone and muscle mass and thus facilitate postsurgical rehabilitation and reduce the risk of recurrent fractures.

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