J Musculoskelet Neuronal Interact 2008; 8(3):244-250

Review Article

Hylonome

Rehabilitation after falls and fractures

Y. Dionyssiotis, I.A. Dontas, D. Economopoulos, G.P. Lyritis

Laboratory for Research of the Musculoskeletal System, University of Athens, KAT Hospital, Kifissia, Greece

Abstract

Falls are one of the most common geriatric problems threatening the independence of older persons. Elderly patients tend to fall more often and have a greater tendency to fracture their bones. Fractures occur particularly in osteoporotic people due to increased bone fragility, resulting in considerable reduction of quality of life, morbidity, and mortality. This article provides information for the rehabilitation of osteoporotic fractures pertaining to the rehabilitation of the fractured patient, based on personal experience and literature. It also outlines a suggested effective and efficient clinical strategy approach for preventing falls in individual patients.

Keywords: Rehabilitation, Falls, Fractures

Introduction

Rehabilitation is a goal-oriented and time-limited process that focuses on making a functionally impaired person reach an optimal mental, physical and social functional level[1]. The dual role of rehabilitation in falls and fractures is presented in Figure 1. The rehabilitation team's aim is, on one hand to restore the functional level of people who sustained a fracture as a consequence of falling; on the other hand, when falling is not combined with fractures, the goal is to avoid the latter by educating the high risk groups. It is advised that any data concerning the history, frequency, characteristics, and the location where falls took place in the past year are collected, whilst monitoring of gait and balance disorders as well as intervening in order to improve both strength and balance, are important elements of the rehabilitation process.

There is an indisputable connection between the way a person falls and the consequent type of injury. Hence, wrist fractures are usually caused after falling either forward or backward with one hand outstretched, hip fractures typically occur after falling sideways, whereas direct falls upon the buttocks are associated with a much lower fracture risk[2]. During aging, a decrease in reaction time is expected, and therefore the ability to respond rapidly and effectively is reduced in older people compared with younger adults[3]. Studies of reaction time in stepping have typically observed a delay in step initiation and execution timing in older people[4,5]. Co-ordination time has also been linked to upper extremity fracture risk, as elderly people often delay in breaking the fall by outstretching the hand[6].

Rehabilitation after hip fracture

Successful operative treatment of hip fracture victims is necessary for the optimization of post-injury mobility and the functional recovery of the patient[7]. Rehabilitation after surgical stabilization of a hip fracture is crucial in order to restore pre-fracture function and avoid long-term institutionalization, the probability of which can be as high as 25% at the first year post-fracture[8].

Two evidence-based clinical practice guidelines suggesting possible treatments and rehabilitation pathways for hip fracture patients, agree that it would be best if they underwent multidisciplinary rehabilitation[9,10]. Multidisciplinary rehabilitation can be defined as the combined and co-ordinated use of medical, social, educational and vocational measures for training or retraining the individual to the highest possible level of function[11]. According to the Scottish Intercollegiate Guidelines Network (SIGN) clinical practice guidelines for hip fracture treatment, a corroborated history must be obtained within the first 48 hours of admission, containing data about the patient's mental status, pre-morbid activity and function,

The authors have no conflict of interest.

Corresponding author: Yannis Dionyssiotis, M.D., Ph.D., Rehabilitation Department, Rhodes General Hospital, 85100, Rhodes, Dodekanese, Greece
E-mail: idiony@otenet.gr

Accepted 24 June 2008

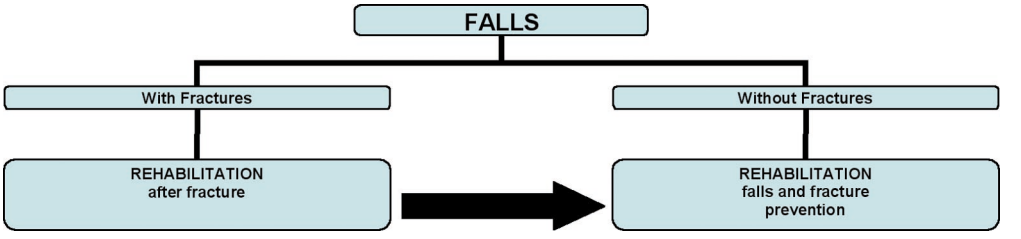

Figure 1. The role of rehabilitation in falls with or without fractures.

the presence of co-morbidity factors and the availability of social support. A multidisciplinary team facilitates the rehabilitation program, whilst patients with co-morbidity factors, poor functional ability or low mental test scores should undergo rehabilitation in a geriatric orthopedic rehabilitation unit. As for nutrition, it is recommended that all patients receive a high protein diet, enriched with minerals and vitamins[9].

The Australian guidelines suggest a co-ordinated rehabilitation program that starts just after admission and provides opportunities for early supported discharge, as long as the patient's mobilization is established. Frail patients should follow an inpatient program and are instructed to continue rehabilitation for some time after their discharge. All participants should be nutritionally assessed, so that they receive the recommended protein and energy supplementation, whilst a nasogastric tube is recommended in severe malnourished individuals. It should be noted that early assisted ambulation should begin 48 hours post-operatively[10].

The presence of other disabilities and co-existing medical problems, and the evaluation of the surgical operation are followed by a thorough clinical examination, through which the local post-operative clinical situation and possible medical problems emerging after surgery are evaluated[12].

Hip fracture patients should start breathing exercises so that pulmonary secretions are drained, thus reducing the risk of atelectasies and other complications deriving from the pulmonary system. "Pump like" energetic exercises (ankle pumps) and dorsal/plantar flexion of the foot, knee joint flexion, exercises for the hip and thigh, abduction exercises for the gluteal muscles and exercises for the quadriceps are important. Exercises of the upper extremities and trunk must also be part of the rehabilitation program, so that the patient can move in bed, stand up from a chair and later on be able to mobilize himself by using crutches or a stick. Abdominal and dorsal muscles should also be exercised isometrically and then energetically, in order to minimize the risk of low back pain during weight-bearing exercises.

There are some limitations on range of motion (ROM) after surgery, depending on the surgical procedure (hip fractures stabilized with internal fixation do not require ROM precautions). As soon as the patient who underwent a prosthetic replacement regains his vigilance, he is instructed to avoid: a) hip flexion greater than 70-90°, b) external rotation of the leg, c) adduction of the leg past midline. Toward this end, the patient must be instructed: a) not to bend forward from the waist more than 90°, b) not to lift the knee on the side of the surgery higher than the hip, and c) not to cross the legs, neither at the knee, nor the ankle. These precautions should be maintained for approximately 12 weeks. Because dislocations occur usually within the first 30 days more clinical studies are needed to determine the optimum length of time to maintain hip precautions[13,14].

By the third day after surgery, the patient should start training from a sitting position. During transfer from bed to chair, the hip must be abducted. Weight-bearing should start later on at 6th to 10th day when the patient is capable of standing on his feet by himself. Most of the patients are more likely to start using a walking frame and then progressively move to using crutches. In the partial weight-bearing stage of rehabilitation, the operated hip is allowed to bear only a load of 20-50% of body weight. Partial weight-bearing should be preserved for 6-12 weeks. Gradually, the patients will be allowed to start walking on crutches for 4-6 weeks. Complete weight-bearing depends on the surgical procedure. Usually, complete weight-bearing is scheduled after a period of 6 weeks following total hip arthroplasty and after 3 months following open reduction and internal fixation[12-14]. The physician should be alert and ready to treat life-threatening medical complications such as cardiopulmonary, deep venous thrombosis and ischemic episode, but also variable complications such as hip pain, uneven limb length, heterotopic ossification, decubitus ulcers and neurological complications that are likely to occur after hip fracture rehabilitation[15-19].

House modifications, as well as the use of accessories minimizing the risk of falling are key elements of occupational therapy (OT). Hip fracture patients should have OT training for skills adaptation and a home visit to get individualized support to improve the ability to perform activities of daily living and to speed up both mental and social recovery[20].

Periodical evaluation from rehabilitation specialists should monitor patients through sequential check-ups at the end of the 1st, 3rd and 6th post-surgical months, and continue at least once a year for the remainder of the patient's life[12]. Patients will return to their pre-morbid level of basic functions within 4-6 weeks of the fracture[21]. More advanced skills (e.g., driving, vocation, avocations) may take a longer period

of recovery or may need to be modified to permit performance. Driving skills are best delayed until at least 8 weeks post-fracture[21,22].

Patients are urged to keep on training even after they are discharged and their period of rehabilitation is over. After their strength is regained, they should follow individually tailored and targeted training for dynamic balance, strength, endurance, flexibility, gait and functional skills, training to improve 'righting' or 'correcting' skills to avoid a fall, backward-chaining and functional floor exercises[23]. The use of hip protectors as a hip fracture prevention strategy is not yet proven in community-dwelling old people. Despite evidence-based limitations, they will probably be useful in those at high risk of falls, who are willing and able to wear them[24].

Evaluation of the functional level of the patient is a critical issue when planning a rehabilitation program. The pre-fracture functional level is crucial to predict the post-fracture functional level after rehabilitation. A commonly used scale internationally to measure general independence is the Functional Independence Measurement (FIM) scale[25]. The FIM scale assesses many parameters concerning hip fractures. Through FIM, factors like mobility and self-care ability were found to be correlated with the intrahospitalization time. Moreover, bladder issues and number of locomotions are correlated with expenditure, whilst problems with their urinary bladder, clothing and mental status are associated with the patient's functionality[25,26].

Rehabilitation after vertebral fracture

There is no doubt that vertebral fractures have a high impact on the quality of life of all patients and that their occurrence is linked with digestive and respiratory morbidities, anxiety, depression and death[27-32]. Thereby, the incidence of a vertebral fracture should be followed by a limited period of bed rest, to avoid the hazards of deconditioning, accelerated bone loss, deep venous thrombosis, pneumonia, decubitus ulcers, disorientation and depression[33]. Bracing is also used in acute non-surgical management, whereas spinal orthoses relieve the pain and promote the healing process by stabilizing the spine. It should be noted that the latter reduces the load applied on the anterior column and vertebral body by restraining any attempt of forward flexion. Even though there is a lack of specific studies comparing various types of orthoses, it is widely accepted that all spine orthoses, whether made of cloth, metal, or plastic, or whether rigid or flexible, use a three-point pressure system[33].

The most broadly used types of spinal orthoses are: a) the TLSO type that provides support to the thoracolumbosacral spine by making it adopt an anatomically correct position (Knight-Taylor, Jewett, CASH or Cruciform Anterior Sternal, Boston), b) the PTS (Posture Training Support) type, which is a device that has shoulder straps connecting above the waist of the back, where a pouch holds small weights[34], c) Spinomed, the new "bracing" philosophy, based on biofeedback theory[35] and d) Osteomed, which is based upon the gate control theory of pain[36].

A program of physical therapy is necessary and helps prevent deformity by strengthening anti-gravity muscles and promoting postural retraining. Breathing exercises promote thoracic expansion and improve the heavily degraded pulmonary function found in patients with spinal osteoporotic fractures[37]. Instruction on the proper way of lifting things, as well as how to appropriately use a walker or a cane, could be beneficial and thus is strongly recommended[38]. Patients with fractures could subject themselves to low-intensity exercise and gentle strengthening programs (e.g., Tai Chi and hydrotherapy) and are strongly recommended to avoid high impact exercise or movements, so that they avoid suffering new vertebral fractures[39]. Forward bending of the spine or flexion exercises, especially in combination with twisting, should be avoided[38]. According to Bassey, this includes several old favourite exercises which are now considered outdated, namely straight-leg toe touches and sit ups (or crunches) for strengthening the abdominal muscles[39]. Sinaki and Mikkelsen reported that the latter are associated with a dramatically increased rate of vertebral fracture in osteoporotic women (89% compared to 16% of those who did extension exercises)[40]. As the acute fracture pain subsides, a walking program can begin with gentle strengthening exercises focusing on spinal extensor muscles[42]. A carefully supervised rehabilitation program should be started after 3 to 4 months, to strengthen the spinal extensor and abdominal muscles more aggressively[33,43].

Rehabilitation after Colles' fracture

Colles' fracture is the most common fracture in people over the age of 40[44]. The reason for prescribing physiotherapy after a fracture of the distal radius is that it serves primary mobilization which is the most important principle of fracture management, whereas rehabilitation programs generally start 7-8 weeks after the injury[45-48]. Physical therapy after a Colles' fracture consists of muscle strengthening, motion range recovery, wound healing and scar adhesion. Early reduction of edema is of primary importance in determining hand functions. Elevation of the hand above the heart's level and an active range of motion exercises are instructed to facilitate the pumping action of hand muscles to decrease swelling. A 15 minute hand-wrap with paraffin should be followed by exercise of equal duration. The hand should be kept in both cold and hot water in order to augment venous return. Exercise programs consist of passive range of motion; transverse scar massages, progressive resistive exercise, massage and an active range of motion exercises. Exercise programs focus on strengthening both extrinsic and intrinsic muscle groups of the hand[47,49]. Fingers 'wall walking', bilateral paper ripping, circular 'dusting', simple 'blackboard writing' and drawing tasks, various opposition and pinching are among the most recommended exercises. These activities are graded according to resistance, type of motion and grasp strength. Splinting helps develop the range of motion. Physical therapy is followed by occupational therapy for 3 weeks[50-52].

Rehabilitation in falls and fracture prevention

The second role of rehabilitation is to avoid falls and fall-related fractures. Falls are a serious problem facing the elderly. Approximately 30% of people over the age of 65 fall each year, reaching 50% of those aged 80 years or more[53]. Falling results in increased mortality, morbidity, reduced functioning and premature nursing home admissions. Falls generally result from an interaction of multiple and diverse risk factors and situations, many of which can be corrected[54]. Falls can also result in deterioration of physical functioning and quality of life, due to injury or due to fear of falling. Nevitt et al. found that 16% of fallers reported that they limited their usual activity because of fear of falling and one third of fallers reduced their participation in social activities[55]. According to Yardley et al., fear of falling is reported by one in four older people in the community and can lead to distress and reduced quality of life, increased medication use and activity restriction, further decline in physical functioning, greater falling risk and admission to institutional care[56].

It is necessary to assess possible intrinsic and extrinsic risk factors for falls, as well as the individual's exposure to risk[57]. Identifying risk factors is as important as appreciating the interaction and probable synergism between multiple risk factors, because the percentage of persons falling increases from 27% for those with no or one risk factor to 78% for those with four or more risk factors[58,59].

Important potentially modifiable risk factors for community-dwelling older adults are: mental status, psychotropic drugs, multiple drugs, environmental hazards, vision, lower extremity impairments, balance, gait status and for institution-dwelling older adults: mental status, depression, urinary incontinence, hypotension, hearing, balance, gait, lower extremity impairments, low activity level (exercise less than once a week), psychotropic drugs, cardiac drugs, analgesics and use of a mechanical restraint. Non-modifiable risk factors (i.e., hemiplegia, blindness) also exist[60].

Interventions to prevent falls may be planned to reduce a single intrinsic or extrinsic risk factor of falling or be broadly focused to reduce multiple risk factors simultaneously[61]. Single evidence-based interventions include exercise, reassessment of medications and environmental modification[54,62]. Although exercise has many proven benefits, the optimal type, duration and intensity of exercise for falls prevention remain unclear. Older people who have had recurrent falls should be offered long-term exercise and balance training.

Tai Chi is a promising type of balance exercise, although it requires further evaluation before it can be recommended as the preferred method for balance training[54]. Tai Chi, which consists of slow, rhythmic movements emphasizing on the trunk rotation, weight shifting, co-ordination, and a gradual narrowing of the lower extremities' position, is thought to be an excellent choice of exercise for the elderly[63].

There is experimental evidence from both cross-sectional and longitudinal studies that Tai Chi exercise has beneficial effects on balance control and that the postural stability is improved more by Tai Chi than by other types of exercise[64-66]. However, Tai Chi has not been shown to reduce falls in frailer older people, so cannot be recommended for falls prevention to a group who have had hip fractures and are likely to be frail[67]. Those with a history of Colles' fractures and with only mild deficits of strength and power are more likely to benefit. It is the slow, smooth, 3-D nature of Tai Chi with its transitions of stance that challenge balance that will help reduce a person's risk of falls; if the person is too frail to lift one foot off the ground and move it forward, then the Tai Chi must be adapted so much that perhaps more static balance work is more appropriate to start with (Skelton DA, personal communication). Most studies regarding training after hip fracture conclude that combined training with task-specific and functionally based exercises may be a sensible way of retraining leg strength, balance and gait ability in elderly people after a hip fracture. The training thus may include a variety of gait exercises, step exercises, stair climbing, and rising from and sitting down on a chair[68-70].

In a review about the effectiveness of interventions to prevent falls in older adults, Chang et al. concluded that exercise programs help prevent falls with no differences between types of exercise[71]. The results from the FICSIT trials (Frailty and Injuries: Cooperative Studies of Intervention Techniques) suggest that interventions that addressed strength alone did not reduce falls. On the other hand, balance training may be more effective in decreasing falls risk than the other exercise components[72]. Gardner et al. concluded that exercise programmes must be regular and sustainable to be effective but more trials are required to determine the exercise type, frequency, duration, and intensity that are most effective in decreasing falls risk in different groups of older people[73]. However, as aging is related to reduced physical functioning, exercise prescription for falls prevention, except balance and strength training, may include exercises to increase the functional capabilities in all elderly people. The suggested solutions are low intensity balance exercises (tandem walking and standing on one's foot) combined with co-ordination exercises. Individuals, who are frail, severely kyphotic or suffer from pain or poor balance, may benefit from water exercise (hydrotherapy). People are also advised to undergo strengthening exercises of the quadriceps, hip abductors/extensors, back extensors and the arm muscles.

Patients who have fallen should have their medications reviewed. Studies have indicated that several categories of medications are potential causes for falls[74]. Further work is required in this area because many drugs commonly used by older persons are not systematically studied as risk factors for falls[75]. Central nervous system drugs, especially psychotropics, warrant particular attention since there is very strong evidence that use of these medications is linked to the occurrence of falls[54,62,74]. Reducing the total number of medications to four or fewer, if feasible, has also been demonstrated to reduce the risk of falling[54,62].

Environmental hazards could be a cause of falls[72]. In reducing environmental hazards, fall prevention programs may need to provide and install safety devices particularly in the

home[71]. Studies have shown that when older patients at increased risk of falls are discharged from hospital, a facilitated environmental home assessment should be considered[54,62].

There is emerging clinical evidence that alfacalcidol, a prodrug of D-hormone, improves muscle function[76]. Dukas et al. have shown that 1 μg alfacalcidol daily significantly reduces the number of falls (-54%) and fallers (-55%) in community-dwelling elderly women and men with a total calcium intake of more than 500 mg daily and normal vitamin D serum levels[77]. Other authors reported that cholecalciferol-calcium supplementation reduces falls by 46% to 65% in community-dwelling older women, but has a neutral effect on falls in men[78].

Prevention may be even more effective when multiple risk factors of falls are taken into account simultaneously. Most multifactorial fall prevention programmes have been successful in reducing the incidence of falls and risk factors of falling, especially when prevention has been individually tailored and targeted to populations at high risk of falling[61]. Multifactorial interventions should include: a) among community-dwelling older persons (i.e., those living in their own homes), gait training and advice on the appropriate use of assistive devices, review and modification of medication, especially psychotropic medication, exercise programs with balance training as one of the components, treatment of postural hypotension, modification of environmental hazards and treatment of cardiovascular disorders, b) among older persons in long-term care and assisted living settings: staff education programs, gait training and advice on the appropriate use of assistive devices and review and modification of medications, especially psychotropic medications[62].

In Greece, programs for fall prevention in urban and rural centers, remote, mountain areas and the islands need to be organised. Furthermore, public authorities are necessary to take action about the issue of falls. It is also worthwhile to identify the population with low bone mass and more than one risk factor for an osteoporotic fracture[79]. Fractures are common injuries and although fracture fixation and surgical techniques have improved, a co-ordinated, multidisciplinary rehabilitation approach emphasizing the patient's functional recovery and restoration of quality of life is vital.

References

1. United Nations. World Programme of Action Concerning Disabled Persons. Division for Social and Policy Development, United Nations 2003. http://www.un.org/esa/socdev/enable/diswpa
2. Nevitt MC, Cummings SR. Type of fall and risk of hip and wrist fractures: the study of osteoporotic fractures. The Study of Osteoporotic Fractures Research Group. J Am Geriatr Soc 1993;41:1226-34.
3. Welford AT, Motor performance. In: Handbook of the Psychology of Aging, Bitten, JE and Schaie, KW (Editors), pp. 450-497, New York, Van Nostrand Reinhold Company, 1977.
4. Maki BE, McIlroy WE. Control of compensatory stepping reactions: age-related impairment and the potential for remedial intervention. Physiother Theory Pract 1999;15:69-90.
5. Rogers MW, Kukulka CG, Brunt D, Cain TD, Hanke TA. The influence of stimulus cue on the initiation of stepping in young and older adults. Arch Phys Med Rehabil 2001;82:619-24.
6. Adelsberg S, Pitman M, Alexander H. Lower extremity fractures: relationship to reaction time and coordination time. Arch Phys Med Rehabil 1989;70:737-9.
7. Koval KJ, Cooley MR. Clinical pathway after hip fracture. Disabil Rehabil 2005;27:1053-60.
8. Munin MC, Seligman K, Dew MA, Quear T, Skidmore ER, Gruen G, Reynolds CF III, Lenze EJ. Effect of rehabilitation site on functional recovery after hip fracture. Arch Phys Med Rehabil 2005;86:367-72.
9. Scottish Intercollegiate Guidelines Network. Prevention and Management of Hip Fracture in Older People. A National Clinical Guideline. Scottish Intercollegiate Guidelines Network, Edinburgh 2002. Guideline 52. Accessed 28 February 2004. http://www.show.scot.nhs.uk/sign/guidelines/published/index.html
10. Chilov M, Cameron ID, March LM. Evidence-based guidelines for fixing broken hips: An update. Med J Australia 2003;179:489-92.
11. Cameron ID. Coordinated multidisciplinary rehabilitation after hip fracture. Disabil Rehabil 2005;27:1081-90.
12. Rucco V, Visentini A, Pellegrini E. The rehabilitation project in hip arthroplasty patients. Eur Med Phys 2003; 39:45-57.
13. Kayali C, Agus H, Ozluk S, Sanli C. Treatment for unstable intertrochanteric fractures in elderly patients: internal fixation versus cone hemiarthroplasty. J Orthop Surg (Hong Kong) 2006;14:240-4.
14. Mont MA, Tankersley WS, Hungerford DS. In: Rehabilitation Secrets. Young MA, O'Yang B, Steins SA, (eds). Hanley and Belfus, Philadelphia, 1997:330-7.
15. Lawrence VA, Hilsenbeck SG, Noveck H, Poses RM, Carson JL. Medical complications and outcomes after hip fracture repair. Arch Intern Med 2002;162:2053-7.
16. Thorngren KG. Optimal treatment of hip fractures. Acta Orthop Scand 1991;62(Suppl.241):31-4.
17. Versluysen M. How elderly patients with femoral fracture develop pressure sores in hospital. Br Med J 1986;292:1311-3.
18. Rodriguez MJ, Austin E, McBride EJ. Peroneal nerve damage following insertion of Austin-Moore prosthesis. Arch Phys Med Rehabil 1964;45:283-5.
19. Bernardini B, Meinecke C, Pagani M. Comorbidity and adverse clinical events in the rehabilitation of older adults after hip fracture. J Am Geriatr Soc 1995;43:894-8.
20. Hagsten B, Svensson O, Gardulf A. Health-related quality of life and self-reported ability concerning ADL and IADL after hip fracture: a randomized trial. Acta

Orthop 2006;77:114-9.
21. Cifu DX. Rehabilitation of the elderly crash victim, in Retchin S (ed.): Geriatric Clinics: Medical Considerations for the Older Driver. 9(2) Philadelphia: WB Saunders Company; 1993:473-483.
22. MacDonald W, Owen JW. The effect of total hip replacement on driving reactions. J Bone Joint Surg Br 1988;70B:202-5.
23. Skelton DA, Dinan S, Campbell M, Rutherford O. Tailored group exercise (Falls Management Exercise - FaME) reduces falls in community-dwelling older frequent fallers (an RCT). Age Ageing 2005;6:636-9.
24. Parker MJ, Gillespie WJ, Gillespie LD. Effectiveness of hip protectors for preventing hip fractures in elderly people: systematic review. BMJ 2006;332:571-4.
25. Shabat S, Mann G, Nyska M, Maffulli N. Scoring systems to evaluate elderly patients with hip fractures. Disabil Rehabil 2005;27:1041-4.
26. Cornwall R, Gilbert MS, Koval KJ, Strauss E, Siu AL. Functional outcomes and mortality vary among different types of hip fractures: a function of patient characteristics. Clin Orthop Relat Res 2004;64-71.
27. Papaioannou A, Watts NB, Kendler DL, Yuen CK, Adachi JD, Ferko N. Diagnosis and management of vertebral fractures in elderly adults. Am J Med 2002;113:220-8.
28. Yamaguchi T, Sugimoto T, Yamauchi M, Matsumori Y, Tsutsumi M, Chihara K. Multiple vertebral fractures are associated with refractory reflux esophagitis in postmenopausal women. J Bone Miner Metab 2005;23:36-40.
29. Tosi LL, Bouxsein ML, Johnell O. Commentary on the AAOS position statement: recommendations for enhancing the care for patients with fragility fractures. Techniques Orthopediques 2004;19:121-5.
30. Cooper C, Atkinson EJ, Jacobsen SJ, O'Fallon WM, Melton LJ III. Population based study of survival after osteoporotic fractures. Am J Epidemiol 1993;137:1001-5.
31. Ismail AA, Cockerill W, Cooper C, Finn JD, Abendroth K, Parisi G, Banzer D, Benevolenskaya LI, Bhalla AK, Armas JB, Cannata JB, Delmas PD, Dequeker J, Dilsen G, Eastell R, Ershova O, Falch JA, Felsch B, Havelka S, Hoszowski K, Jajic I,Kragl U, Johnell O, Lopez Vaz A, Lorenc R, Lyritis G, Marchand F, Masaryk P,Matthis C, Miazgowski T, Pols HA, Poor G, Rapado A, Raspe HH, Reid DM, Reisinger W, Janott J, Scheidt-Nave C, Stepan J, Todd C, Weber K, Woolf AD, Ambrecht G,Gowin W, Felsenberg D, Lunt M, Kanis JA, Reeve J, Silman AJ, O'Neill TW. Prevalent vertebral deformity predicts incident hip though not distal forearm fracture: results from the European Prospective Osteoporosis Study. Osteoporos Int 2001;12(2):85-90.
32. Gold DT. Osteoporosis and quality of life psychosocial outcomes and interventions for individual patients. Clin Geriatr Med 2003;19:271-80.
33. Mazanec DJ, Podichetty VK, Mompoint A, Potnis A.Vertebral compression fractures: manage aggressively to prevent sequelae.Cleve Clin J Med 2003;70:147-56.
34. Sinaki M,Lynn SG. Reducing the risk of falls through proprioceptive dynamic posture training in osteoporotic women with kyphotic posturing: a randomized pilot study. Am J Phys Med Rehabil 2002;81:241-6.
35. Pfeifer M, Begerow B, Minne HW. Effects of a new spinal orthosis on posture, trunk strength, and quality of life in women with postmenopausal osteoporosis: a randomized trial. Am J Phys Med Rehabil 2004;83:177-86.
36. Hildebrandt HD, Vogt L. Der "Osteoporosebody"- eine multifunktionale Orthese. Orthopädie-Technik 2002; 2, Februar 53. Jahrgang:90-96.
37. Schlaich C, Minne HW, Bruckner T, Wagner G, Gebest HJ, Grunze M, Ziegler R, Leidig-Bruckner G. Reduced pulmonary function in patients with spinal osteoporotic fractures. Osteoporos Int 1998;8:261-7.
38. Bonner FJ Jr, Sinaki M, Grabois M, Shipp KM, Lane JM, Lindsay R, Gold DT, Cosman F, Bouxsein ML, Weinstein JN, Gallagher RM, Melton LJ III, Salcido RS, Gordon SL. Health professional's guide to rehabilitation of the patient with osteoporosis. Osteoporos Int 2003;14(Suppl.2):S1-22.
39. Bassey EJ. Exercise for prevention of osteoporotic fracture. Age Ageing 2001;30(Suppl.4):29-31.
40. Sinaki M, Mikkelsen BA. Postmenopausal spinal osteoporosis: flexion versus extension exercises. Arch Phys Med Rehabil 1984;65:593-6.
41. Pfeifer M, Hinz C, Minne HW. Rehabilitation bei Osteoporose. J Menopause 2005;12:7-13. www.osteoporosis.org.au.
42. Rapado A. General management of vertebral fractures. Bone 1996;18:191S-6S.
43. Sinaki M. Musculoskeletal rehabilitation. In: Riggs BL, Melton LJ, editors. Osteoporosis: Etiology, Diagnosis, and Management, 2nd ed. Philadelphia: Lippincott-Raven, 1995:435-473.
44. Apley GA, Soloman L. Apley's system of orthopaedics and fractures, 7th edn. Butterworth Heinemann, Oxford, 1993:150.
45. Adams JC, Hamblen DL . Outline of fractures, 10th edn. Churchill Livingstone, Edinburgh, 1992.
46. Gupta A. The treatment of Colles' fracture. Immobilisation with the wrist dorsiflexed. J Bone Joint Surg Br 1991;73:312-5.
47. Aspenberg P, Kopilov P. Hydroxyapatite spacer for open reduction of Colles' fracture. Scand J Plast Reconstr Surg Hand Surg 1994;28:157-9.
48. Jones LA. The assessment of hand function: a critical review of techniques. J Hand Surg [Am] 1989; 14(2Pt1):221-8.
49. Morey KR and Watson AH. Team approach to treatment of the posttraumatic stiff hand. A case report. Phys Ther 1986;66:225-8.
50. Kopylov P, Johnell O, Redlund-Johnell I, Bengner U. Fractures of the distal end of the radius in young adults:

a 30-year follow-up. J Hand Surg [Br] 1993;18:45-9.
51. Roysam GS.The distal radio-ulnar joint in Colles' fractures. J Bone Joint Surg Br 1993;75(1):58-60.
52. Christensen OM, Kunov A, Hansen FF, Christiansen TC, Krasheninnikoff M. Occupational therapy and Colles' fractures. Int Orthop 2001;25:43-5.
53. Skelton DA, Becker C, Lamb SE, Close JCT, Zijlstra W, Yardley L, Todd CJ. Prevention of Falls Network Europe: a thematic network aimed at introducing good practice in effective falls prevention across Europe. Eur J Ageing 2004;1(1):89-94.
54. Guideline for the Prevention of Falls in Older Persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. J Am Geriatr Soc 2001; 49:664-72.
55. Nevitt MC, Cummings SR, Hudes ES. Risk factors for injurious falls: a prospective study. J Gerontol 1991;5:M164-70.
56. Yardley L, Beyer N, Hauer K, Kempen G, Piot-Ziegler C, Todd C. Development and initial validation of the Falls Efficacy Scale-International (FES-I). Age Ageing 2005;34:614-9.
57. Todd C, Skelton D. What are the main risk factors for falls among older people and what are the most effective interventions to prevent these falls? 2004, Copenhagen WHO Regional Office for Europe (Health Evidence Network Report). http://www.euro.who.int/document/E82552.pdf
58. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1988;319:1701-7.
59. Graafmans WC, Ooms ME, Hofstee HMA, Bezemer PD, Bouter LM, Lips P. Falls in the elderly: a prospective study of risk factors and risk profiles. Am J Epidemiol 1996;143:1129-36.
60. Moreland J, Richardson J, Chan DH, O'Neill J, Bellissimo A, Grum RM, Shanks L. Evidence-based guidelines for the secondary prevention of falls in older adults. Gerontology 2003;49:93-116.
61. Sjösten NM, Salonoja M, Piirtola M, Vahlberg T, Isoaho R, Hyttinen H, Aarnio P, Kivelä SL. A multifactorial fall prevention programme in home-dwelling elderly people: a randomized-controlled trial. Public Health 2007;121(4):308-18.
62. Tinetti ME. Clinical practice. Preventing falls in elderly persons. N Engl J Med 2003;348:42-9.
63. Mark BS. Combined Tai Chi Chuan. Boston, Mass: Chinese Wushu Research Institute; 1979.
64. Wolf SL, Coogler C, Xu T. Exploring the basis for Tai Chi Chuan as a therapeutic exercise approach. Arch Phys Med Rehabil 1997;78:886-92.
65. Wolfson L, Whipple R, Derby C, Judge J, King M, Amerman P, Schmidt J, Smyers D. Balance and strength training in older adults: intervention gains and Tai Chi maintenance. J Am Geriatr Soc 1996;44:498-506.
66. Tse SK, Bailey DM. Tai chi and postural control in the well elderly. Am J Occup Ther 1992;46:295-300.
67. Wolf SL, Sattin RW, Kutner M, O'Grady M, Greenspan AI, Gregor RJ. Intense tai chi exercise training and fall occurrences in older, transitionally frail adults: a randomized, controlled trial. J Am Geriatr Soc 2003;51:1693-701.
68. Sherrington C, Lord SR, Herbert RD. A randomized controlled trial of weight-bearing versus non-weight-bearing exercise for improving physical ability after usual care for hip fracture. Arch Phys Med Rehabil 2004;85:710-6.
69. Hauer K, Specht N, Schuler M, Bärtsch P, Oster P. Intensive physical training in geriatric patients after severe falls and hip surgery. Age Ageing 2002;31:49-57.
70. Lindelöf N, Littbrand H, Lindström B, Nyberg L. Weighted belt exercise for older frail women with hip fracture – a single subject experimental design study. Advances in Physiotherapy 2002;4:54-64.
71. Chang JT, Morton SC, Rubenstein LZ, Mojica WA, Maglione M, Suttorp MJ, Roth EA, Shekelle PG. Interventions for the prevention of falls in older adults: systematic review and meta-analysis of randomised clinical trials. BMJ 2004;328:680-7.
72. Lord SR, Sherrington C, Menz HB, Close J. Falls in Older People: Risk Factors and Strategies for Prevention. Second Edition. New York: Cambridge University Press; 2007.
73. Gardner MM, Robertson MC, Campbell AJ. Exercise in preventing falls and fall related injuries in older people: a review of randomised controlled trials. Br J Sports Med 2000;34:7-17.
74. Hartikainen S, Lönnroos E, Louhivuori K. Medication as a risk factor for falls: critical systematic review. J Gerontol A Biol Sci Med Sci 2007;62:1172-81.
75. Wyman JF, Croghan CF, Nachreiner NM, Gross CR, Stock HH, Talley K, Monigold M. Effectiveness of education and individualized counseling in reducing environmental hazards in the homes of community-dwelling older women. J Am Geriatr Soc 2007;55:1548-56.
76. Runge M, Schacht E. Multifactorial pathogenesis of falls as a basis for multifactorial interventions. J Musculoskelet Neuronal Interact 2005;5:127-34.
77. Dukas L, Bischoff HA, Lindpaintner LS, Schacht E, Birkner-Binder D, Damm TN, Thalmann B, Stahelin HB. Alfacalcidol reduces the number of fallers in a community-dwelling elderly population with a minimum calcium intake of more than 500 mg daily. J Am Geriatr Soc 2004;52:230-6.
78. Bischoff-Ferrari HA, Orav EJ, Dawson-Hughes B. Effect of cholecalciferol plus calcium on falling in ambulatory older men and women: a 3-year randomized controlled trial. Arch Intern Med 2006;166:424-30.
79. Dontas IA, Yiannakopoulos CK. Risk factors and prevention of osteoporosis-related fractures. J Musculoskelet Neuronal Interact 2007;7:268-72.