Evidence Supporting Exercise and Rehabilitation in Osteoporosis

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Principles of Bone Physiology

- Bone Remodeling
  - Two types of bone, compact and spongy.
    - Compact bone looks solid and hard and is found on the outer part of bones.
    - Spongy bone is filled with holes, just like a sponge, and is found on the inside of bones.
  - The first signs of osteoporosis are seen in bones that have a lot of spongy bone, such as the spine, hip, and wrist.
- Wolf's law
  - Bone's response to stress

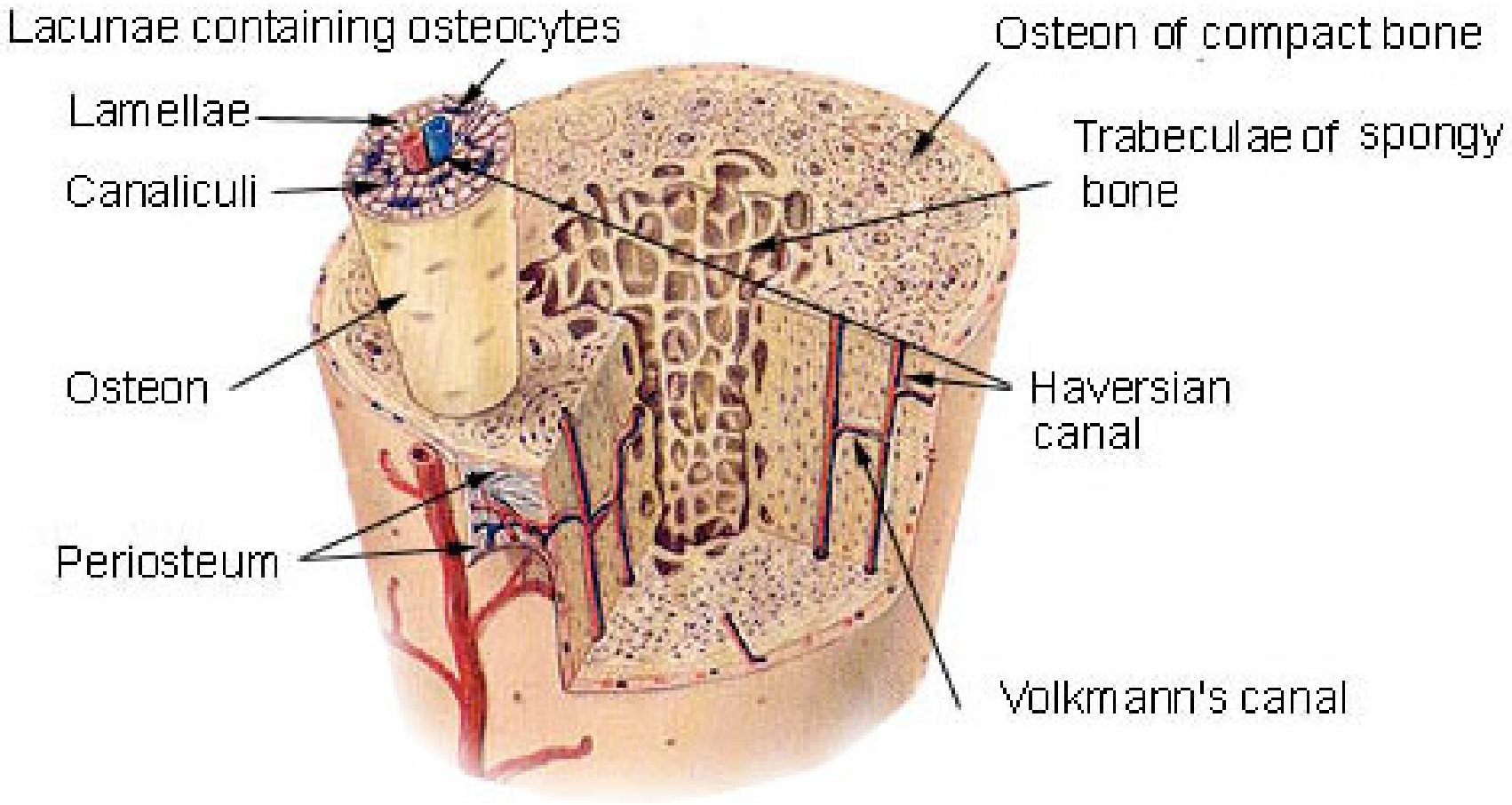
Bone Remodeling

- Compact bone consists of closely packed osteons or haversian systems which are surrounded by concentric rings (lamellae) of matrix.
- The bone cells (osteocytes) are between the rings of matrix (in the lacunae).

Bone Remodeling

- Spongy (cancellous) bone is lighter and less dense than compact.
- Spongy bone consists of plates (trabeculae) and bars of bone adjacent to small, irregular cavities that contain red bone marrow.
- The canaliculi connect to the adjacent cavities, instead of a central haversian canal, to receive their blood supply.

Compact Bone & Spongy (Cancellous Bone)



http://training.seer.cancer.gov/module_anatomy/unit3_2_bone_tissue.html

Bone Remodeling is Dynamic

- Continuous modeling and remodeling (resorption and reformation of resorbed tissue).
- These processes are dependent on the metabolic activity of its constituent cells:
  - osteoblasts form bone,
  - osteocytes maintain bone
  - osteoclasts resorb bone.
- Nearly all bone diseases, or pathologies in fracture healing of bone, manifest aberrations in bone matrix production and/or the mineralization of this matrix.

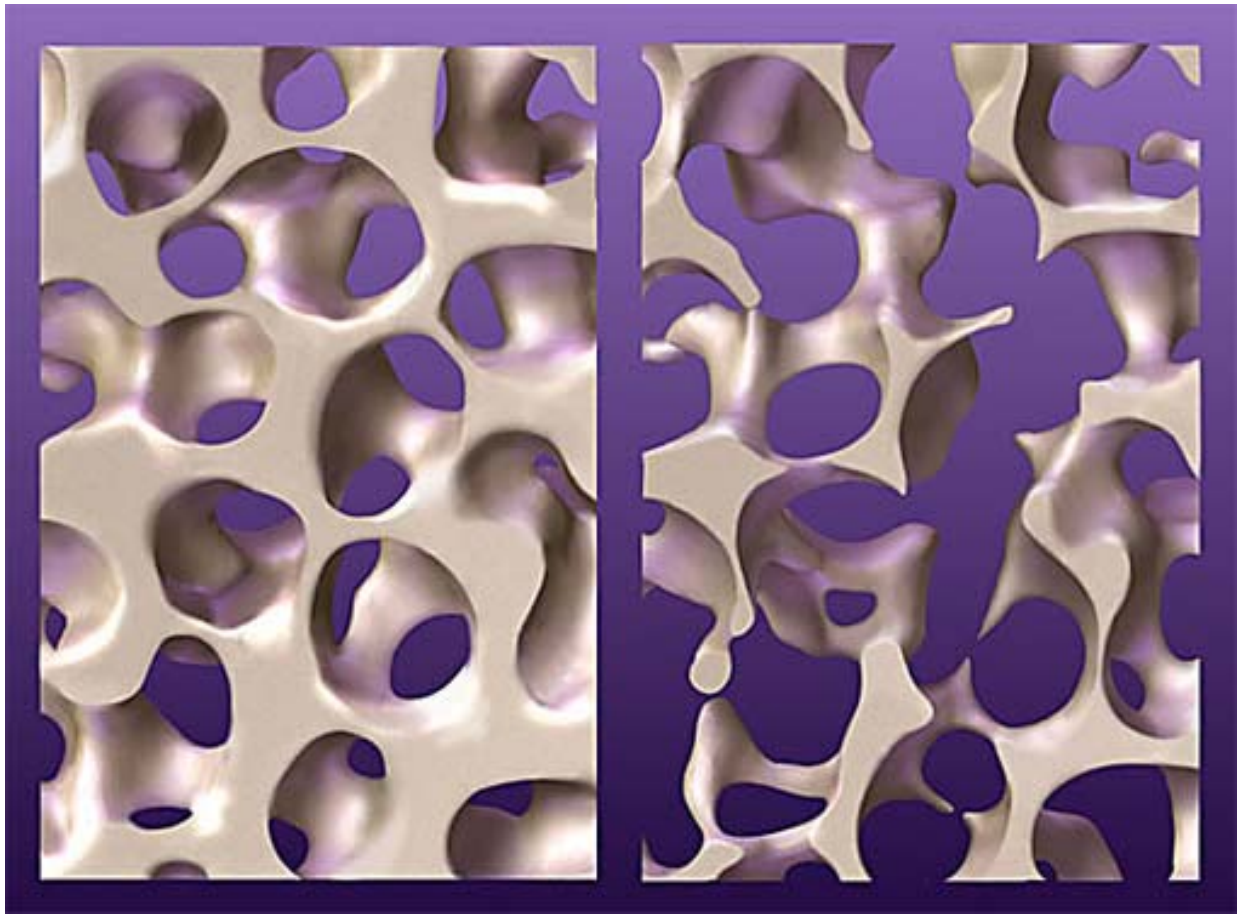
Wolf's Law – Example of Bone Remodeling

- Wolff's Law "In the 19th century, surgeon Julius Wolff proposed that mechanical stress was responsible for determining the architecture of bone...." (Forwood & Turner, 1995, p. 197).

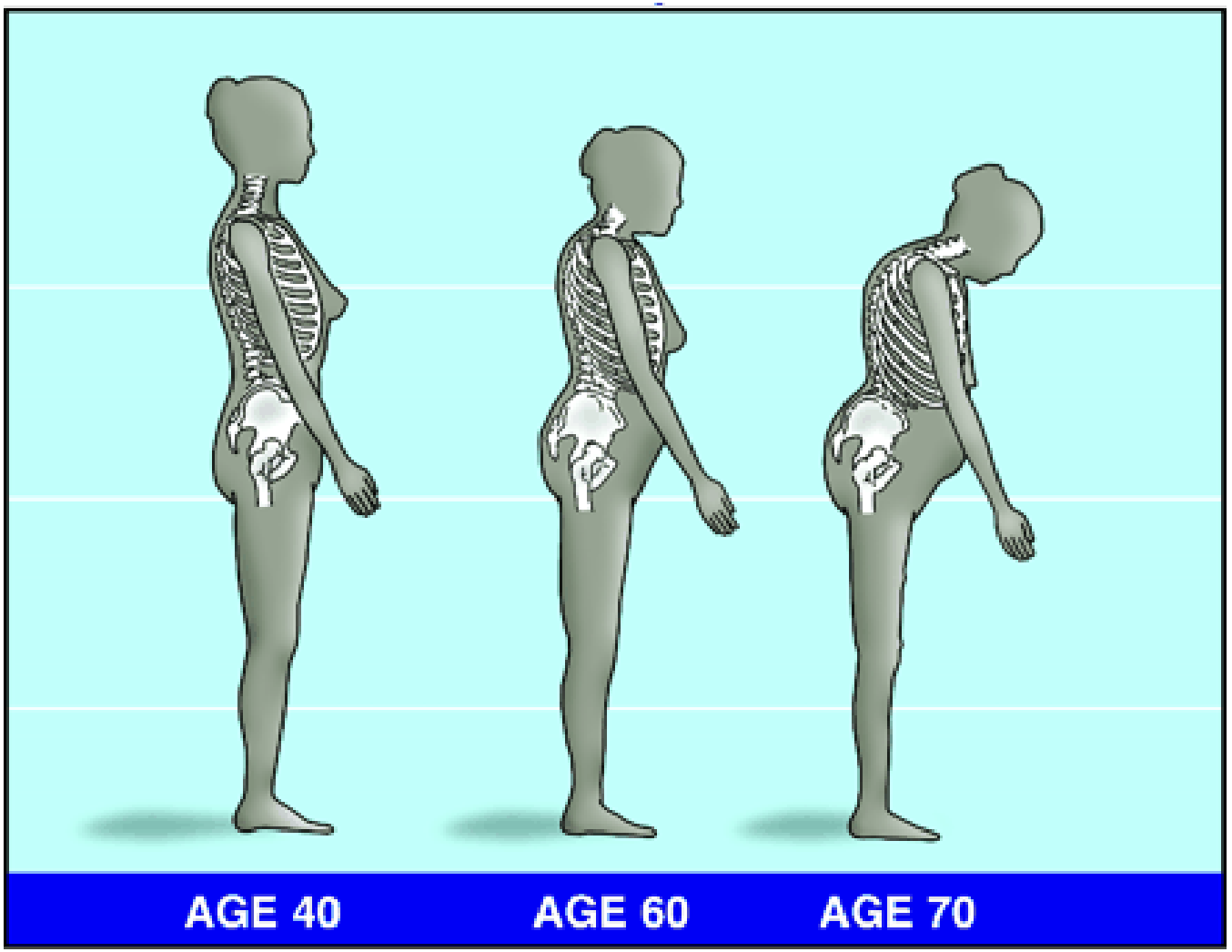
- "Remodeling of bone ... occurs in response to physical stresses - or to the lack of them - in that bone is deposited in sites subjected to stress and is resorbed from sites where there is little stress" (Salter, 1970, p.7).

Bone Pathology

- Bone changes with menopause
  - excessive bone loss produces thinning and increased porosity of the trabecular bone of the axial skeleton (vertebrae, ribs, and pelvis).
  - Cortices of cylindrical bones are thinned from the by endosteal resorption, resulting in enlargement of the medullary cavity without a change in the outside diameter of the bone. (loss of spongy bone)
  - Vertebral bodies (thoracolumbar especially) may be weakened by microfractures and collapse anteriorly. Result is compression fractures and wedging of the vertebrae, a loss of stature, and kyphotic deformity of the spine ("dowager's hump").



http://www.gcarlson.com/anatomical_osteobone.htm



www.fasebj.org/cgi/content/full/15/10/1677e/F2

Management of Bone Loss

- Medications
- Diet
- *Exercise*

Exercise and OP

- Applying Wolf's Law

EBP: Exercise in MS

Cochrane Review

- Nine high-methodological-quality RCTs(260 participants) met the inclusion criteria. Six trials focused on comparison of exercise therapy versus no exercise therapy, whereas three trials compared two interventions that both met our definition of exercise therapy.
- Best evidence synthesis showed
  - strong evidence in favor of exercise therapy compared to no exercise therapy in terms of muscle power function, exercise tolerance functions and mobility-related activities.
  - Moderate evidence was found for improving mood.
  - No evidence was observed for exercise therapy on fatigue and perception of handicap when compared to no exercise therapy.
  - Finally, no evidence was found that specific exercise therapy programmes were more successful in improving activities and participation than other exercise treatments.

Rietberg, M B. Brooks, et.al. [Review] [45 refs]Cochrane Database of Systematic Reviews. 2005.

EBP: Exercise in Managing Osteoporosis

Evidence supporting OP management in

- Post-Menopausal
- Other population groups

What do we know about MS?

Meta-Analysis on Walking to Promote bone Density

- Literature search for studies examining the effect of walking on BMD in postmenopausal women and men and women aged 50 years and older - ten studies met inclusion criteria
- The results of this meta-analysis do not suggest that walking interventions alone will limit demineralization at all skeletal sites. Perhaps other forms of exercise in addition to walking should be incorporated into training regimens for patients at risk for osteoporosis.

Palombaro, Kerstin M. 2005.

Healthy Post-Menopausal Women

Trunk muscle strength and self-reported exercise habits: do they predict subsequent bone loss in healthy post- menopausal women?

- 109 community-dwelling ambulatory postmenopausal Japanese women (age: 59.9 +/- 6.5 years) without any diseases affecting bone metabolism at baseline, followed for 4 years.
- Bone mineral density at baseline and at follow up was measured at the spine by DEXA
- isokinetic concentric and eccentric peak torques of the trunk flexors and extensors were measured at baseline
- exercise habits of the subjects were evaluated through detailed interviews.

- RESULTS: eccentric trunk flexor and extensor torques correlated with a change in bone mineral density while exercise habits showed no correlation.
- Postmenopausal women with decreased trunk muscle torque may be at increased risk for osteoporosis and should be a target group for preventive measures.

Iki, Masayuki. Saito, Yukie. Et. al. 2006 Feb.

Post- Menopausal Women: Exercise and Calcium Intake

Examined exercise frequency with calcium intake (CI) with change in bone mineral density (BMD), measurement with DEXA.

- 167 calcium-supplemented (800 mg/day) sedentary women (56.1+/-4.5 years) randomized to a 4 year progressive strength training exercise program or to control. Fifty-four percent of the women were using hormone therapy (HT) at baseline.
- Exercisers: two sets of six to eight repetitions of exercises at 70-80% of one repetition maximum, three times weekly.
- RESULTS: Exercise frequency was positively and significantly related to changes in femur trochanter and neck, lumbar spine, and total body BMD.
- Significant, positive, association between BMD change and ExFreq supports the long-term usefulness of strength training exercise for the prevention of osteoporosis in postmenopausal women, especially HT users.

Cussler, Ellen C. Going, Scott B. et. al. 2005 Dec.

Type of Exercise to Promote Remodeling

- Compared the effect of slow and fast resistance exercises on 53 postmenopausal women randomly assigned to strength training (ST) or power training group (PT).
- Intervention: progressive resistance training, gymnastics session, and home training for 12 mo. During the resistance training, the ST group used slow and the PT group fast movements. All subjects were supplemented with Ca and vitamin D.
- BMD measured at the lumbar spine, proximal femur, and distal forearm by DEXA
- significant between-group differences were observed for BMD at the lumbar spine ($P < 0.05$) and the total hip ($P < 0.05$). PT group maintained BMD at the spine and the hip, the ST group lost significantly at both sites.

Power training was more effective than strength training in reducing bone loss in postmenopausal women.

Stengel, S V. Kemmler, W. et. al. 2005 Jul.

Older Women with Low Bone Mass

Comparison of 3 group-based exercise programs (resistance training, agility training and general stretching) on back pain and health-related quality of life in older (aged 75-85 years) community-dwelling women with low bone mass (i.e., osteopenia or osteoporosis).

- 25-week randomized controlled trial, 98 community-dwelling women with low bone mass between the ages of 75 to 85 years old.

- All three types of group-based exercise programs significantly reduced back pain and its related disabilities, but only resistance and agility training significantly improved health-related quality of life in community-dwelling older women with low bone mass.

Liu-Ambrose, Teresa Y L. Khan, Karim M. et.al. 2005 Nov.

Older Women Weight Bearing Exercise

Effect of combined weight-bearing training program 2x/week on bone mineral density and neuromuscular function.

- 48 community living women [66-87 years old] participated in a 12-month prospective, randomized, controlled, trial. Pairwise age-matched and randomly assigned to either an exercise group (n=24) or a control group (n=24).
- Fifty minute exercise program of a combination of strengthening, aerobic, balance and coordination exercises.
- RESULTS: intervention group significant increments in bone mineral density of the Ward's triangle (8.4%, $P<0.01$) as well as improvement in maximum walking speed (11.4%, $P<0.001$) and isometric grip strength (9.9%, $P<0.05$), as compared to the control group.
- CONCLUSION: combined weight-bearing training program might reduce fracture risk factors by improving bone density as well as muscle strength and walking ability.

Englund, Undis. Littbrand, Hakan. et.al. 2005 Sep.

Physically Frail Elderly Women

- Does exercise training added to ongoing hormone replacement therapy (HRT) increases bone mineral density (BMD) in physically frail elderly women?
- Prospective controlled trial of 28 women on HRT, aged 75 and older with physical frailty.
- Participants were assigned to 9 months of supervised (EXER) or home (HOME) exercise. The EXER program started with physical therapy and gradually incorporated resistance and endurance training. The HOME program consisted of flexibility exercises.
- Larger increases in lumbar spine BMD in response to EXER than with HOME (3.5% vs 1.5%, P =.048), with a trend for larger increases in total body BMD (1.5% vs 0.2%, P =.058). There were no significant between-group differences in hip BMD.

Villareal, Dennis T. Binder, Ellen F. 2003 Jul.

FES in Spinal Cord Injury

Change in bone mineral density (BMD) after spinal cord injury (SCI). Can BMD loss be reversed with functional electric stimulation cycling exercises (FESCE).

- Fifteen males with SCI were included. Fifteen able-bodied males were also tested to compare BMD.
- FESCE for six months, then discontinued. BMD was performed before the FESCE, immediately after six months of the FESCE, and at the end of the subsequent six months.
- Before the FESCE, the BMD of the SCI subjects in every site, except the lumbar spine, was lower than that of the able-bodied subjects.
- RESULTS: After six months of FESCE, BMD of the distal femur (DF) and proximal tibia (PT) increased significantly, and BMD of the calcaneus (heel) showed a trend of increase. However, the BMD in the DF, PT, and heel decreased significantly after the subsequent six months without FESCE. The BMD of the femoral neck (FN) decreased progressively throughout the program

Chen, Shih-Ching. Lai, Chien-Hung. 2005 Nov 30.

MS and OP

Bone mass assessed in patients with MS in comparison to healthy age- and sex-matched controls. 31patients with MS and 30 matched healthy controls

- People with MS significantly lower BMD at the lumbar spine (L2-L4) and femur trochanter compared to the matched controls. BMD of the lumbar spine was nearly 1 SD lower in MS patients compared with the healthy reference population. MS patients had significantly lower vitamin D levels compared to controls.
- Patients should be encouraged to have adequate sunlight exposure and to increase their mobility. Specific strengthening exercises for hip and back muscles in MS patients would have a substantial impact on bone density, osteoporosis, fracture risk, and mobility.

Ozgocmen, Salih. Bulut, Serpil. 2005.

Incidence of OP in Men with MS

- Forty consecutive male MS patients, age mean 51.2 +/- 8.7 years, and mean EDSS of 5.8 +/- 1.9 were evaluated with DEXA scan.
- Of these, 17.5% patients were relapsing-remitting (RR) MS, 57.5% were secondary progressive (SP) MS and 25% were primary progressive (PP) MS.
- RESULTS: Thirty-two (80%) of patients had reduced bone mass of either lumbar spine or the femoral neck; of these 17 patients (42.5%) had osteopenia and 15 patients (37.5%) had osteoporosis. Twenty-one per cent (eight out of 38 patients) had vertebral, rib or extremities fractures.
- CONCLUSIONS: The proportion of male MS patients with reduced bone mass is high and disproportionate to their age and ambulation, consistent with an association between the MS disease process and pathological bone loss.

Weinstock-Guttman, Bianca. Gallagher, Eileen. 2004 Apr.

MS: Exercise and OP

- Historical Perspective: study in1989 at Queen Elizabeth Hospital, University of Toronto, Canada.
- 80 per cent of patients complied with the requirements of the exercise program and that those who exercised reported improvement in general well being, stamina, mobility and pain tolerance.
- The exercise group also showed a significant improvement in VO 2 max (p less than 0.001) and bone mass (p less than 0.02) after one year of exercise.
- None of the patients developed fracture as a direct result of the exercise.

Chow R, Harrison J, Dornan J. 1989.

Current Recommendations for MS

- Men and women with MS should participate in an exercise program to promote muscle power, mobility and mood (Cochrane review)
- Research in OP demonstrates that exercise consisting of weight bearing and weight training is effective in maintaining and in some studies improving BMD
- For people with MS, the type of exercise performed should be prescribed by a physical therapist with knowledge in MS and OP

Future Research Needed

Clinical Trials in rehabilitation need to examine different types of exercise in MS :

- weight bearing, closed chain for home program
- walking program
- isokinetic and isotonic exercise
- power vs. strength training