Physical Activity and Osteoporosis

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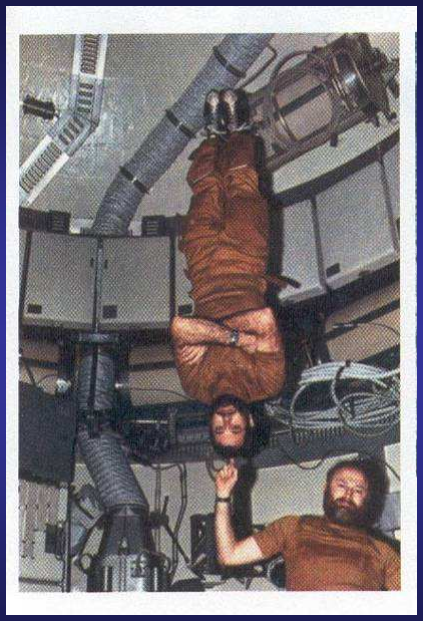
Determinants of Peak Bone Mass

- Race
- Sex
- Family history (genetics)
- Exercise
- Leanness
- Calcium intake & Vit. D
- Menstrual history

Start young……

Determinants of Rate of Bone Loss

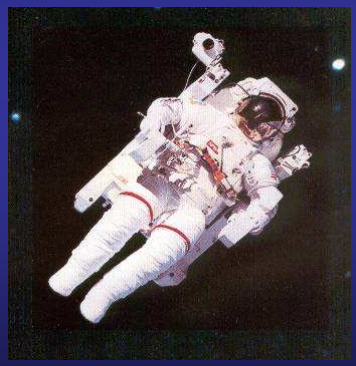
- Menopause
- Other hormonal changes
- Smoking and alcohol
- Reduced calcium absorption (↓ Vit. D)
- Inactivity/activity



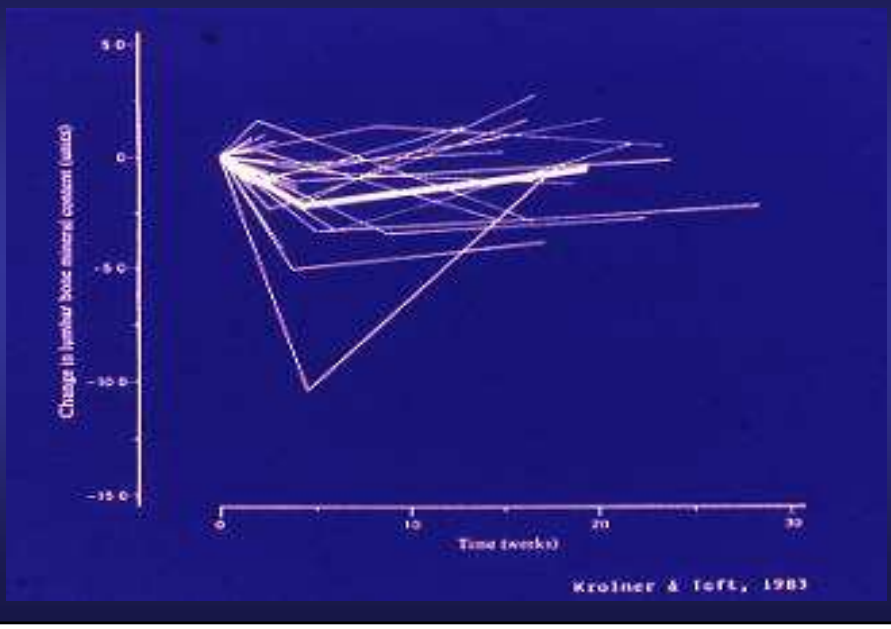
Astronauts lose bone in the weightless environment

Similar to prolonged bed rest

Worst in weight-bearing sites eg. legs and spine



Effect of bed rest on bone density



Activity & Hip Fracture Risk

- Epidemiological evidence suggests that being physically active can reduce the incidence of hip fractures by 50%.
- Effect could be due to improved BMD, strength, balance and co-ordination.
- Activities such as standing, walking and stair-climbing important.

Sedentary vs active lifestyles

- >3 hrs per week targeted exercise
  - Osteoporosis - 2 x less likely
  - Fall-related injuries - 2 x less likely
  - Hip fracture - 2 x less likely
- WHO, 1996 "regular physical activity helps to
  - "preserve independent living" and
  - "postpone the age associated declines in balance and co-ordination that are major risk factors for falls"

Systematic Reviews

- Cochrane 2002 – Bonaiuiti et al.
  - Up to year 2000, 18 RCTs, poor methodology generally
  - Aerobics, weight bearing and resistance exercises effective on spine BMD
  - Brisk walking effective on spine and hip BMD
- Maturitas 2009 – Schmitt et al.
  - 2000 to 2008, 7 more trials, 3 were RCTs
  - Individually adapted, intense, high impact exercise programmes most effective at increasing BMD
  - Public health basis – brisk walking, aerobics, Tai Chi help maintain BMD (if not increase it) but adherence much better

Lifestyle Impact on bone

- Population - 4198 men and women. Trømso study, Norway.
- Outcomes over 6 years
  - 1994/5 (aged 50-74) and 2001 (aged 56-80).
  - Distal and ultradistal forearm (SXA)
- Sedentary, smoking, thin people have an increased forearm risk of 69% in men and 85% in women
- Better to have BMI >30kg/m2; not smoke and be active (>3 hrs/wk).

Wilsgaard et al. Am J Epidem 2009

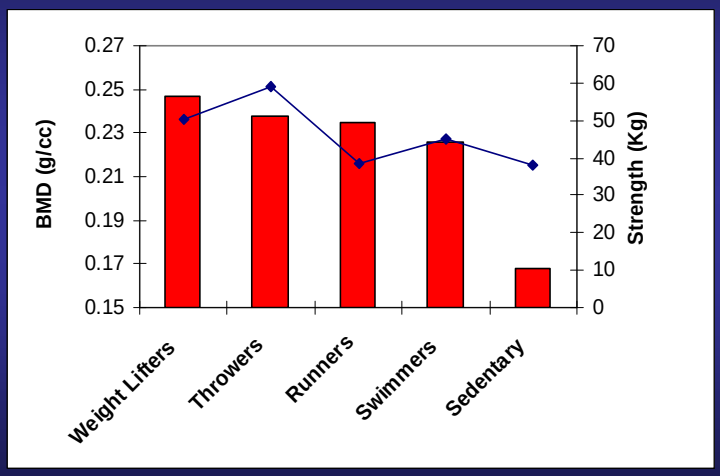
Physical Activity and Osteoporotic Fractures

- Moderate to vigorous physical activity ➔hip fracture risk reduction
  - 45% (95 CI 31-56) in men
  - 38% (95 CI 31-44) in women
- But…U shaped curve of risk, those most and least active more likely to fracture
- Huge RCT needed
  - Fractures (hip)
  - Rate ratio 0.75, 7129 european women or 3467 high risk women or 21781 european men!

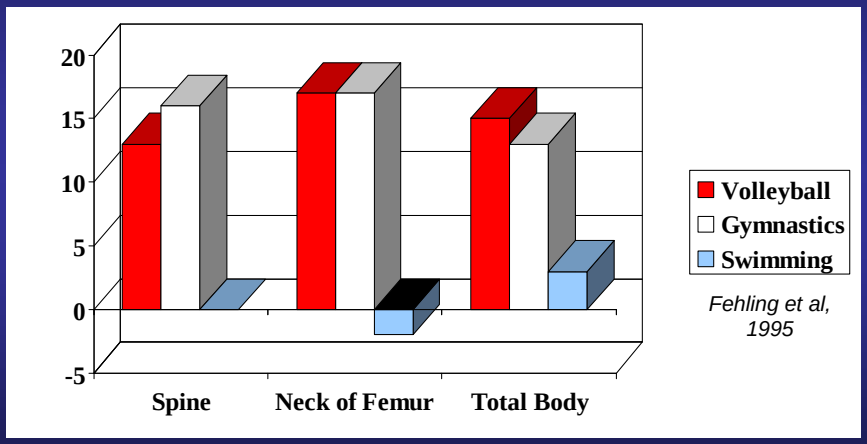
Moayyeri A. Ann Epidemiol. 2008

BMD in Male Athletes

Nilsson & Westlin, 1971



BMD in Females athletes: % difference from sedentary controls

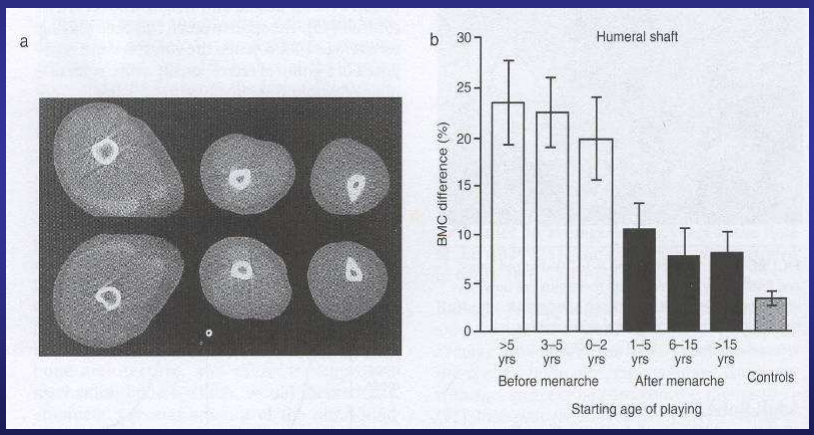


Fehling et al, 1995

However, swimming may have beneficial effects to elasticity and microstructure of bone, if not density (Yung et al., 2005)

Tennis Players

"Site specificity"



Hoapasalo et al, 2000

Changing incidence of fractures with increasing age

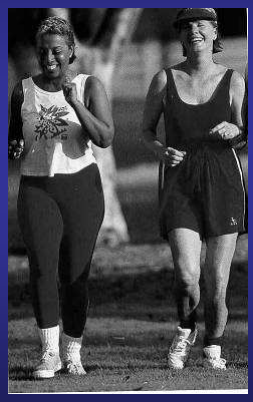
- 50 to 65 yrs - wrist
- 55 to 85 yrs - spine
- 75 to 85 yrs - hip

  (because of poor reaction, coordination and reflexes)

But increasing physical activity may not always be safe…….!

Some exercise is risky for bone…

- Women, upper arm fracture
- Excluded
  - bisphosphonates, survival < 1yr, cognitive impairment, too frail
- Intervention: Brisk walking
- Control: exercise of upper arm
- Falls risk (Brisk walking > control)



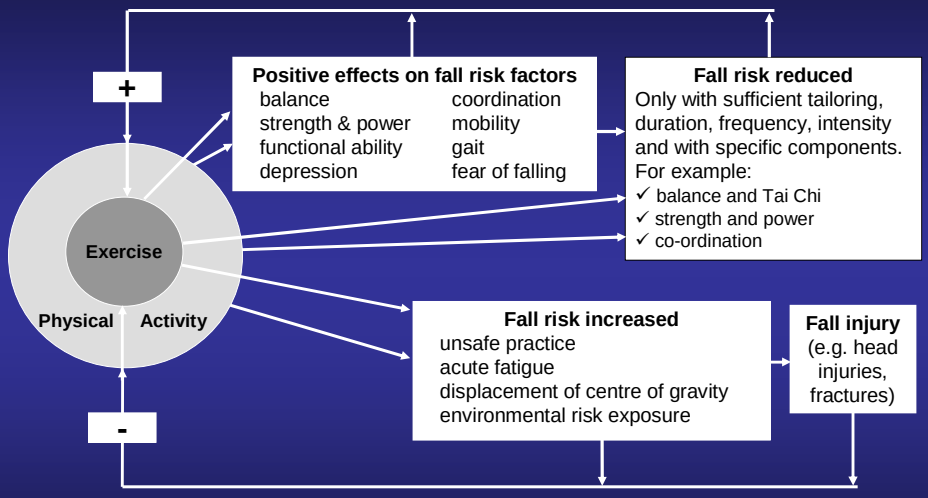
Ebrahim et al. (1997)

Potential Dangers of Exercise

Type of Exercise	Reoccurrence of Fracture
• Back extension	16%
• Flexion (abd. curls)	89%
• Combined	53%
• No exercise	67%

Sinaki & Mickelson 1982

Proposed Conceptual Model



Adapted from Skelton, 2001, *Age Ageing*

Insufficient tailoring or specificity

OSTEOPOROSIS MANAGEMENT – PRE AND POST MENOP.WOMEN

Bassey et al. 1995	6 months; daily; Post-menop. Heel drops; low impact Supervised once per week	◄► non significant increase in hip BMD
Nelson et al. 1991	12 mths; 3 p/w Walking rapidly; 8lb belt	◄► spine and hip BMD
Bravo et al. 1997	12 mths; 3 p/w; Osteopenic. Water-based jumping and strength	◄► hip BMD ▼ spine BMD ▲ fitness
Cavanaugh et al. 1988 Hatori et al. 1993	Walking below anaerobic threshold	▼ spine BMD
Sinaki et al. 1996	36 mths; 3 p/w; Post-menop. Non strenuous weight training Supervised once per week	◄► spine, hip or radius BMD ▲ muscle mass

Specificity to prevent or manage OP

OSTEOPOROSIS MANAGEMENT - POST MENOPAUSAL WOMEN

Sinaki et al. 1984	1-6 years; spinal OP and loss of height. Back extension and flexion (in prone and sitting); combined	Extn; 16% further spinal wedging Flexn = 89% further wedging Combined = 53% further wedging Control (no exercise) = 67% further wedging
Ayalon et al. 1987 Simpkin et al. 1987	5 mths; 3 p/w; lumbar spine changes. Limb loading; torsion; tension; hanging; pulling; pushing	▲ 3.8% distal forearm BMD

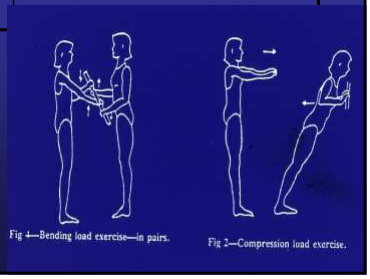


Fig 1—Bending load exercise—in pairs.

Fig 2—Compression load exercise.

Specificity to prevent or manage OP

OSTEOPOROSIS MANAGEMENT – PRE AND POST MENOP. WOMEN

Pruitt et al. 1992	1 yr; 3 p/w; Post Menopausal women. Weight training machines incl. Back extension and flexion	▲ 1.6% spine BMD
Nelson et al. 1994	1 yr; 3 p/w; Post Menopausal women. Weight training	▲ 1% spine BMD and hip BMD
Bassey et al. 1994	6 mths; daily; Pre Menopausal women. High impact jumping supervised once a week, daily at home	▲ 3.4% hip BMD
Kohrt et al. 1995 1997 1997	1 yr; 3 p/w; Post Menopausal women. Impact loading; vigorous walking; jogging; stair-climbing Stair-climbing / descending Weight training; free weights; machines; standing	▲ 2.3% spine and 3.3% hip BMD ▲ 1.8% spine BMD; ▼ hip BMD ▲ 1.5% spine BMD; ▼ hip BMD
Welsh et al. 1996	1 yr; 3 p/w; Post Menopausal women. Seniors fitness medium to low impact jumps; step; floor strength and wrist loading; free weights	▲ 1.6% hip BMD ◄► spine BMD

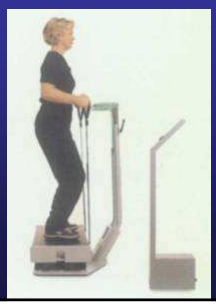
Specificity to prevent or manage OP

OSTEOPOROSIS MANAGEMENT - POST MENOPAUSAL WOMEN

Nelson et al. 1991	1 yr; 3 p/w; Post Menopausal women. Walking with weighted belt + Calcium	▲ 3% spine BMD
Notelowicz et al.1991	1 yr; 3 p/w; Post Menopausal women. Exercise + HRT	▲ 8% spine BMD

Whole body Vibration

- RCT, 70 post menopausal women (58-74 yrs)
- Whole Body Vibration vs Resistance Training vs Control
- 35-40Hz
- 3 x p/w, 24 weeks, <20 mins
- WBV – strength 15%, Hip BMD 1%
- Resistance – strength increased but not BMD
- No vibration related side effects



Verschueren SM et al. J Bone Miner Res 2004; 19: 352-359

Exercise in Older **Men** – 1 Year

- 180 men aged 50-79, Australian, healthy, normal to below average hip BMD (+0.4 to -2.4 SD)
- RCT – Exercise only; Exercise and fortified milk; Fortified Milk; Control – 12 months
- Interventions
  - High intensity progressive resistance training, 3 x p/w (60 to 75 mins) in groups with qualified instructors. Plus weight bearing exercises (lunges, jumps) with ground reaction forces greater than 1.5x body weight
  - Fortified Milk – per day, 1000mg Calcium + 800 IU Vit D
- Results
  - Exercise led to 1.8% net gain in femoral neck BMD (DXA)
  - Compliance 67% exercise, 90% milk
  - Additional fortified milk made no difference
  - All treatment groups led to a 1.5% net gain in lumbar spine BMD

Kukulijan et al. Osteop Int 2009

Pre-menopausal women, 9 mths

- 58 pre-menopausal women aged 30-50 yrs, USA
- RCT – Strength training vs control
- Interventions
  - RCT Strength training 2 x p/w 15 weeks then unsupervised for remaining 39 weeks (Gymnasium instructor to 4 participants)
  - Control
- Results
  - At 15 wks and at 39 wks no between group difference in total body and regional BMD (DXA) or lean / fat mass
  - Compliance 92% first 15 wks, 89% up to 39 wks
  - Trend (NS) 2.2% net gain in spine

Singh et al. Joint Bone Spine 2009

Post-menopausal women, 18 mths

- 64 post-menopausal women aged 55-74 yrs, Japan
- RCT – Multimodal exercise vs control
- Interventions
  - Aerobic; antigravity (sumo style stamping etc); circuit; strength training + home based exercise. Initially 1 p/wk supervised and 3 p/wk home, > 3 mths only 1 supervised session/mth and 3 p/w home.
  - Control
- Results
  - Bone strength (speed of sound, ultrasound) calcaneus maintained in *both* groups at 12 mths
  - One leg stance balance improved in the exercise group
  - Half of exercise group remained exercising 3 p/wk after 12 mths
  - At 18 months bone strength significantly lower in controls (-0.8%) & returned to baseline in exercisers
  - Only those exercising 3 p/wk or more maintained balance

Cao et al. J Bone Min Res 2009

Physical Activity and Bone **post**-menopausal women

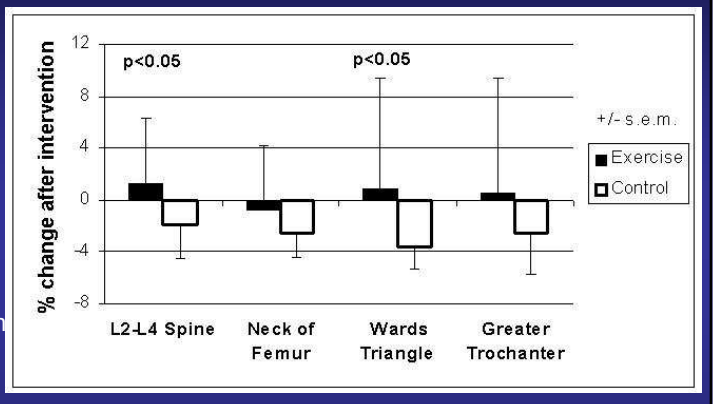
- Population – 136 Women aged 68 ± 7 yrs (BMI 26 ± 4), USA
- Outcomes every 6 mths for 3 yrs
  - PA (ADNFS)
    - Heavy housework, gardening, DIY, stairs, walking and pace, sports and recreation and total activity
  - Total body, femur and spine BMD (DXA)
- Results
  - Drop out rate nearly 30% (n=39)
  - More hours/week of brisk walking – higher total body, femur and spine BMD, higher spine BMC (1-4%)
  - More weight bearing activity – higher femur BMD
  - More sports/recreational activities – higher total body BMD (1-2%)
  - Heavy housework (>1.3 hrs/wk) - higher BMD at femur and spine (1-3%)

Ilich et al. Calc Tissue Int. 2008

FaME – BONE Results

9 month duration
3 p/w – 1 hr

DURING FOLLOW UP
Exercisers had **half** the risk of falls compared to controls (RR 0.53)
+ less likely to sustain injurious falls (RR 0.39)



Significant difference with time and group for L2-L4 spine and Wards Triangle (F=3.46, p<0.05). Exercisers n=32, Controls n=14.
Time between visit 1 and visit 2 = mean 10.9 (sd 2.7) months

Skelton et al. JAPA 2004; Age Ageing 2005

Exercise for Patients with Osteoporosis

- Carter et al., 2002
  - Osteofit programme, 2 p/w 20 weeks
  - Improved balance and strength
- Sinaki et al., 2005
  - SPEED programme, 2 supervised sessions then 4 weeks at home
  - Reduced pain, improved strength and balance
- Grahn Kronhed et al., 2005
  - Community 10 yr education programme, increase PA, diet, smoking and environment
  - Reduction in fractures

EXERCISE ACTIVITIES

Gwen Fitzpatrick lost sixteen inches in height due to vertebral fracturs; during 30 years of fractures no treatment was provided to prevent further bone loss

ACSM Position Stand 2004 Physical Activity and Bone Health

- Basic principles of training:
  - Specificity (site)
  - Overload (progressively)
  - Reversibility (Keep at it)
  - Initial values (lower starting BMD, greater response)
  - Diminishing Returns (plateau / ceiling)

ACSM Position Stand 2004 Physical Activity and Bone Health

- MODE
  - Weight bearing activities
- INTENSITY
  - Moderate to high, in terms of bone loading forces
- FREQUENCY
  - Weight bearing endurance activities 3-5 x p/w
  - Resistance Exercise 2-3 x p/w
- DURATION
  - 30-60 mins of a combination of weight bearing endurance and resistance exercise targeting all muscle groups

Exercise and Osteoporosis Prevention and Management Guidelines CSP

- Severe Osteoporosis - BMD < 2.5 + #
  - Targeted gait and postural balance training
  - Functional local muscular endurance and strength training (eg. Sit to stand, stairs)
  - Functional ROM and flexibility training
- Osteoporosis - BMD <2.5 without #
  - Targeted postural , gait and low impact endurance training (eg. Stepping)
  - Functional and open chain strength and bone loading training
  - Functional ROM and flexibility training
- Osteopenia - BMD <1 to <2.5
  - Targeted low-medium impact and endurance training (post menopausal)
  - Targeted medium impact and endurance training (pre menopausal)
- Normal - BMD >1
  - Medium – High impact endurance training
  - Open / closed chain strength training
  - Complex challenging balance training
  - Flexibility

Warm-Up ► Work Out incl. Correct lifting ► Warm-Down

EFFECTS OF TRAINING

Exercise can slow or reverse age related bone loss provided it is:

- **Weight resisted** - weight training
  - impact
  - loading
- **Site specific** - wrist, hip, spine
- **Peak Strain** - hold the movement
- **Fast Strain** - effective and brief
- **Error Rich** - tennis, squash, fitness class

Strategy = short periods of site specific, high strain rate in unusual relationships

Exercise and Bone

- Physical activity becomes *more* important as you grow older.
- Physical activity *can* reduce falls and fractures.
- Physical activity *can* maintain independence.
- Posture and balance are *essential*.
- Strength, flexibility and stamina *also* important.
- Long term commitment is *essential*.

"*Man does not cease to play because he grows old. Man grows old because he ceases to play*"

George Bernard Shaw

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