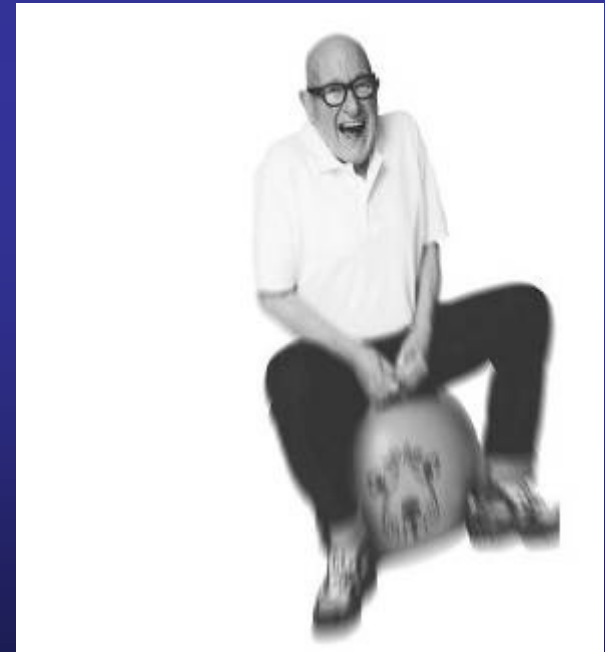


Physical Activity and Bone Health

Dr Dawn Skelton PhD

School of Nursing, Midwifery and Social Work
University of Manchester

Co-ordinator of Prevention of Falls
Network Europe





Prevention of Falls Network Europe

Log out [steve]

Profile

You have no new messages

Memberlist

Usergroups

Discussion Board

FAQ

Search

About ProFaNE

Resource Directory

Resource Map

Calendar

News

Help

Members Area

ProFaNE Leaders

Work Package 1

Work Package 2

Work Package 3

Work Package 4



The University of Manchester

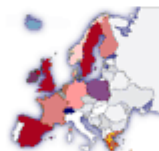
ProFaNE
 School of Nursing, Midwifery and Social Work,
 Coupland III,
 University of Manchester
 Oxford Road,
 Manchester
 M13 9PL
 Great Britain

Welcome to the ProFaNE Online Community

The ProFaNE Online Community is an active working group of Health Care Practitioners, Researchers and Public Health Specialists dedicated to the prevention of falls in Europe and beyond. [Read more about the ProFaNE Network](#)



Ever find yourself short of time? We know how hard it is to keep up with developments in Falls Prevention, so, we do it for you! A regular Newsletter is available to everyone who registers that will help you keep up to date with all the latest publications, events and new resources relevant to falls prevention. To subscribe to the ProFaNE Community Update Newsletter all you need to do is [Register with the ProFaNE Community!](#).



The ProFaNE Resource Map is now available for anyone to use. This section of the web site is devoted to presenting geographically oriented information about Falls Prevention resources and information pertinent to Falls Prevention within Europe. With approximately 180 map views and over 350 resources, assessment measures and organisations listed, this is one of the richest resources for Falls Prevention available on the web.



The annual ProFaNE newsletter is now available with a great overview of what has happened in the ProFaNE community over the last year; key publications, reports from the network meeting and work package meetings, dissemination events, news of the website developments, future meetings and lots of pictures to enjoy.

[Read all about what has been happening in ProFaNE over the last year](#)

www.profane.eu.org

- Basic layout – accessibility
- Public availability
- ProFaNE members only section
- Discussion Board – public and private
- Resources – database and entry
- Plus – Weekly e-newsletter



Determinants of Peak Bone Mass

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



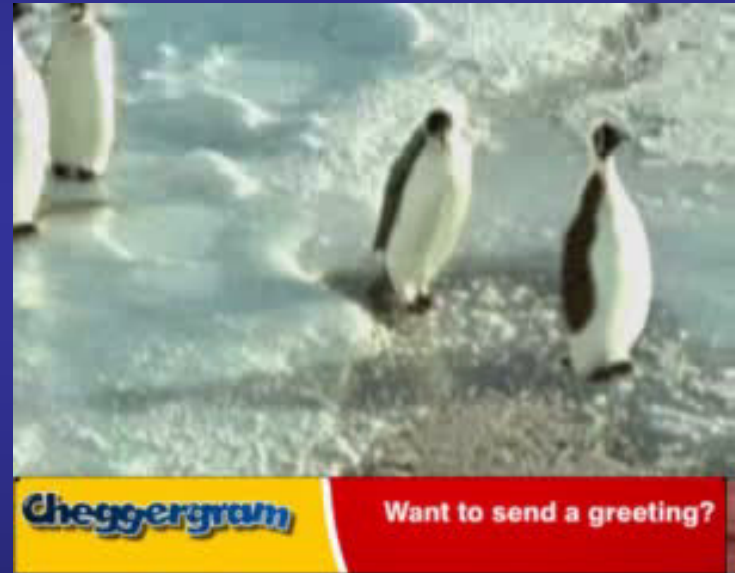
Start young.....

Determinants of Rate of Bone Loss

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



We are all *trippers*....but when do we become fallers?



Not all falls lead to injury



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”

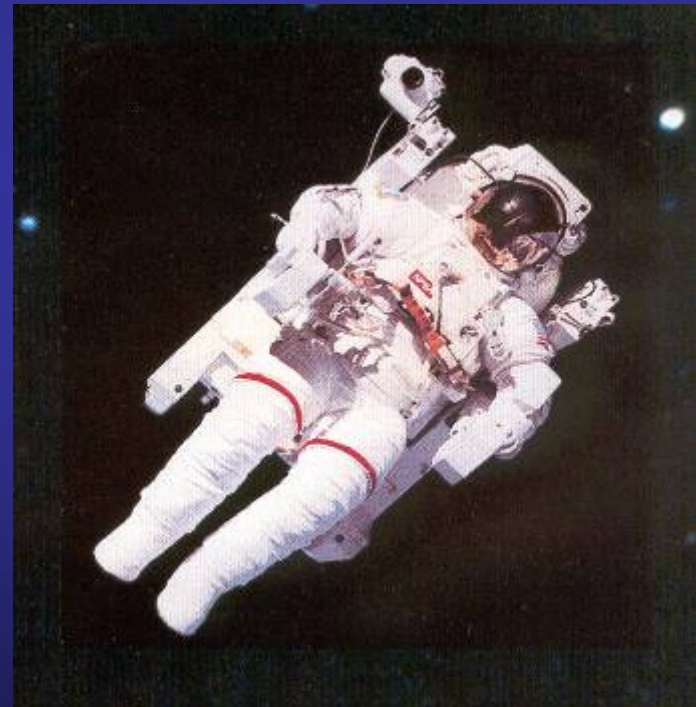




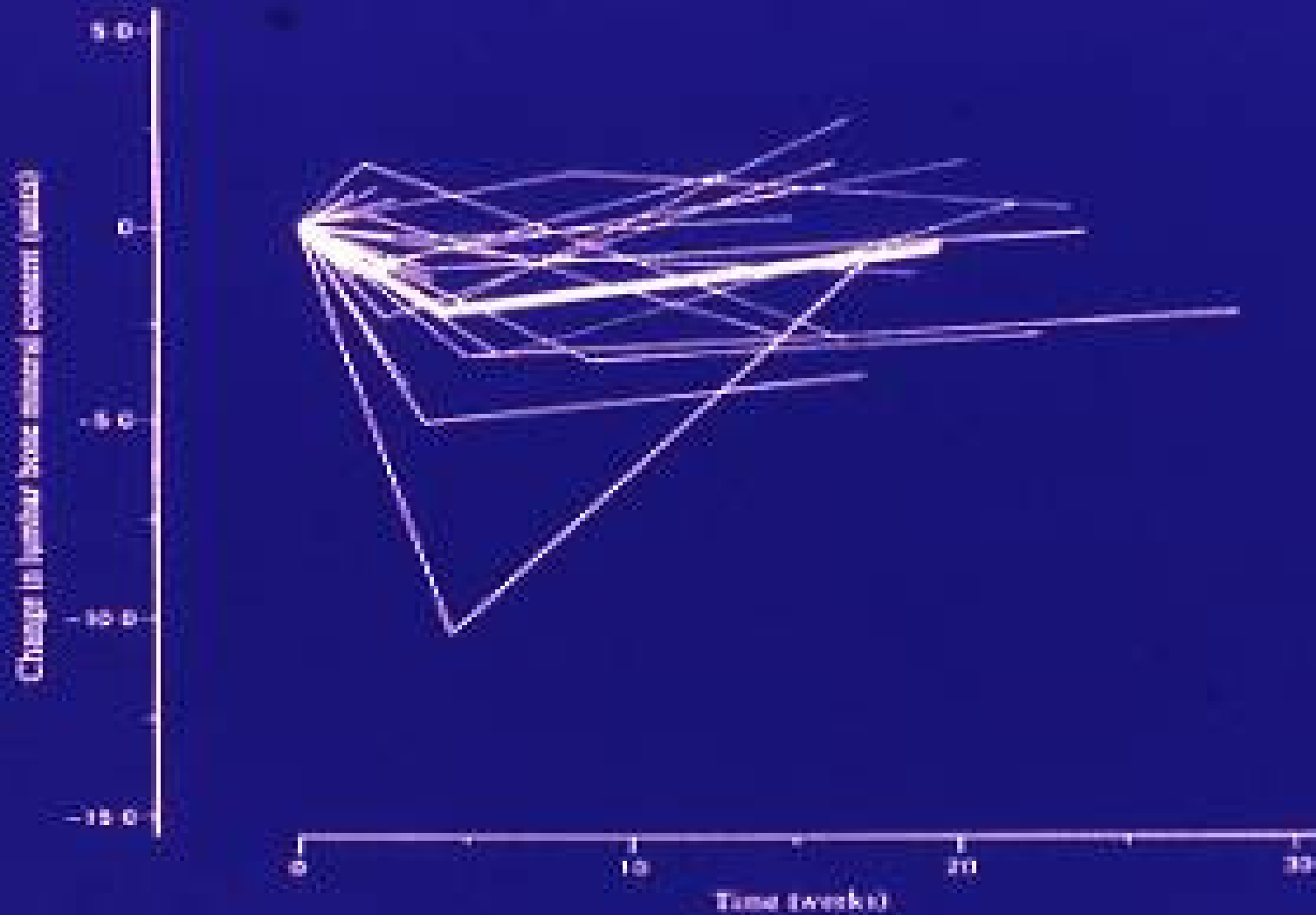
Astronauts lose bone in the weightless environment

Similar to prolonged bed rest

Worst in weight-bearing sites eg. legs and spine



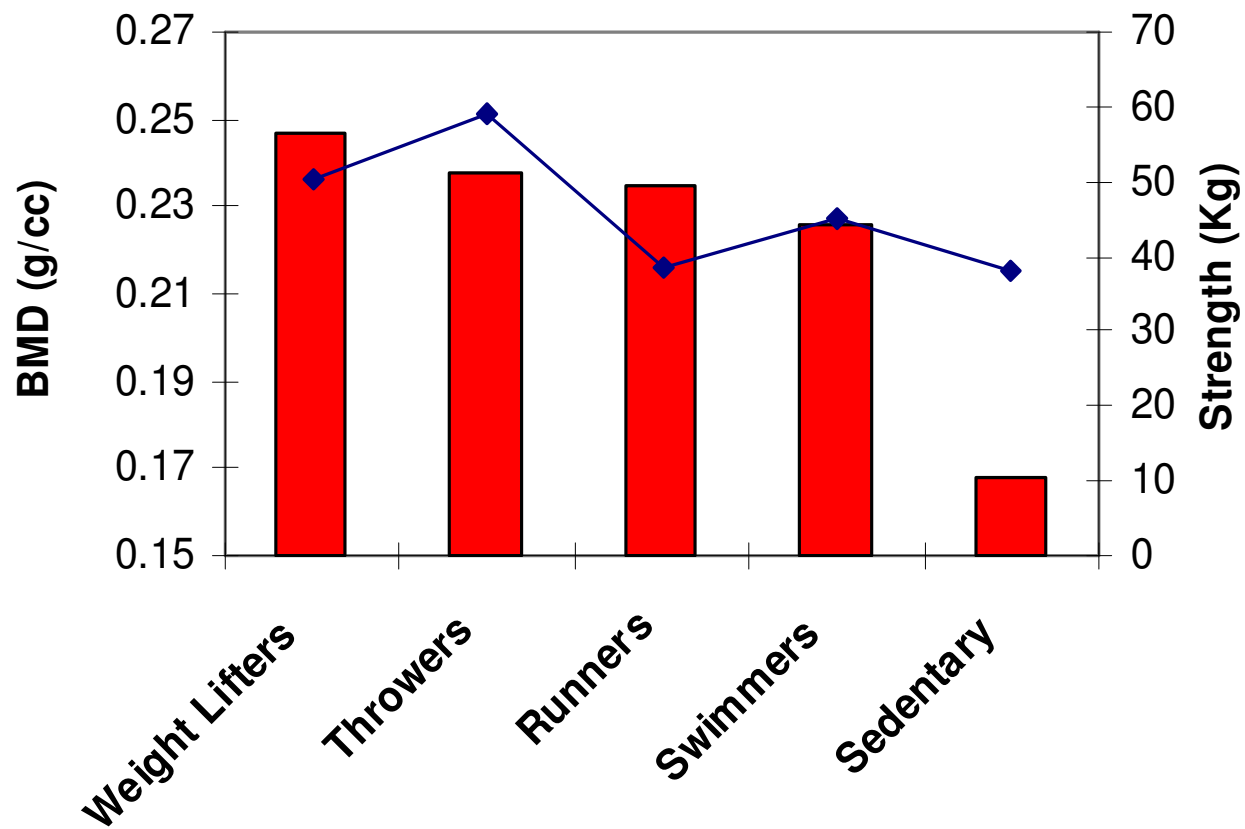
Effect of bed rest on bone density



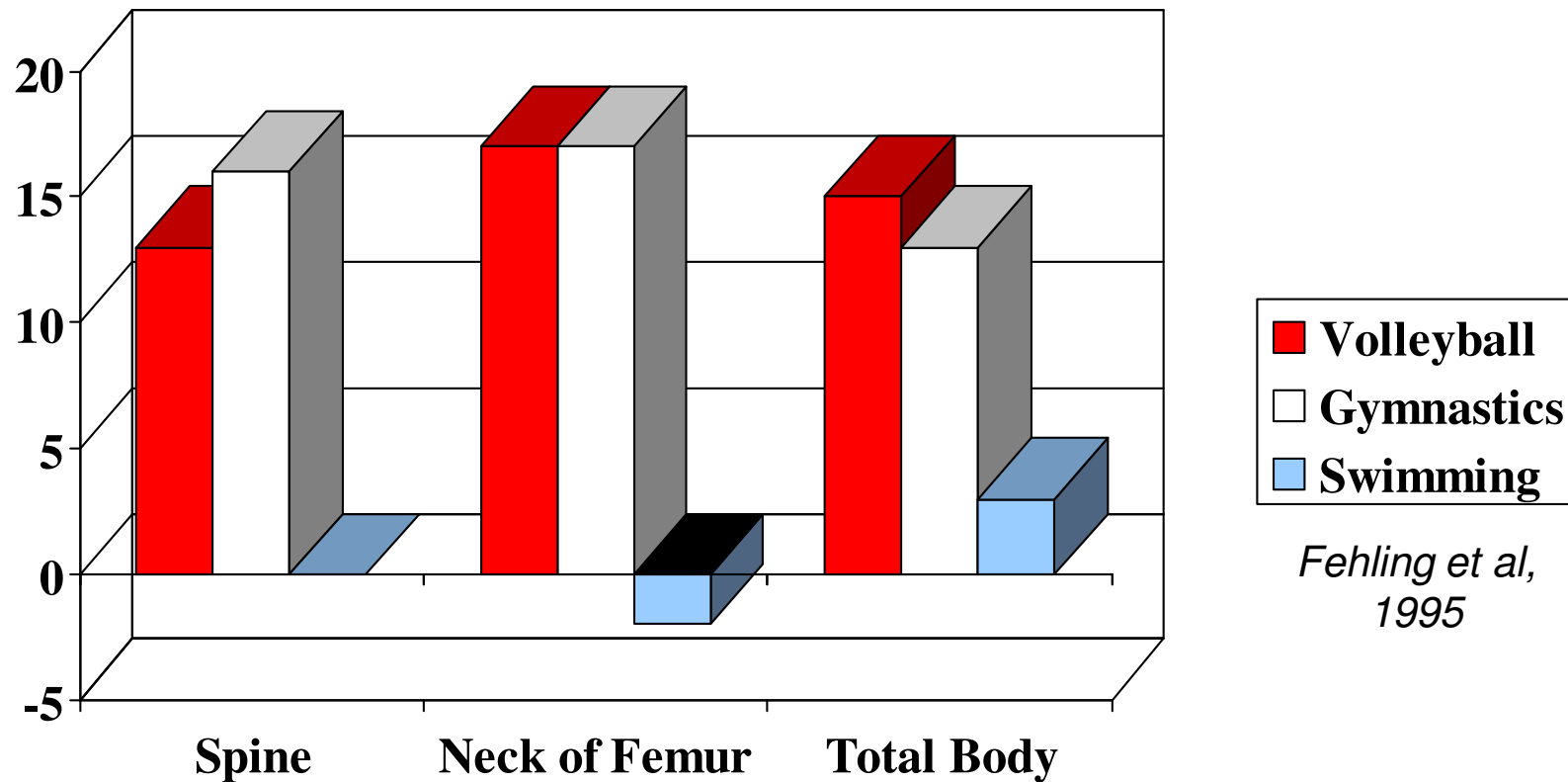
Kroemer & Leff, 1983

BMD in Male Athletes

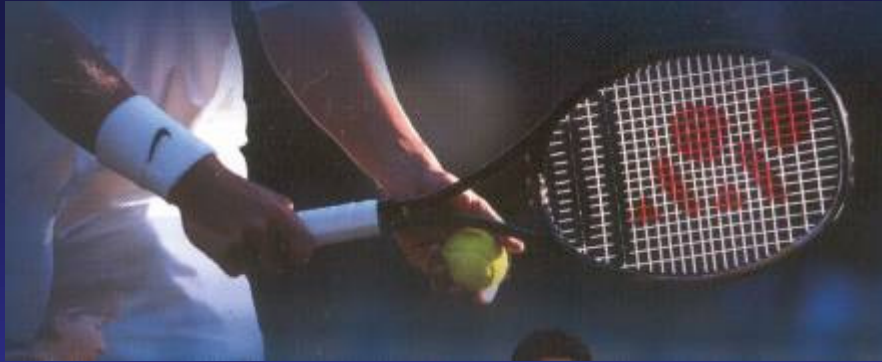
Nilsson & Westlin, 1971



BMD in Females athletes: % difference from sedentary controls



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

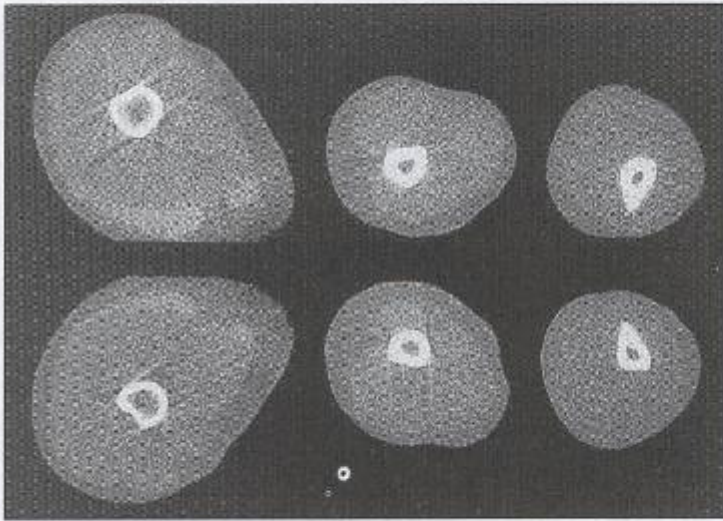


Tennis Players

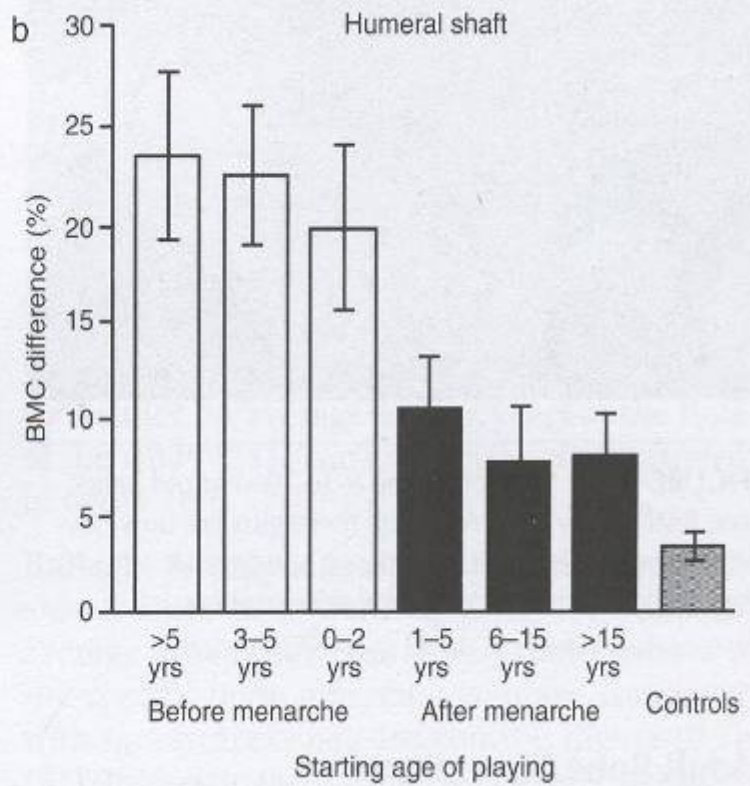
“Site specificity”

Hoapasalo et al, 2000

a

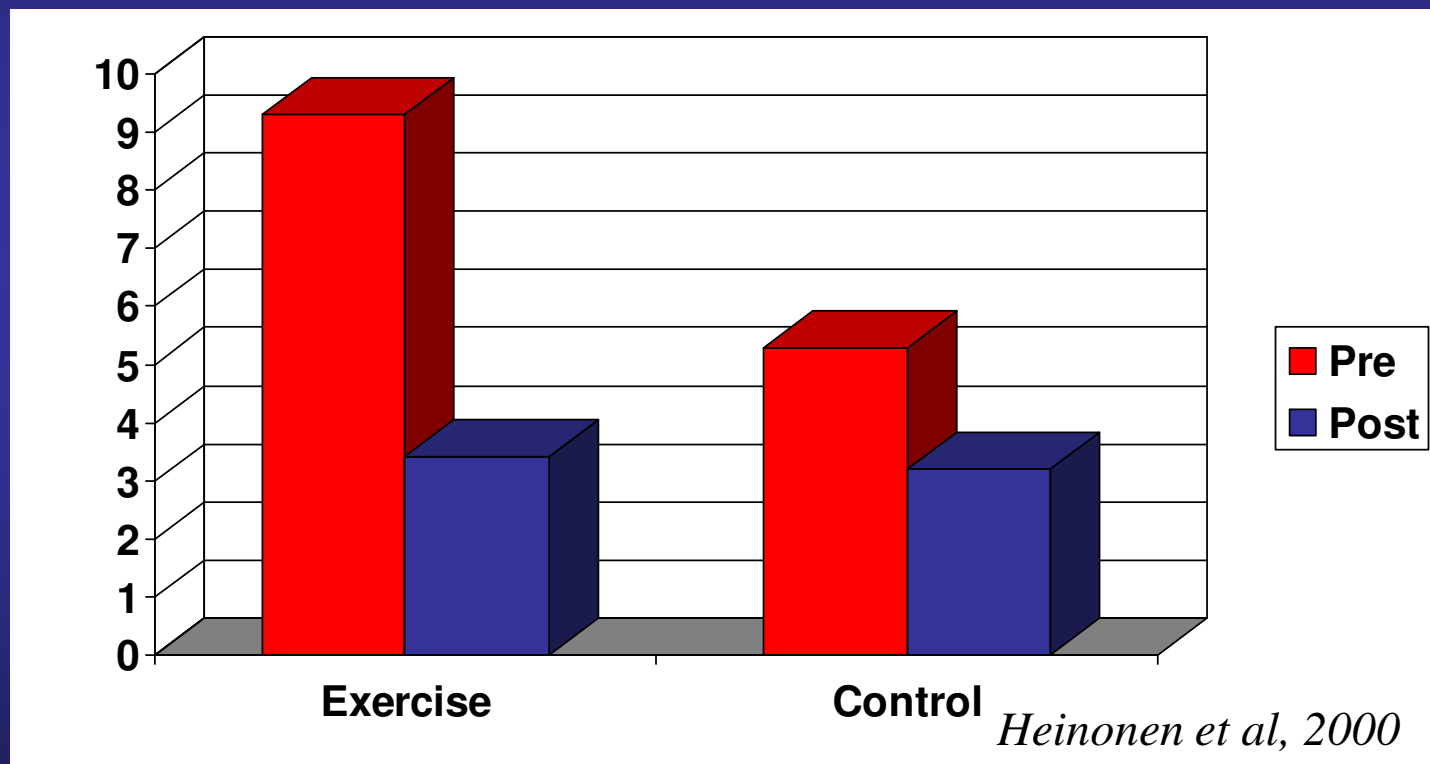


b



Step aerobics and femoral neck BMD in pre- and post-pubescent girls. “Window of Opportunity” to gain bone

% gain from year before



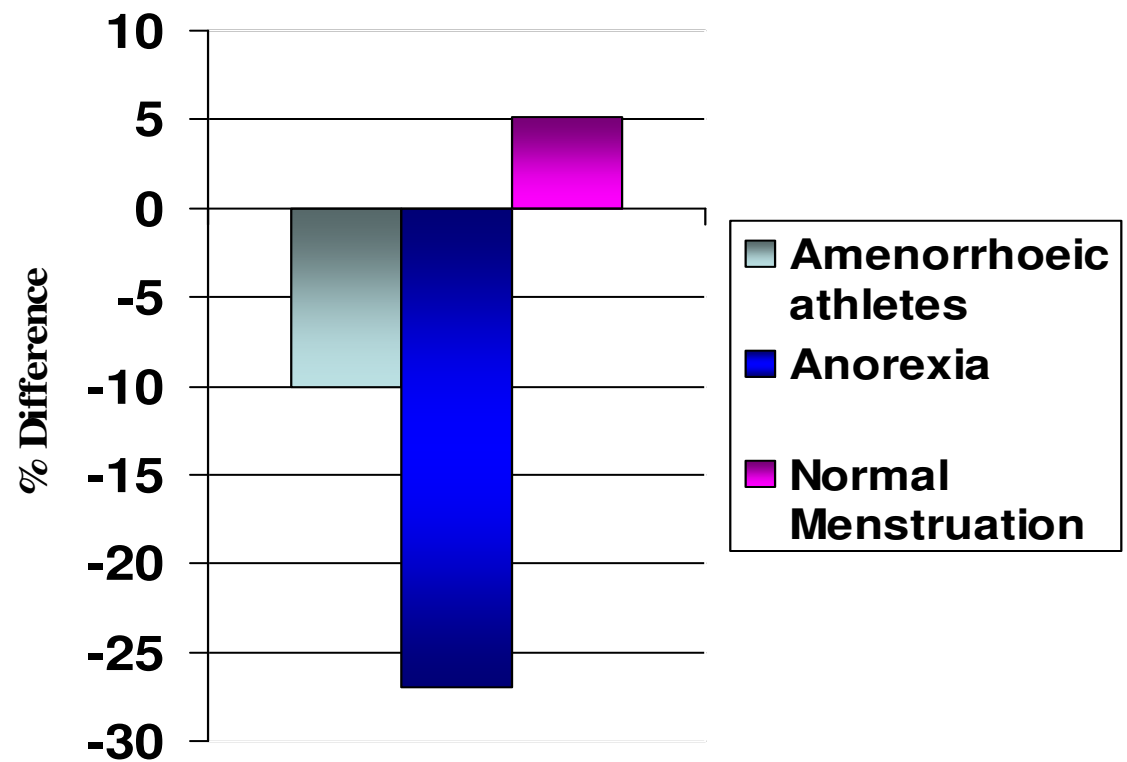
The highest level of skeletal benefits are seen (Karllson, 2004) when physical activity and exercise are increased, pre-puberty, in both boys and girls.

Fit but fragile?

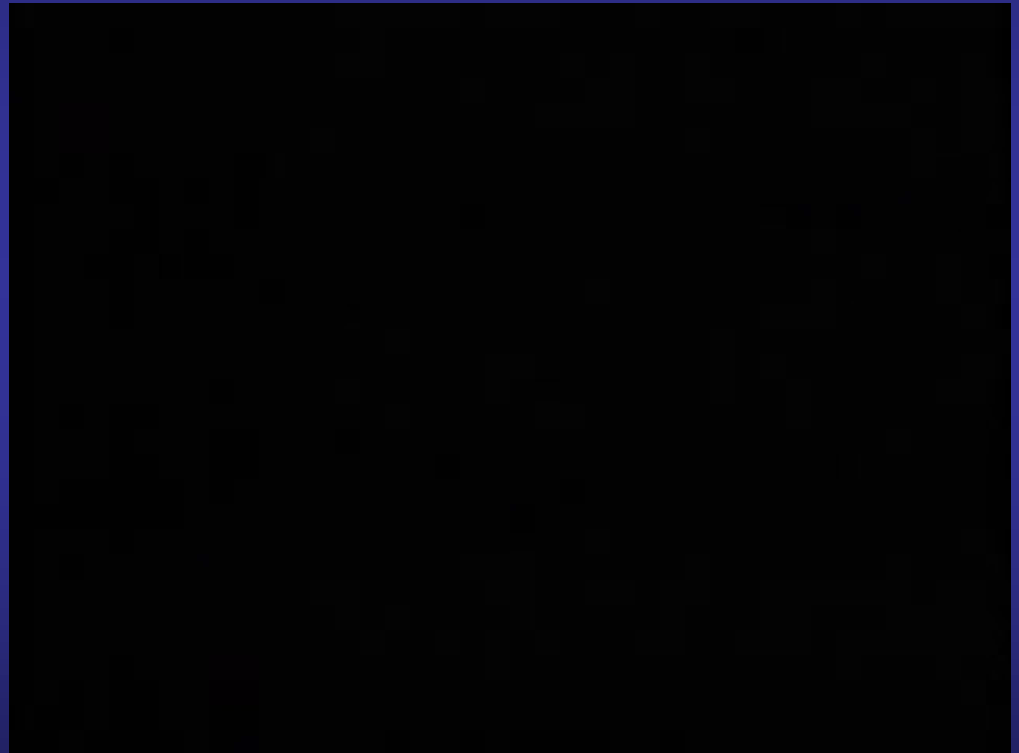
Advice on Bone Health for
Young Women Athletes and Dancers,
their Coaches and Teachers



Spine BMD – Effect of Menstruation and Diet



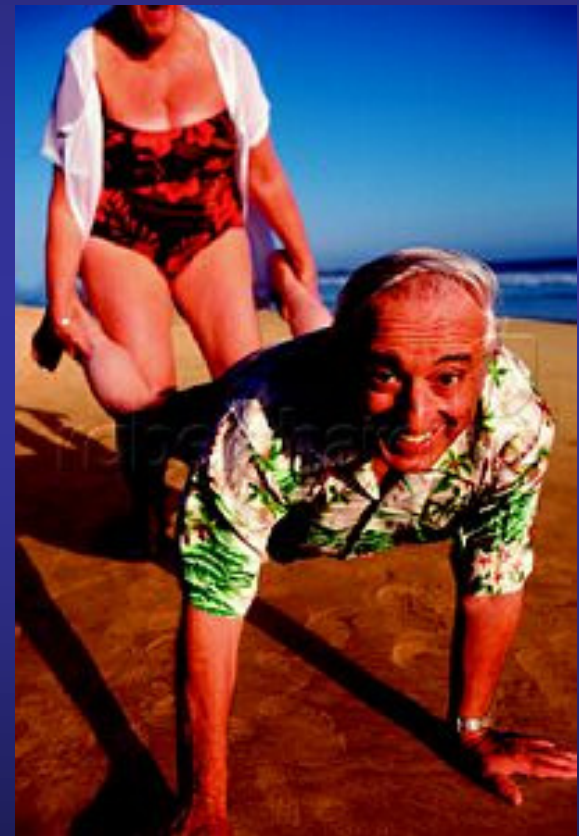
But increasing physical activity may not always be safe.....!



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)



NOS Guidelines

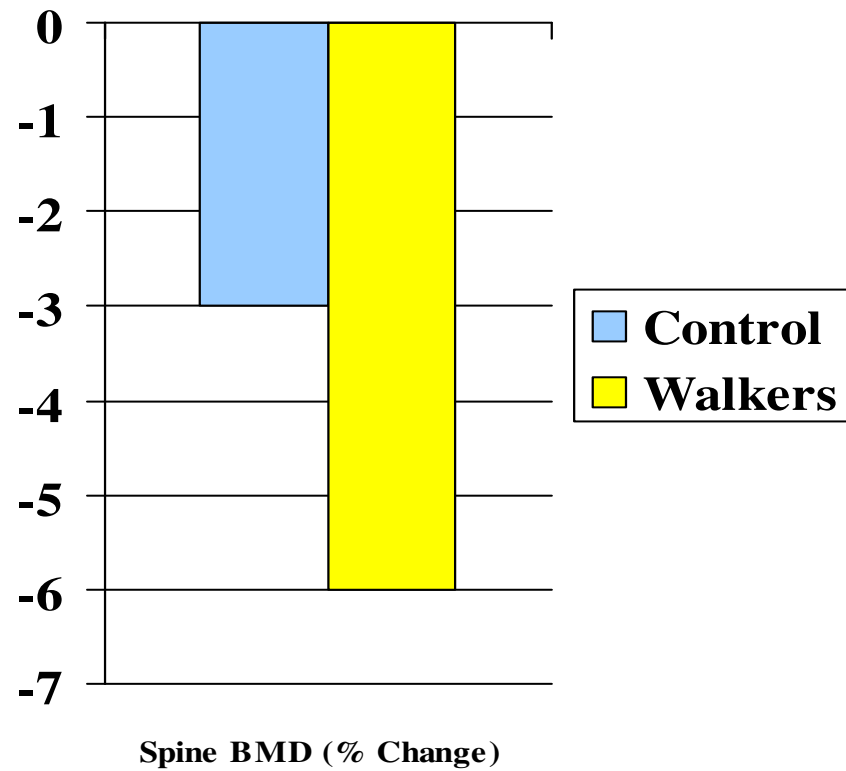
- 3 x per week
- 20-30 minutes
- Weight bearing exercises
 - Weight training, stair climbing, walking, running, jogging, dancing, aerobics, racquet sports, court sports, field sports.....
- To help maintain a healthy bone mass

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	Walking below anaerobic threshold	▼ spine BMD
Hatori et al. 1993		
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

1 Year Walking Programme



Cavanaugh & Cann, 1988

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 4—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

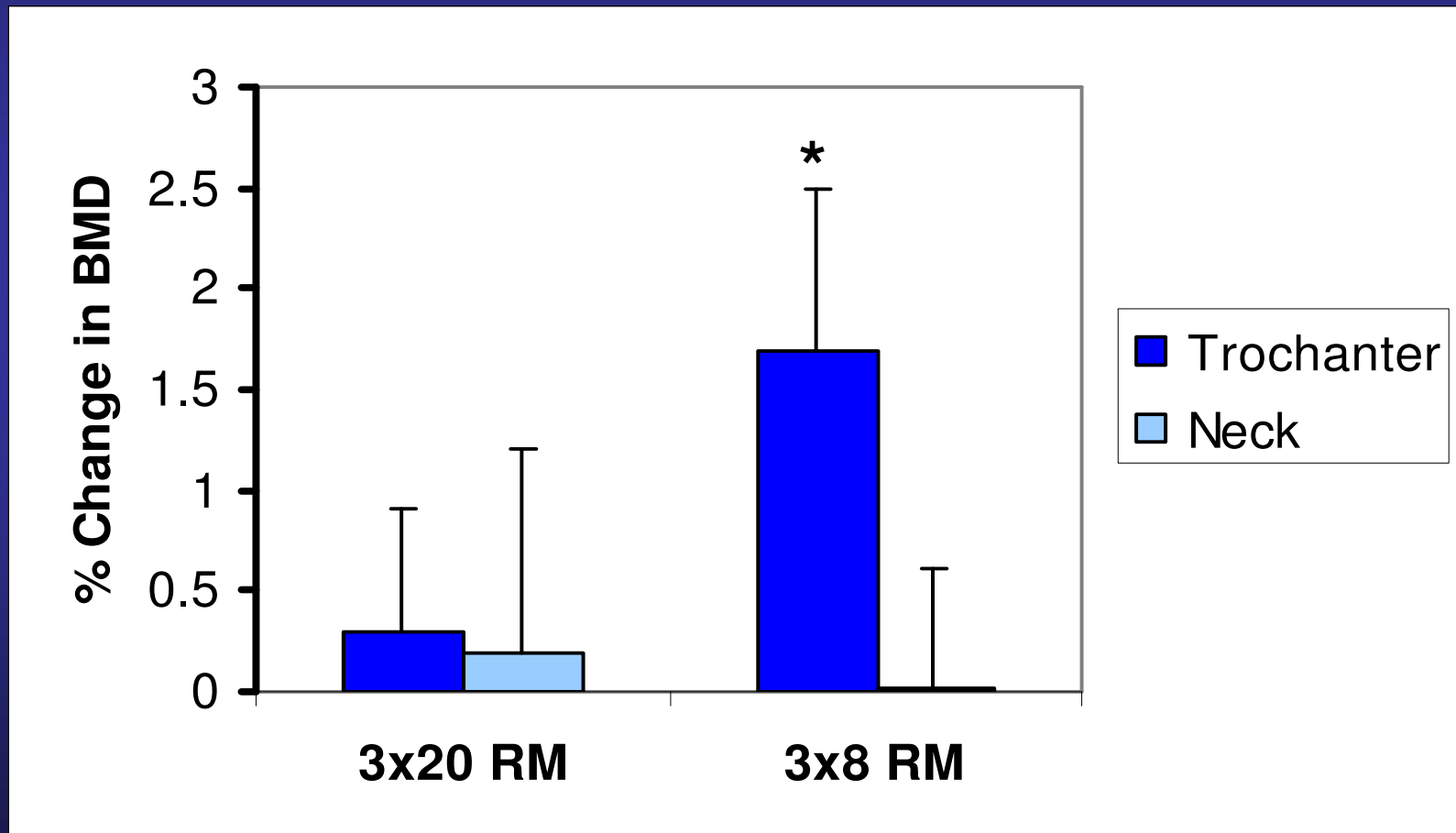
Specificity to prevent or manage OP

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

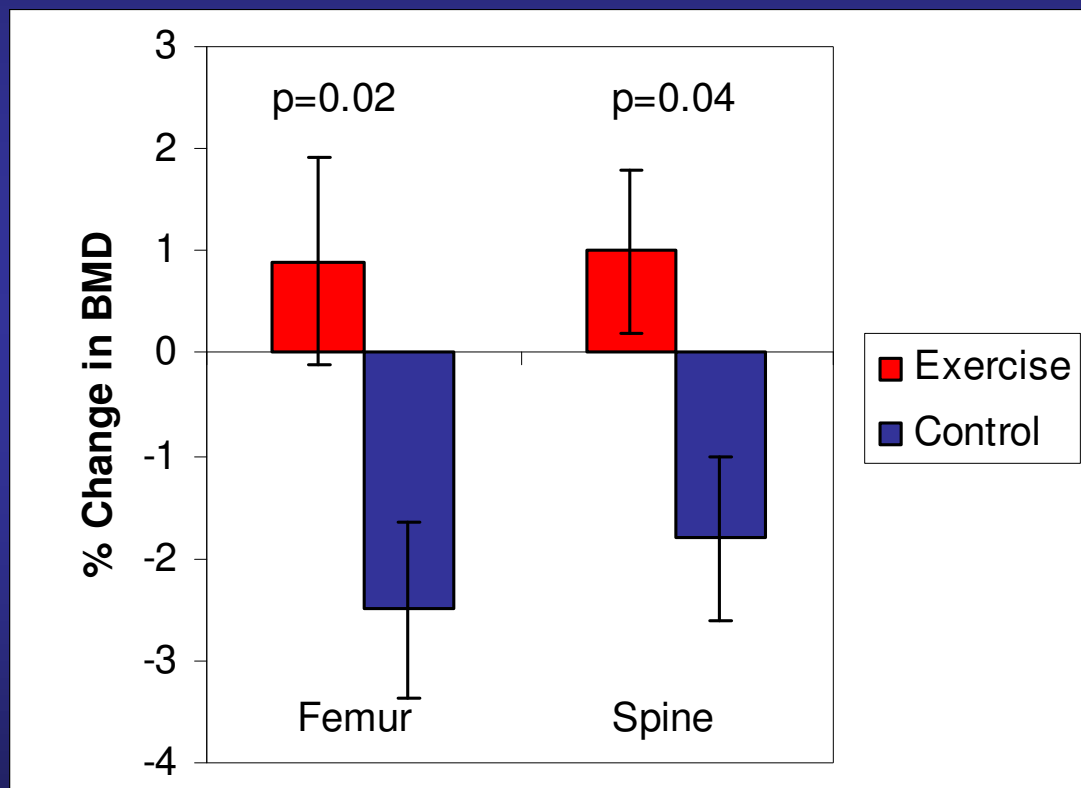
Loading Cycles

Kerr et al, 1996



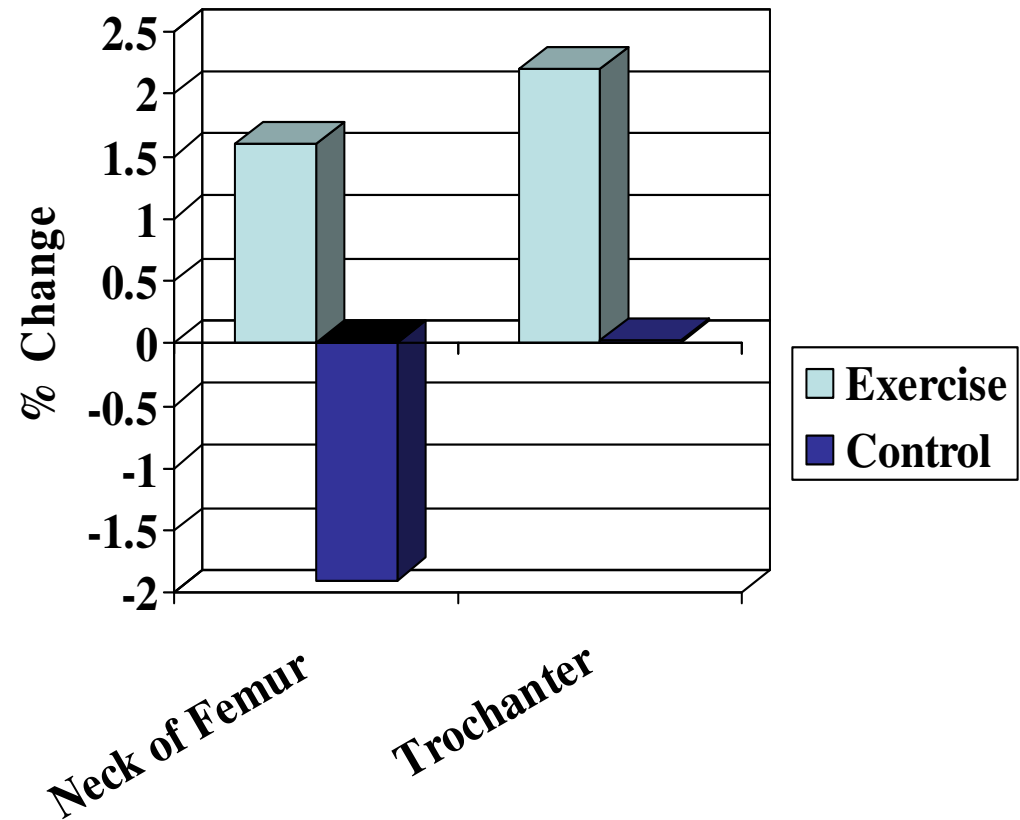


High intensity strength training.



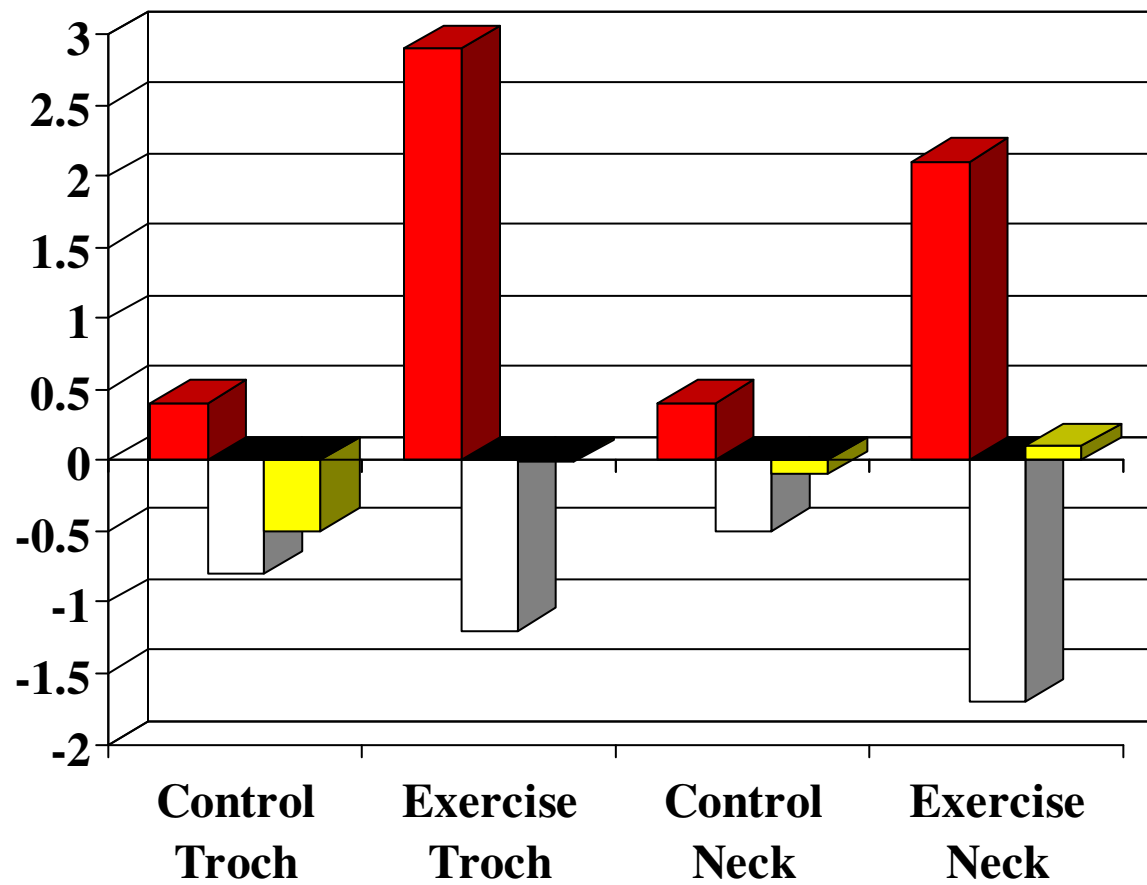
Nelson et al, 1994

Impact Exercise



Welsh & Rutherford, 1996

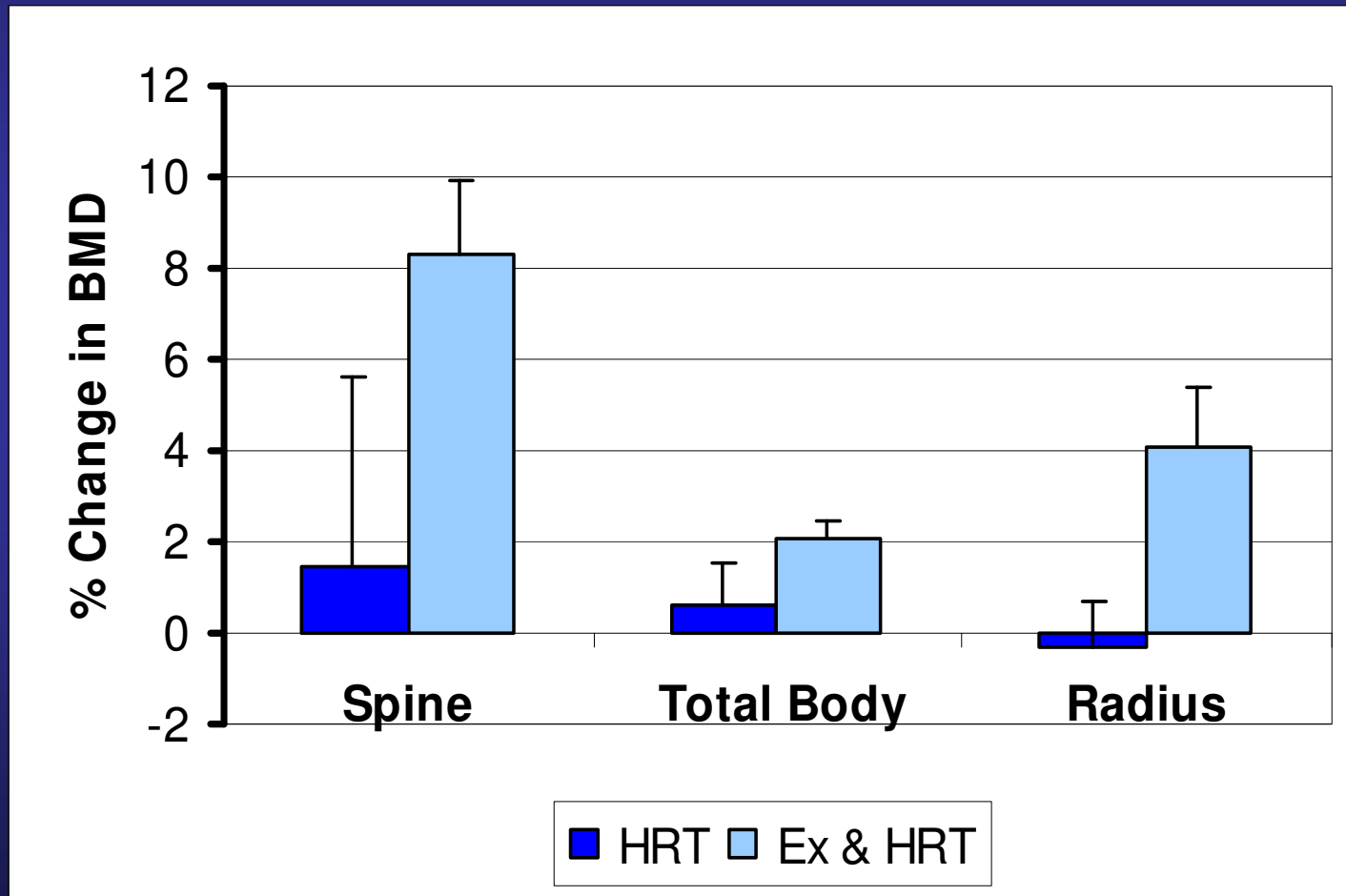
Bassey et al, 1998 Jumping Exercise



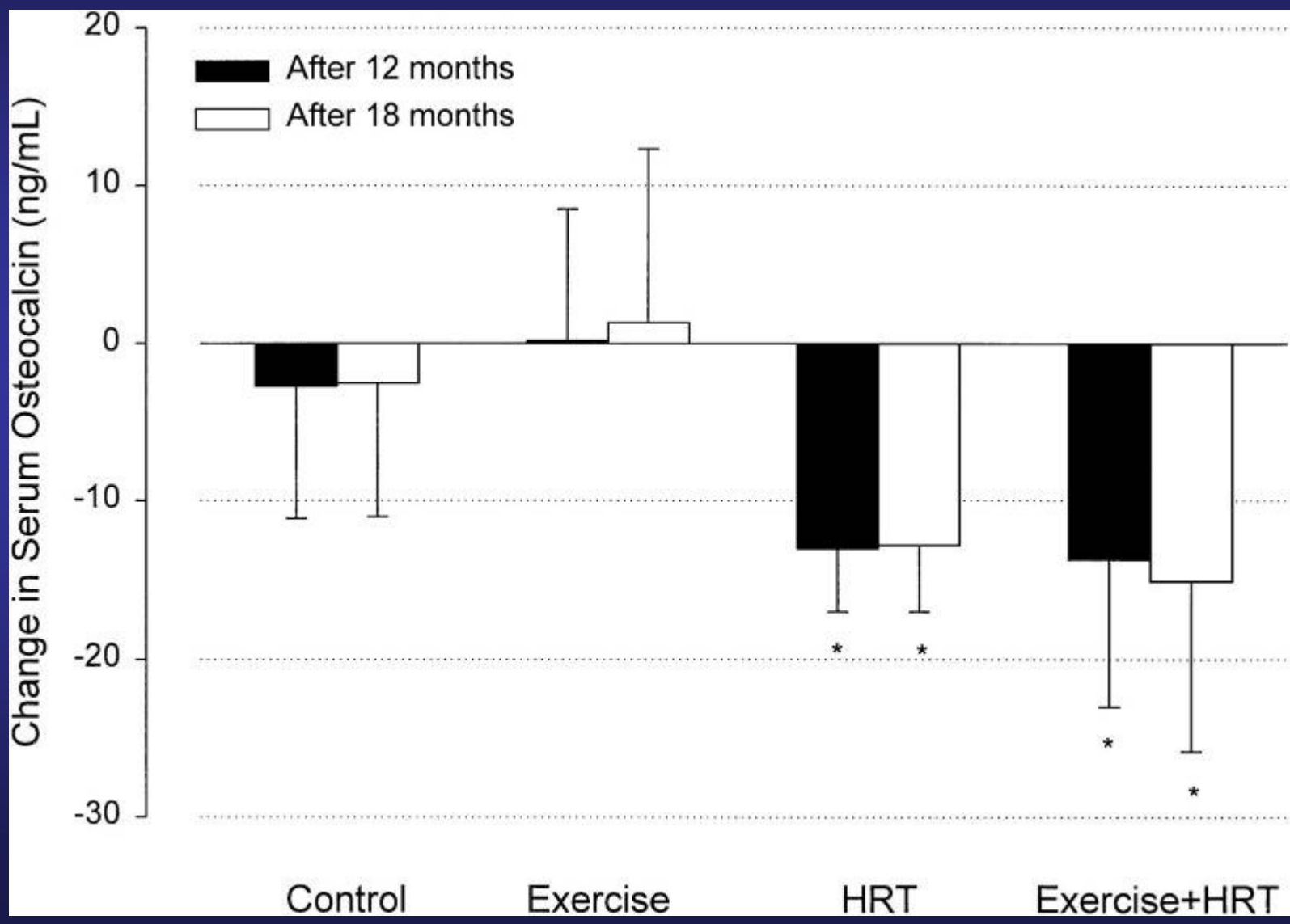
■ Young
□ Post-Men
■ +HRT

HRT and Exercise

Notelovitz et al, 1991



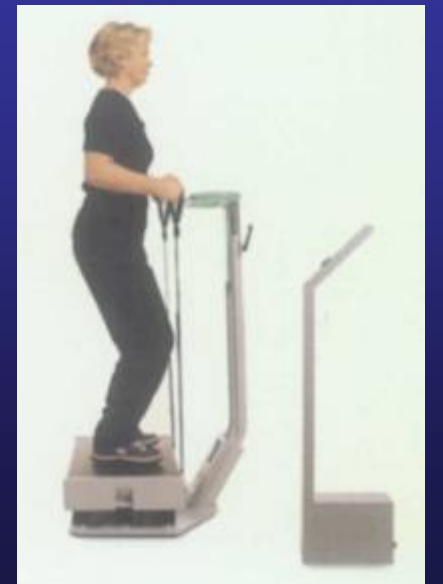
Osteocalcin – marker of bone turnover



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



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

Detraining

- Retired tennis and soccer players still have better bone density than sedentary counterparts and still have site specific differences in BMD two years later (Karlsson, 2004)
- However, younger adults doing leg presses for a year, then stopping, had returned to pre-exercise BMD 3 months later (Karlsson, 2004)
- Lifetime risk of a fracture is not always lower in former athletes.
- It appears that for most of us, exercise benefits to BMD diminish as soon as we stop doing the right activity to maintain it.

Some exercise is risky for bone...

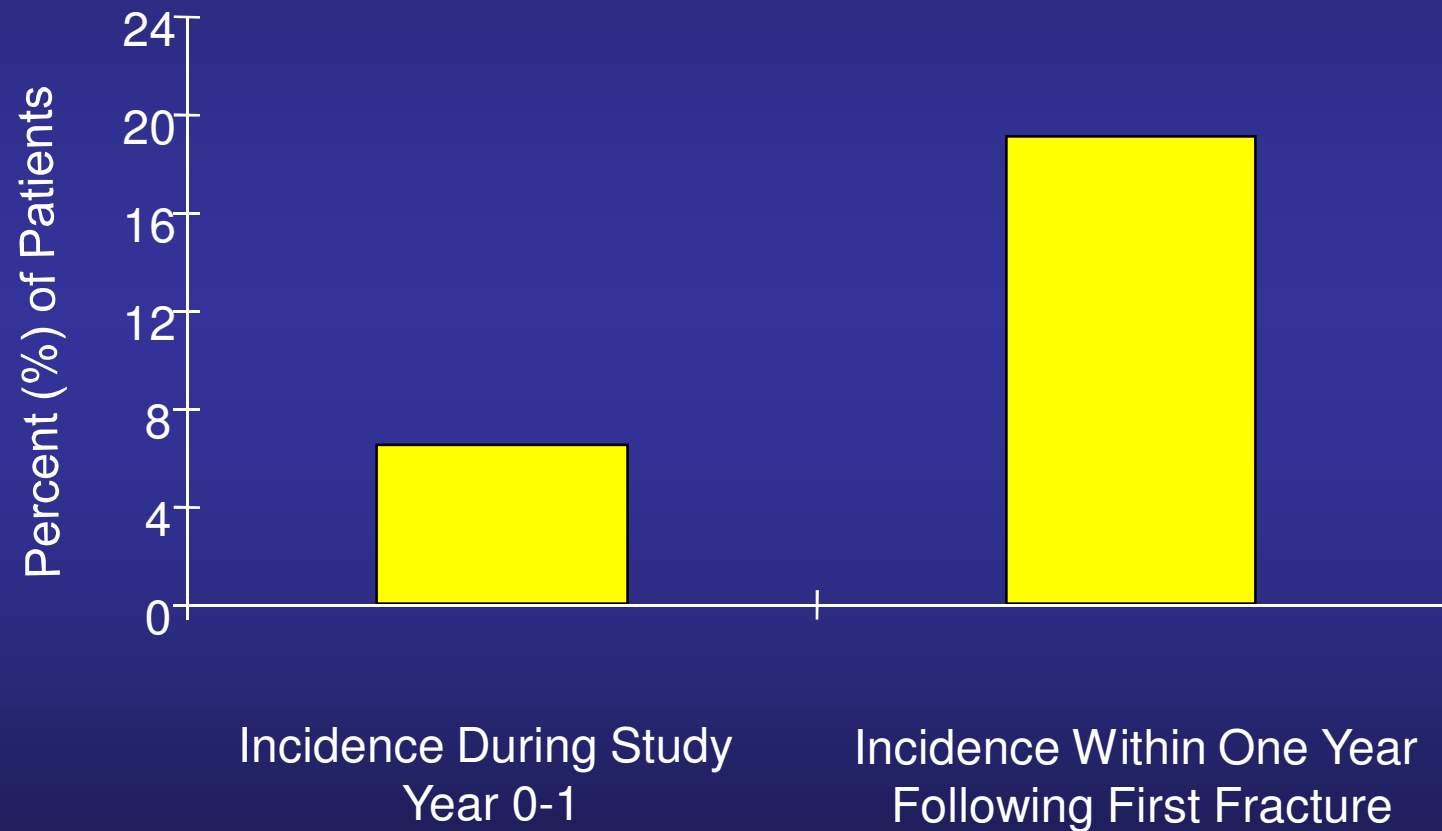
- Women, upper arm fracture
- Excluded
 - bisphosphonates, survival < 1yr, cognitive impairment, too frail
- Intervention: Brisk walking
- Control: exercise of upper arm
- Falls risk (Brisk walking > control)



Ebrahim et al. (1997)

Risk is Higher Immediately Following a Vertebral Fracture

1 in 5 Postmenopausal Women Will Fracture Again Within One Year



[Lindsay et al 2001 JAMA]:

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

Bonewise Sessions - DON'T'S

Avoid or Adapt

- supine abdominal curls
- resisted backward rowing
- double leg extensions
- seated resisted abdominal work
- side lying resisted abduction involving adducted start position
- lat. pull down to back
- asymmetrical, misaligned lateral raise/shoulder press

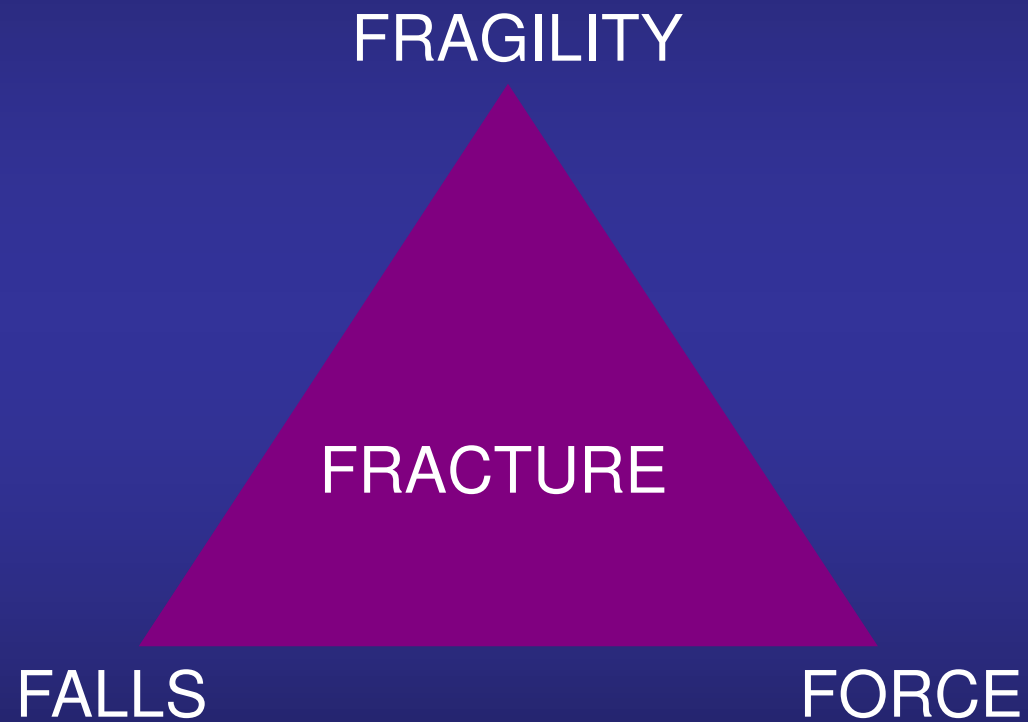


Inactivity related disease?

- Disuse rather than disease?
- 1 wk bed rest ↓ strength by ~ **20%**
- 1 wk bed rest ↓ spine BMD by ~**1%**
- Nursing home residents spend **80-90%**
of their time seated or lying down
- leading to 'Inactivity related
disability' and increased
likelihood of falls and fractures



Fracture Prevention Triangle



Daily Physical activity and use of a walking aid in relation to falls in elderly people in residential care [Graafmans et al. 2003]

- N=563, mean age 82 years, men and women, cross-sectional study
- Falls in the highest quartile compared to the lowest quartile of physical activity reduced by 50%
- Walking aid protected against falls in the intermediate (third) quartile

Pilot Programme to reduce falls in a nursing home [Hofmann et al. 2003]

- Interventions:
 - Environmental : Room furniture repositioned
 - Staffing : additional staff member during times of highest falls
 - Restorative activity programme
- Compared to before the programme:
 - 38% sig. reduction in total falls (479 vs 299 falls)
 - 50% reduction total fractures (16 vs 8 fractures)

Whole Body Vibration- Decreasing risks for Frail elders?

- 42 residents, Nursing Home, RCT
- Whole Body Vibration (PBV) & Physical Therapy (PT) vs PT only
- 2 x p/w, 6 wks training
- WBV improved
 - gait (Tinetti 2.4 pts)
 - Balance (Tinetti 3.5 pts)
 - Timed Up and Go (11 secs)
 - Quality of Life (SF36 8/9 domains)

Bruyere O et al. Arch Phys Med Rehabil 2005;86: 303-307

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

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

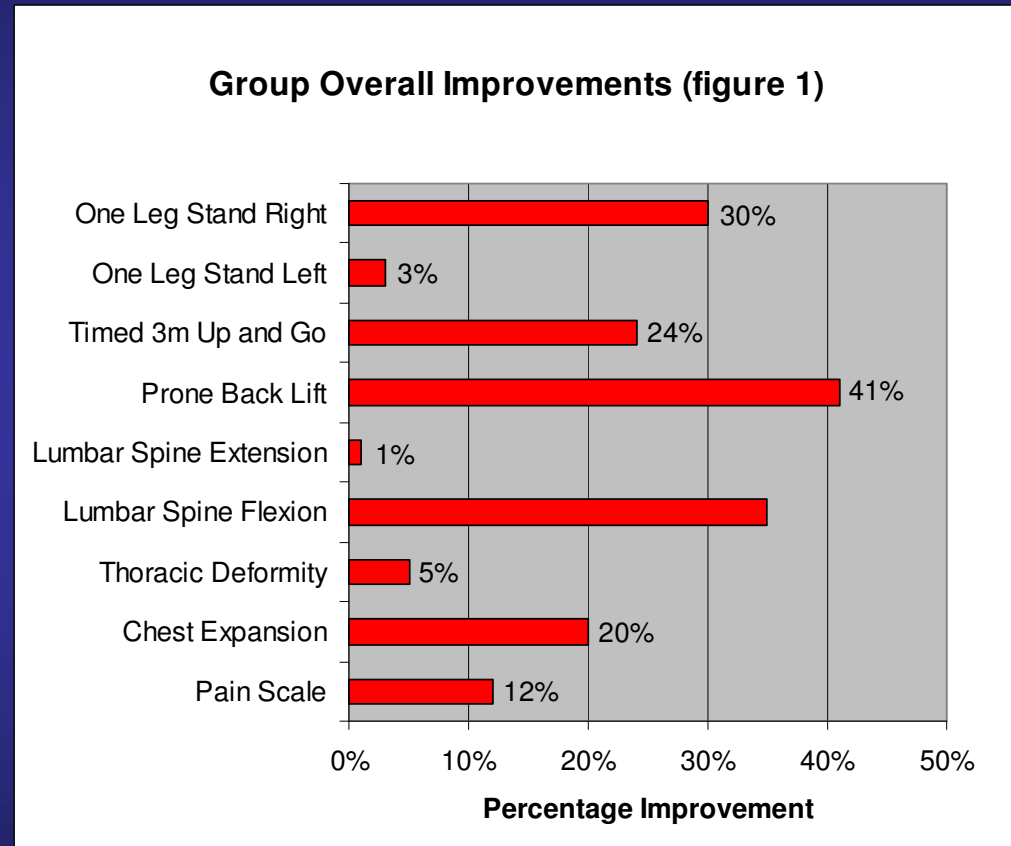


Gwen Fitzpatrick lost sixteen inches in height due to vertebral fractures; during 30 years of fractures no treatment was provided to prevent further bone loss

Results from a BoneWise Service

SAMPLE

- 36 patients (f 34, m 2)
- Mean age 64 (43-84)
- High risk patients
 - T score >-3
 - Previous history of fracture
 - Significant medical pathology



A.Francis, S.Dinan, S.Moss, S.Watts, C.Prelevic, Poster presented at NOS Annual Conference 2001

FALLS - FaME

DURING INTERVENTION

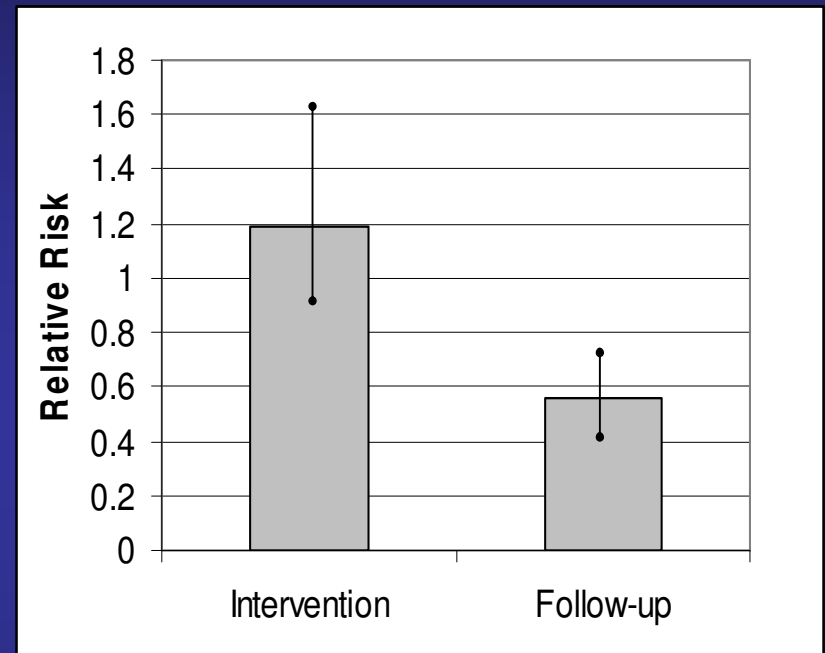
- Exercisers slightly increased risk of falls compared to controls (RR 1.19)
- BUT less likely to sustain injurious fall (RR 0.51)

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)

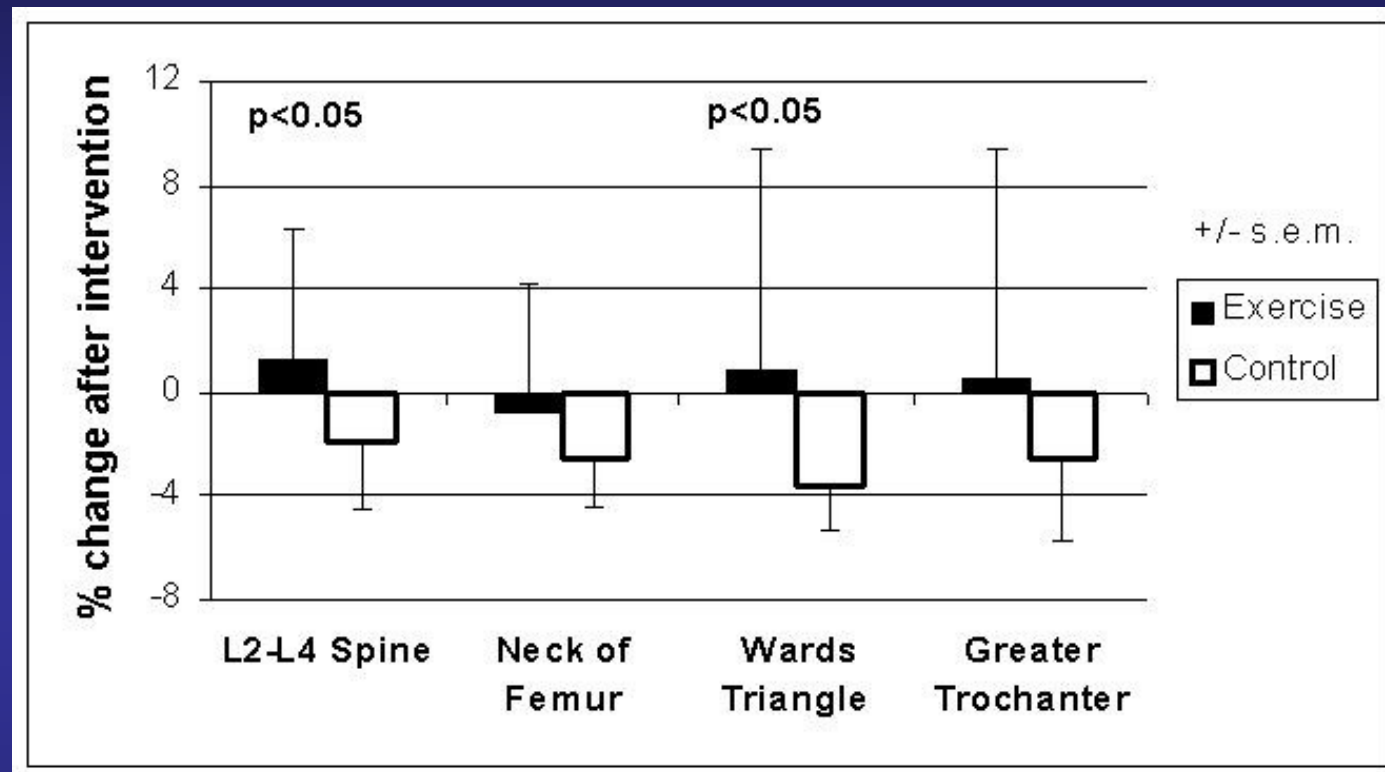
THREE YEARS FROM BASELINE

- **10%** of exercisers had died, were in Hospital or in a nursing home vs **33%** of controls



Skelton et al. JAPA 2004; Age Ageing 2005

FaME – BONE Results



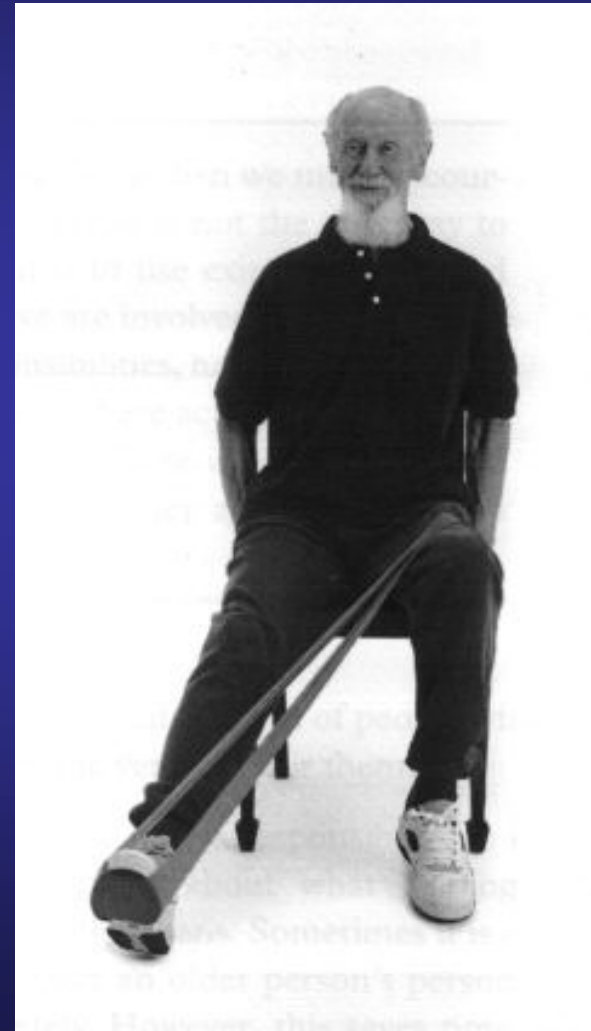
Significant difference with time and group for L2-L4 spine and Wards Triangle ($F=3.46$, $p<0.05$). Exercisers $n=32$, Controls $n=14$.

Time between visit 1 and visit 2 = mean 10.9 (sd 2.7) months

Heart Transplant Patients

- Men
- 6 months resistance exercise
- Greater relative gains in BMD than seen in other studies on older adults

Braith et al. 1996



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 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

**THIS TALK WILL BE AVAILABLE TO DOWNLOAD FROM
www.laterlifetraining.co.uk (Publications link)**

Bonewise: Session Format

Warm Up (5 mins)

PR1	Circulation exercises:	March behind chair, side steps
	Mobility exercises:	Side bends, heel toe, trunk twist
	Stretching exercises:	Standing Lats, Calf, Seated Hamstring, Pecs

Put chairs away. Practice safe & correct lifting technique

PR2/CV + Dynamic Balance

Circulation exercises:	Begin walking activities
Walking intervals (divide class into 2 groups):	Brisk walk and 'bouncy' walk laps. Side step while waiting.

Bonewise: Session Format

The Workout

MSE

Standing Wall drops 1x12 (followed by pec stretch)
Walk on heels/Walk on toes (for balance & Ankle
strengthenener)

Repeat Wall drops

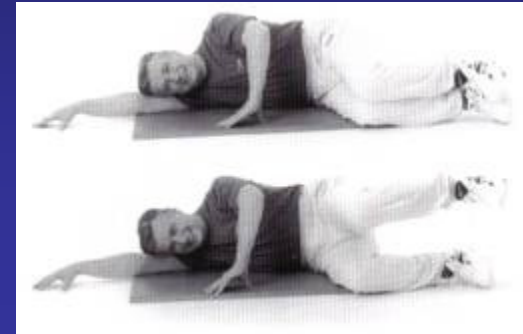


Bonewise: Session Format

The Workout

MSE

Floor work	Back raise	1 x 10
	Quad stretch	
	Back raise	1 x 10
	Static abs	
	Back raise	1 x 10
	Prone hip extension (lying flat with option of leg weight <u>or</u> in box position)	
	Back raise	1 x 10
	Hip abduction (right, side lying with option of leg weight)	1 x 10
	Lat stretch (side lying)	
	Hip abduction (right, side lying)	1 x 10
	Rest	



Bonewise: Session Format

The Workout

MSE

Box position (1) hand forwards of box position, shift weight onto hands

(2) hands wider than box position, shift weight onto hands



Strong Bones



Strong Bones



Strong Bones

Bonewise: Session Format

The Workout

MSE

Hand weight
exercises

Option of standing or seated

1 x 8-10

Arm curl

1 x 8-10

Calf raises

1 x 8-10

Wrist curl

1 x 8-10

Shoulder press (seated)

1 x 8-10

Thigh lift (seated)

1 x 8-10

Squats/lunges with weights

1 x 8-10

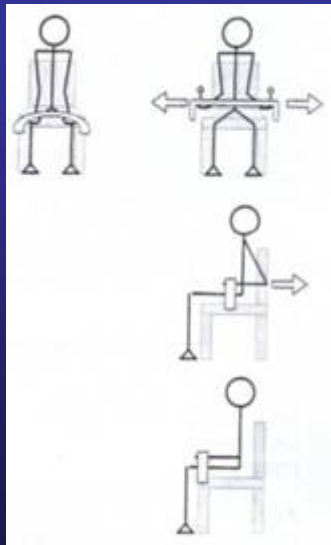


Bonewise: Session Format

The Workout

MSE

Seated band exercises



Leg press	1 x 5
Chest press	1 x 8-10
Trapezius (Isometric backward row)	2 x 8
Tricep extension (overhead where possible, underfoot where not)	1 x 8
Wrist squeezing, twisting, pulling (rolled band)	1 x 5

Bonewise: Session Format

Cool Down

Pulse lowerer

Flexibility stretches

Relaxation 1 min

Refresh in standing