Physical Activity and Bone Health

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Network Europe
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

Krogher & Toft, 1983
BMD in Male Athletes

Nilsson & Westlin, 1971

Strength (Kg)

BMD (g/cc)

Weight Lifters  Thowers  Runners  Swimmers  Sedentary

0.15  0.17  0.19  0.21  0.23  0.25  0.27

0  10  20  30  40  50  60  70
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
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

**Graph:**
- % Difference
- Amenorrhoeic athletes
- Anorexia
- Normal Menstruation

The graph shows the effect of different conditions on Spine BMD, with normal menstruation having the least negative impact, followed by amenorrhoeic athletes and anorexia, which have more pronounced negative effects.
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

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Duration/Intensity</th>
<th>Details</th>
<th>BMD Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bassey et al.</td>
<td>1995</td>
<td>6 months; daily</td>
<td>Post-menop. Heel drops; low impact Supervised once per week</td>
<td><img src="image" alt="non significant increase in hip BMD" /></td>
</tr>
<tr>
<td>Nelson et al.</td>
<td>1991</td>
<td>12 mths; 3 p/w</td>
<td>Walking rapidly; 8lb belt</td>
<td><img src="image" alt="spine and hip BMD" /></td>
</tr>
<tr>
<td>Bravo et al.</td>
<td>1997</td>
<td>12 mths; 3 p/w</td>
<td>Osteopenic. Water-based jumping and strength</td>
<td><img src="image" alt="hip BMD" /> <img src="image" alt="spine BMD" /> <img src="image" alt="fitness" /></td>
</tr>
<tr>
<td>Cavanaugh et al.</td>
<td>1988</td>
<td>Walking below anaerobic threshold</td>
<td></td>
<td><img src="image" alt="spine BMD" /></td>
</tr>
<tr>
<td>Hatori et al.</td>
<td>1993</td>
<td>36 mths; 3 p/w</td>
<td>Post-menop. Non strenuous weight training Supervised once per week</td>
<td><img src="image" alt="spine, hip or radius BMD" /> <img src="image" alt="muscle mass" /></td>
</tr>
<tr>
<td>Sinaki et al.</td>
<td>1996</td>
<td>36 mths; 3 p/w</td>
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<td><img src="image" alt="spine, hip or radius BMD" /> <img src="image" alt="muscle mass" /></td>
</tr>
</tbody>
</table>
1 Year Walking Programme

Cavanaugh & Cann, 1988
## Specificity to prevent or manage OP

### OSTEOPOROSIS MANAGEMENT - POST MENOPAUSAL WOMEN

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
</table>
| 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 | 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.](image1)

![Fig 2—Compression load exercise.](image2)
### Specificity to prevent or manage OP

**OSTEOPOROSIS MANAGEMENT – PRE AND POST MENOP. WOMEN**

<table>
<thead>
<tr>
<th>Study</th>
<th>Duration</th>
<th>Menopausal Status</th>
<th>Exercise Details</th>
<th>BMD Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pruitt et al. 1992</td>
<td>1 yr; 3 p/w</td>
<td>Post Menopausal women</td>
<td>Weight training machines incl. Back extension and flexion</td>
<td>▲ 1.6% spine BMD</td>
</tr>
<tr>
<td>Nelson et al. 1994</td>
<td>1 yr; 3 p/w</td>
<td>Post Menopausal women</td>
<td>Weight training</td>
<td>▲ 1% spine BMD and hip BMD</td>
</tr>
<tr>
<td>Bassey et al. 1994</td>
<td>6 mths; daily</td>
<td>Pre Menopausal women</td>
<td>High impact jumping supervised once a week, daily at home</td>
<td>▲ 3.4% hip BMD</td>
</tr>
<tr>
<td>Kohrt et al. 1995 1997</td>
<td>1 yr; 3 p/w</td>
<td>Post Menopausal women</td>
<td>Impact loading; vigorous walking; jogging; stair-climbing</td>
<td>▲ 2.3% spine and 3.3% hip BMD</td>
</tr>
<tr>
<td></td>
<td>1997</td>
<td></td>
<td>Stair-climbing / descending</td>
<td>▲ 1.8% spine BMD; ▼ hip BMD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weight training; free weights; machines; standing</td>
<td>▲ 1.5% spine BMD; ▼ hip BMD</td>
</tr>
<tr>
<td>Welsh et al. 1996</td>
<td>1 yr; 3 p/w</td>
<td>Post Menopausal women</td>
<td>Seniors fitness medium to low impact jumps; step; floor strength and wrist loading; free weights</td>
<td>▲ 1.6% hip BMD; ◀◀ spine BMD</td>
</tr>
</tbody>
</table>
### Specificity to prevent or manage OP

**OSTEOPOROSIS MANAGEMENT - POST MENOPAUSAL WOMEN**

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention Details</th>
<th>Change in Spine BMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson et al. 1991</td>
<td>1 yr; 3 p/w; Post Menopausal women. Walking with weighted belt + Calcium</td>
<td>▲ 3% spine BMD</td>
</tr>
<tr>
<td>Notelowicz et al. 1991</td>
<td>1 yr; 3 p/w; Post Menopausal women. Exercise + HRT</td>
<td>▲ 8% spine BMD</td>
</tr>
</tbody>
</table>
Loading Cycles
Kerr et al, 1996

% Change in BMD

- **Trochanter**
- **Neck**

<table>
<thead>
<tr>
<th></th>
<th>3x20 RM</th>
<th>3x8 RM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trochanter</strong></td>
<td><img src="trochanter.png" alt="image" /></td>
<td><img src="trochanter.png" alt="image" /></td>
</tr>
<tr>
<td><strong>Neck</strong></td>
<td><img src="neck.png" alt="image" /></td>
<td><img src="neck.png" alt="image" /></td>
</tr>
</tbody>
</table>

* Significant difference
High intensity strength training.

Nelson et al, 1994
Impact Exercise

Welsh & Rutherford, 1996
Bassey et al, 1998
Jumping Exercise

Control Troch  Exercise Troch  Control Neck  Exercise Neck

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
• 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 < 1 yr, 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

<table>
<thead>
<tr>
<th>Type of Exercise</th>
<th>Reoccurrence of Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back extension</td>
<td>16%</td>
</tr>
<tr>
<td>Flexion (abd. curls)</td>
<td>89%</td>
</tr>
<tr>
<td>Combined</td>
<td>53%</td>
</tr>
<tr>
<td>No exercise</td>
<td>67%</td>
</tr>
</tbody>
</table>

*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?

• Dis*use* 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

- Fracture
- Fragility
- Force
- Falls

National Institute for Health, USA 1999
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)

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 (e.g. Sit to stand, stairs)
  - Functional ROM and flexibility training

- **Osteoporosis - BMD <2.5 without #**
  - Targeted postural, gait and low impact endurance training (e.g. 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

• Targeted Bone Loading (propulsion/resistance)
• Targeted Bone Protecting (resistance)
• Dynamic Endurance (walking/stepping/circuits)
• Dynamic Balance
• Flexibility & Postural
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
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 strengthener)
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 or 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
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