Bone Training

Why is bone training important?
- Bone density declines through adulthood
- Low bone density (osteoporosis) places person (men as well as women) at increased risk of bone fractures, in later years
- Stimulating development of bone density at all ages is widely recommended

Drugs

Nutrition

Exercise

Readings:
- Selected articles referenced within lecture are not required readings

What is the goal of bone training?
Bone mineral density (BMD), size and shape all affect bone strength (so don’t just consider BMD to be the outcome measure that must be improved)

- So, bone strength can be increased with no measurable change in BMD (1-4)
Is bone training effective on BMD?

- It has been demonstrated that physically active people (e.g., tennis players, gymnasts) have stronger bones with increased BMD [2-4]

BUT

- The effectiveness of exercise to prevent bone loss in humans is debated [5, 14]
  - BUT: just slowing a loss of BMD could be better than the decline that occurs without exercise, so an exercise regime that fails to increase BMD may not be a waste of time

Is bone training effective on fracture rate?

- The effectiveness of exercise to prevent bone fractures is unknown [4, 6, 7, 14]
  - No randomized controlled studies that use fracture incidence as the outcome measure

What type of training is effective to stimulate bone development?

- The relative importance of muscle contraction forces or gravitational forces associated with surface impacts as the most important mechanical stimulus to bone during exercise is debated. May depend on bone location and role (e.g., weight bearing?) [8-10, 14]

What type of training is effective to stimulate bone development? [1]

- Osteogenesis is stimulated by dynamic, not static loading
  - High impact exercises that produce high rates of deformation is a strong stimulus to osteogenesis [14]

- Higher frequency (cycles/sec) of loading is a stronger osteogenic stimulus [1]
  - OR Low freq (i.e. 10 sec between impacts) [14]
  - Rapidly repeated loads are better than ones with time intervals
What type of training is effective to stimulate bone development?

- Bone cells become desensitized to repeated mechanical stimulation, and need a 4-8 hr rest period before sensitivity fully returns
  - 95% of mechanical sensitivity is lost after only 20 loading cycles (e.g., jumps)
  - Doing a large # of loads (e.g., jumps) at one time is a waste of time
  - Better to do a few (high frequency) dynamic loads, spread throughout the week
- Assumes 3x body wt = “mild-impact loading”

(1, 4, 11, 14)

What is the acceleration produced by different types of training?

(12)

What type of training is effective to stimulate bone development?

- To improve hip BMD in healthy premenopausal women, < 100 accelerations per day at levels exceeding 3.9 g

(12)

“Novel” or “Unusual” strains may provide more effective stimulus = not the normal loading directions

(3, 6, 4, 14)
What type of training is effective to stimulate bone development?

Resistance Training??? Walking???

Portions of Abstract: ...

...exercise modalities requiring high forces and/or generating high impacts have the greatest osteogenic potential. Not all exercise modalities have shown positive effects on bone mass. For example, unloaded exercise such as swimming has no impact on bone mass, while walking or running has limited positive effects.

It is not clear which training method is superior for bone stimulation in adults, although scientific evidence points to a combination of high-impact (i.e., jumping) and weight-lifting exercises. Exercise involving high impacts, even a relatively small amount, appears to be the most efficient for enhancing bone mass, except in postmenopausal women. Several types of resistance exercise have been tested also with positive results, especially when the intensity of the exercise is high and the speed of movement elevated. A handful of other studies have reported little or no effect on bone density. ....Impact and resistance exercise should be advocated for the prevention of osteoporosis. For those with osteoporosis, weight-bearing exercise in general, and resistance exercise in particular, as tolerated, along with exercise targeted to improve balance, mobility and posture, should be recommended...

Resistance training (a variety of programs reviewed) produces a 1% - 3% increase in BMD or BMC (Bone Mineral Content) in clinically relevant sites, in pre- and post-menopausal women

- High load, low repetition exercise was effective; low load, high repetition exercise was not
- Insufficient studies in men
- Studies in women have largely used traditional strength programs (e.g 2-3 sets, 8-12 reps, 70-80 % 1-RM, 2-3 x/wk), but the effect of other resistance training dose patterns has not been explored
- Walking is not a novel, multidirectional stimulus, and so is far less effective (if effective at all) as a bone stimulus
- Remember: other factors may influence the effect of training on bone (e.g., nutrition, estrogren/HRT/menopause, body composition, initial bone density)

Post-menopausal women

- High impact only and odd-impact only protocols were ineffective
  - odd-impact = e.g., step classes, agility exercise & games where body changes direction in not typical directions

Mixed loading programs:

- combining impact (e.g, jogging) & other low-impact loading (e.g., stair climbing or walking), or
- activities mixing impact activity with high-magnitude exercise such as resistance training reduces bone loss at hip & spine
## What type of training is most effective to stimulate bone development?

### Summary:
- Impact (e.g., Jumps or activities that include jumping)
- Produce force >3 - 4 x body wt (running, jumping)
- Daily (or 2 sessions/day, 8 hr interval)
- Rapid jumps
- >40/day - <100/day??
- Mixed Loading??

### CAUTIONS:
1. For people who HAVE OSTEOPOROSIS training activities must avoid high loads through the vertebral bodies to prevent vertebral fractures.
2. In older individuals, light load high rep exercise (e.g., jogging) > 5 hours /wk may produce bone loss.
   - Due to low body fat, low weight, inflammatory mediators affecting bone metabolism.
3. In young cyclists, 1-yr competitive training produced BMD loss at hip, neck, trochanter & shaft (not lumbar spine).

## What type of training is effective to stimulate bone development?

### CAUTIONS:
1. "Lots of Exercise in Midlife May Lead to Osteoarthritis" by Randy Dottinga HealthDay Reporter

   http://www.healthday.com/News/HDN/19935584.html

   SOURCES: Joseph Guettler, M.D., orthopedic surgeon and sports medicine specialist, William Beaumont Hospital, Bingham Farms, Mich.; Christoph Stehling, M.D., research fellow, Department of Radiology and Biomedical Imaging, University of California, San Francisco, Radiological Society of North America. Nov. 30, 2009

   "A new study suggests that high levels of physical activity boost the risk of internal knee damage that could lead to osteoarthritis."

   The findings "speak to the importance of low-impact aerobic activity, especially in knees that are aging and may not be as resilient as they used to be."
   - "This study ... suggest that high-impact, weight-bearing physical activity, such as running and jumping, may be worse for cartilage health."
   - "Conversely, low-impact activities, such as swimming and cycling, may protect diseased cartilage and prevent healthy cartilage from developing disease."
   - "activities involving twisting, jumping and pivoting are especially hazardous. Don't overdo it when it comes to activities like basketball and soccer."
   - "Instead, consider alternatives like walking, swimming, biking, cross-country skiing and training on elliptical machines."

2. In collegiate basketball players, total body & leg BMD decreased over 1-yr competitive training (total body BMD decreased 3.3% in 4 months).
3. The optimal exercise prescription for bone may vary across the lifespan with age, health and nutrition.
References
5. Bonaiuti et al, Exercise for preventing and treating osteoporosis in postmenopausal women. Cochrane Database of Systematic Reviews. 2002

References

References