Bone Density and Practical Applications

Class Design – Bone Density and Balance
Helping to minimize Bone Density loss and improve balance
Risks of Osteoporosis

• By age 75
  – women lose between 25% and 40% bone mass

• Professional male bikers
  – 10yrs – 20 yrs. Older skeleton

• Lack of exercise effects everyone
National Institute of Health

• Osteoporosis is a major threat to 28,000,000 Americans (80% women)
• One out of two women and one out of 8 men - osteoporosis related fracture
• 80,000 men per year have a hip fracture – 1/3 die
• 1,500,000 fractures / yr. - $ 14 billion
Bone Properties vs. Age

Figure 2.8.3  Summarized results of the effect of age on mechanical properties of femoral cortical bone (based on data from Yamada, 1970, and Burstein et al., 1976, with permission of Williams & Wilkins, Baltimore, Maryland).
Astronauts in Space

Figure 2.8.2  Calcium balance of astronauts on Skylab missions undergoing immediate change upon entry into space (from Rambout and Goode, 1985, with permission).
Compressive breaking forces in the middle portion of wet femoral shafts in longitudinal direction (based on data from Yamada, 1970, with permission of Williams & Wilkins, Baltimore, Maryland).
Bone Failure with age

Relation between ultimate stress and age. Using linear regression analysis, age accounted for 55% of the variation observed in mechanical stress data. Measurements were made on femora of 25 men and 22 women aged 20 to 105 years at the time of death (from McCalden et al., 1993, with permission).
Do medications help?
Drugs – Choice?
MEDICATIONS

- Alendronate (Fosamax)
- Raloxifene (Evista)
- Risedronate Sodium (Actinel)
- Hormone Therapy
DETECTION

- Individual Fractures
- Bone Mineral Density (BMD)
- Dual energy x-ray absorption DEXA
- Ultrasound
- Quantitative CAT Scan (QCT)
Exercise
Resent Research
Can exercise help the spine of a postmenopausal women over a 3 – year period?

The bones are just not the same
Exercise maintains bone density at spine and hip EFOPSS: a 3-year longitudinal study in early postmenopausal women

Osteoporosis Int. 2006 17: 133-142
Exercise maintains bone density at spine and hip – 38 months

- DXA lumbar spine
  0.8% versus -3.3%

- QCT trabecular bone
  1.1% versus -7.7%

- QCT cortical bone
  5.3% versus -2.6%
Exercise maintains bone density at spine and hip – 38 months

• DXA total hip
  - 0.2% versus -1.9%

• DXA distal forearm
  - 2.8% versus –3.8%

• QCT cortical bone
  5.3% versus -2.6%
Exercise maintains bone density at spine and hip – 38 months

- DXA lumbar spine – between group
  4.1%

- QCT trabecular bone – between group
  8.8%

- QCT cortical bone – between group
  7.9%
Exercise maintains bone density at spine and hip – 38 months

- DXA total hip – between group
  - 2.1%

- DXA distal forearm – between group
  - 1%
Exercise maintains bone density at spine and hip – 38 months

• Spine
  – Pain frequency and intensity reduced
Resent Research
Can we just exercise at home and solve our bone mass problems?
Predictors of compliance with a home-based exercise program added to usual medical care in preventing postmenopausal osteoporosis: an 18-month prospective study

Osteoporosis Int. (2005) 16: 325-331
Hone-based exercise programs

• 18 month compliance rate
  17.8%

• Factors
  – Contraindication for hormone replacement
  – General physical function
  – NO FEEDBACK
Bone Problems

– Kyphosis
  • Spinal Hump

– Wrist Fractures

– Spinal Fractures

– Hip Fractures
Don’t fall – No fractures
Fall Prevention

• Be careful!
  – Time
  – Surfaces
  – Contact Surfaces

• Exercise
Can water exercise improve balance?
"Effectiveness of water exercise on postural mobility in the well elderly: an experimental study on balance enhancement."
Improving Balance

- Average age ~ 80 years
- Program length 5 weeks
- Testing functional reach
- Land exercise balance increase 1 week
- Water exercise balance increase every week
Class Balance Planning

- Provide objective to class
- “Risks” in the water versus “Fracture” on land
- Brain range of balance location – Warm-up – Exercise - Cool-down
Total Body Synchronization
Maria Sykorova-Pritz

- Shift side to side
- Go to lifting a foot off the floor
- Shift front and back
- Go to lifting a foot off the floor
- Have class feel their own bodies
Exercise Motions

• Stand on one leg
  – Knee kick other and turn
• Switch sides

• Turning jumping jacks
Stretching

• Balance on one leg
  – Move body around hip joint

• Stretch to the side with the foot behind
Effects of Impacts

• Exercise
  – Tennis player 20% bigger bone on one side
  – Olympic Lifters 50% greater spinal density
  – Astronauts lose bone mass even with exercising
  – Osteoblasts control osteoclasts
Can impacts prevent all bone loss?
Effects of Lifetime Volleyball Exercise on Bone Mineral Densities in Lumbar Spine, Calcaneus and Tibia for Pre-, Peri- and Postmenopausal Women

Annual bone loss rates

- tibia and calcaneus  Lifetime << Control
- Lumbar spine Lifetime = Control

Levels of bone

- tibia and calcaneus  Lifetime >> Control
- Lumbar spine Lifetime >> Control

M. Ito1, T. Nakamura2, S. Ikeda2, Y. Tahara8, R. Hashmi1, K. Tsurusaki1, M. Uetani1 and K. Hayashi1, 1Department of Radiology, Nagasaki University School of Medicine; 2. Department of Orthopedic Surgery, University of Occupational and Environmental Health, Kitakyushu; and 3Department of Health and Physical Education, Faculty of Education, Nagasaki University, Nagasaki, Japan.
New Concepts

• Calcium loss when sweating
  – 200 mg / hour (Bikers)

• Cells respond to ion fluid flow from impact exercise (current)

• Fluid vanishes after two strikes
Can aquatic exercise help individuals with osteoporosis?
Current Finding

• Evaluation of Hormonal Response and Ultrasonic Changes in the Heel Bone by Aquatic Exercise in Sedentary Postmenopausal Women

  – Increased level of serum growth factor 1, growth hormone and calcitonin (36%, 75%, 54%)
  – Decreased level of parathormone (31%)
  – Positive Ultrasound finding
"Influence of aquatic and weight-bearing exercises on quantitative ultrasound variables in postmenopausal women.

RESULTS

• Calcaneal BUA increased in aquatic exercise by 3.1%.

• Calcaneal BUA increased weight-bearing exercise groups by 4.2%

• Calcaneal BUA decreased control group by 1.3%

Mushi Harush
Masters Thesis

• Benefits in bone density from aquatics

• Many areas
Planning Concepts

• The 10 Second Gap - MAGIC
  – 14 Times greater Gains
  – American College of Sports Medicine 2004

• Fluid flow communication

• Allow non-impact time ~15 – 20 seconds
VISCOELASTIC – Velocity

\[ F = kx + cv \]
Biomechanics
Bone Density

• Cortical Shell Size
  – Force across

• Trabecular Bone
  – Axial load
Biomechanics
Biomechanics
Biomechanics
Muscle Attachments
Biomechanics
Muscular
Biomechanics
Muscular - High
Biomechanics
Muscular - Low
Biomechanics
Muscular Mix
Planning Factors

- Provide Objective to class
- Apply force quickly (Impact)
- Impact various direction
- Allow recovery time (be active)
New Class Planning

Jump - Kick

• Jump to one leg and kick the other knee for 10 - 20 second

• Jump to other leg

• Repeat
New Class Planning

Jumping Jacks

• 4 high

• ~20 seconds neck level (little impact)

• Repeat
New Class Planning

Jumping Jacks
Neck level
• 2X Legs together knees up and drive down
• 2X Legs apart knees up and drive down
• ~20 sec - neck level legs cross (little impact)
• repeat
New Class Planning

Cross country Ski

- 4X Knees up and through
- ~ 20 sec Neck level without real impact
- Repeat