Optimizing Bone Health
“No bones about it!”

Julie Matel, MS, RD, CDE
Overview

- A bit about bones: defining osteoporosis
- Implications of osteoporosis
- What affects bone health in CF?
- How do we measure bone health in CF?
- How can we achieve and maintain strong bones?
Osteoporosis: Defining the Problem

“A skeletal disorder characterized by compromised bone strength predisposing to an increased risk of fracture”

(Courtesy of Andrea Kelly MD, MSCE, University of Pennsylvania)
The Human Cost of Osteoporosis

- Impaired function, decreased mobility
- More bone loss due to decreased activity
- Compressed abdomen, decreased appetite
- Reduced pulmonary function
- Sleep disorders
- Decreased survival

(Courtesy of Andrea Kelly MD, MSCE, University of Pennsylvania)
Peak Bone Mass is Achieved by 30 years of Age

(Courtesy of Andrea Kelly MD, MSCE, University of Pennsylvania)
Strongest predictor of BMD in old age is BMD at a young age

**CF**--Decreased bone formation

**CF**--Accelerated bone loss
Bone is Dynamic

(Courtesy of Andrea Kelly MD, MSCE, University of Pennsylvania)
Disruption in Osteoblast and Osteoclast Function in CF

(Courtesy of Andrea Kelly MD, MSCE, University of Pennsylvania)

Increased resorption
Increased osteoclast #
Increased activity

Decreased formation
Decreased osteoblast #
Decreased activity
Compromised Bone Health in CF

Adults
- Increased fracture rates
- “Undiagnosed” vertebral and rib fractures
- Kyphosis
- Decreased vital capacity
- Pain

Children
- Fracture rates may not be increased
- Bone mineral accrual appears compromised, particularly during puberty

(Courtesy of Andrea Kelly MD, MSCE, University of Pennsylvania)
Factors Contributing to Bone Disease in CF (R. Aris, 2005)

Low Bone Density (CF)

- Pancreatic Insufficiency
- Vitamin D, K, & Calcium Insufficiency
- Malnutrition and Poor Growth
- Sex Hormone Insufficiency
- Inflammatory Cytokines
- Steroid Medications
- Diabetes

Factors:
- Low Bone Density (CF)
- Pancreatic Insufficiency
- Vitamin D, K, & Calcium Insufficiency
- Malnutrition and Poor Growth
- Sex Hormone Insufficiency
- Inflammatory Cytokines
- Steroid Medications
- Diabetes
Screening Guidelines

- Screen all adults
- LPCH: screen all children > 12 years old
- Screen children > 8 years old if…
  - < 90% ideal body weight,
  - FEV1 less than 50%ile predicted,
  - Extensive glucocorticoid therapy
  - Delayed puberty
  - History of fractures

(Aris, R, 2005)
Dual Energy X-Ray Absorptiometry (DEXA)
Additional Monitoring Guidelines to Maximize Bone Health

- Annual Labs
  - Vitamin D
  - Prothrombin time (indirect vitamin K)
- Monitor Body Mass Index (BMI)
Factors to Optimize Bone Health

- Achieve Optimal BMI
- Ensure Adequate Calcium Intake
- Reduce Inflammation
- Ensure Adequate K and D
- Weight Bearing Exercise
- Optimize Enzyme Rx
Optimize Body Mass Index (BMI) kg/m²

- Goal of 22 Adult Females
- Goal of 23 in Adult Males
- Goal of greater than 50th %ile in infants and children
Ensure Adequate Calcium Intake

- Choose foods high in calcium
- If supplements are recommended, take with meals in divided doses throughout the day
# Recommendations for Calcium Intake

<table>
<thead>
<tr>
<th>Age</th>
<th>Dietary Reference Intake Calcium (mg/day)*</th>
<th>Daily High-Calcium Food Servings Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 months</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>6 – 12 months</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>1-3 years</td>
<td>700</td>
<td>3</td>
</tr>
<tr>
<td>4-8 years</td>
<td>1000</td>
<td>3 - 4</td>
</tr>
<tr>
<td>9-13 years</td>
<td>1300</td>
<td>4</td>
</tr>
<tr>
<td>14-18 years</td>
<td>1300</td>
<td>4</td>
</tr>
<tr>
<td>Adult</td>
<td>1000</td>
<td>3</td>
</tr>
</tbody>
</table>

*(up to 1500 mg daily)*
# Calcium Rich Foods

<table>
<thead>
<tr>
<th>High Calcium Foods</th>
<th>Medium Calcium Foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serving size: 1 cup milk, yogurt, pudding or 1 ½ ounces of cheese</td>
<td>½ cup</td>
</tr>
<tr>
<td>300 mg calcium per serving</td>
<td>75-150 mg calcium per serving</td>
</tr>
<tr>
<td>Milk</td>
<td>1/8 of a 12” pizza</td>
</tr>
<tr>
<td>Yogurt</td>
<td>Cottage cheese</td>
</tr>
<tr>
<td>Milkshake</td>
<td>Frozen yogurt or ice cream</td>
</tr>
<tr>
<td>String cheese</td>
<td>Tofu (calcium-set)</td>
</tr>
<tr>
<td>Pudding or custard</td>
<td>Corn tortillas (2)</td>
</tr>
<tr>
<td>Calcium enriched orange juice</td>
<td>Broccoli</td>
</tr>
<tr>
<td>Calcium enriched orange juice</td>
<td>Refried beans</td>
</tr>
<tr>
<td></td>
<td>Almonds (1/2 cup)</td>
</tr>
</tbody>
</table>
Vitamin K and Bone Health in CF

- Fat soluble vitamin
- Osteocalcin, a protein produced by bone building cells, requires vitamin K
- Low levels seen in CF
- Pro-thrombin time is an indirect measure of vitamin K
- Recommended intakes: 300-500 mcg daily
- To ensure adequate levels, supplementation is recommended in people with CF
About half of our vitamin K needs are thought to be bacterially produced.

Courtesy of K. Penniston, PhD, RD, University of Wisconsin
Dietary Sources of Vitamin K

- Dark green leafy vegetables: spinach, broccoli, turnip greens, swiss chard
Vitamin D and Bone Health in CF

- Fat soluble vitamin
- Necessary for calcium absorption
- Low levels (less than 30 ng/ml) are seen in people with CF
- Recommended supplementation, 400-800 IU/day
Sources of Vitamin D

- Sun light
- Milk (fortified)
- Fortified Cereals and soy products
- Fish (mackerel, canned sardines, fish-liver oils, cod-liver oil)
Optimize Enzyme Therapy

- Take enzymes right before and/or during meals and snacks
- Discard enzymes that are beyond their expiration date
- Store enzymes in a cool dry place
- Take with **EVERYTHING EXCEPT**: foods that contain simple sugars such as hard candy, fruit, fruit juice, jello, soda
- Take vitamin supplements with enzymes at meal times
For Younger Children…

- **Do not** sprinkle enzyme beads on food and let sit
- Give enzyme beads in the first bite or two in an acidic food (such as applesauce, other fruit purees, jelly, ketchup)
- Avoid grazing/snacking all day long
- Don’t forget enzymes with milk/supplements that are consumed alone
How do I know if my enzymes are working well?

<table>
<thead>
<tr>
<th>Unhealthy Bowel Movements</th>
<th>Healthy Bowel Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent BMs</td>
<td>1-2 BM/day</td>
</tr>
<tr>
<td>More than 48 hrs without BM</td>
<td>Sink</td>
</tr>
<tr>
<td>Loose/diarrhea BM</td>
<td>Odor no worse than other family members</td>
</tr>
<tr>
<td>Excessive gas/bloating</td>
<td>Solid BM</td>
</tr>
<tr>
<td>Floating/greasy BMs</td>
<td>Brown in color</td>
</tr>
<tr>
<td>Foul odor</td>
<td>No strain or discomfort</td>
</tr>
<tr>
<td>Hard to pass</td>
<td></td>
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Exercise and Bone Health in CF

- Mechanical Stress
- Inflammation
- Inactivity

Balance between Bone Deposition and Bone Loss
Principles of Exercise Training

- Balanced program
  - Aerobic training
  - Resistance training
  - Flexibility
- Specificity of training for task
  - This will differ developmentally
- Avoid bad outcomes
  - Injury (e.g. muscle/joint)

Courtesy of Anne K. Swisher, Ph.D., P.T., C.C.S.
West Virginia University
Exercise is tailored to particular age and stage of CF
High-Velocity Loading

- Jumping rope
- Sports (volleyball, basketball)
High-Velocity Loading

- Needs to be progressive as bone adapts
- Unusual strains better than doing the same thing every time
- Multiple short sessions 2-3 times per week for total of 20-30 min (10-50 jumps per day)
Low-Velocity Loading

- Resistance training: Barbell squats, seated rows
- Walking, swimming
Low-Velocity Loading

- Safer for those with established osteoporosis or fractures
- Still engages mechanical stress of muscle on bone insertion sites
- Probably better for preventing further loss than gaining BMD
Systemic hormones, inflammatory cytokines, and localized growth factors all affect bone remodeling.

Elevated levels of cytokines and GFs (e.g., TNF-alpha, VEGF, various interleukins) found in serum and respiratory tract of CF pts may stimulate osteoclast activity.

Anti-Inflammatory Diet

- Rich in Antioxidants and omega 3 fatty acids
- Ie: brightly colored fruits and vegetables, whole grains, beans, salmon, nuts
### High Calorie Anti-Inflammatory Foods

<table>
<thead>
<tr>
<th>Food</th>
<th>Calories</th>
</tr>
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<tbody>
<tr>
<td>Olive oil added to Vegetables</td>
<td>120 per Tablespoon</td>
</tr>
<tr>
<td>Salmon</td>
<td>230 per 4 ounces</td>
</tr>
<tr>
<td>Avocado</td>
<td>230 per cup</td>
</tr>
<tr>
<td>Almonds</td>
<td>270 per ½ cup</td>
</tr>
<tr>
<td>Dried mango</td>
<td>130 for 6 pieces</td>
</tr>
<tr>
<td>Almond Butter</td>
<td>200 for 2 Tablespoons</td>
</tr>
<tr>
<td>Fruit Smoothie</td>
<td>200 for 12-16 ounces</td>
</tr>
</tbody>
</table>
Examples of “Anti-Inflammatory” Diets

**MEDITERRANEAN DIET PYRAMID**
From: Women’s Heart Foundation, womensheart.org, accessed 10/10/2011

Courtesy of K. Penniston, PhD, RD
University of Wisconsin

**ANTI-INFLAMMATORY FOOD PYRAMID** (Dr. Weil)
Limited evidence for this diet exists. One reference is: Hotamisligil & Erbay, Nature Reviews Immunology, 2008

Red meat - a few times per month in very small amounts
A few times per week

Fish

Cheese and yogurt

Olive Oil

Vegetables

Beans, Legumes, Nuts

Sweets

Eggs

Poultry

A few times per week

Daily

Bread, pasta, rice, couscous, polenta, bulgur, other grains, and potatoes

**HEALTHY SWEETS** (such as plain dark chocolate) Sparingly
**RED WINE** (optional) No more than 1-2 glasses a day
**SUPPLEMENTS** Daily
**TEA** (white, green, oolong) 2-4 cups a day
**HEALTHY HERBS & SPICES** (such as garlic, ginger, turmeric, cinnamon) Unlimited amounts

**OTHER SOURCES OF PROTEIN** (high quality natural choices and yogurt, omega-3 enriched eggs, wild rice, poultry, lean meats) 1-2 a week

**COOKED ASIAN MUSHROOMS** Unlimited amounts

**WHOLE SOY FOODS** (tofu, tempeh) 1-2 a day

**FISH & SEAFOOD** (wild Alaskan salmon, Alaskan black cod, sardines) 2-4 a week

**HEALTHY FATS** (extra virgin olive oil, expeller-pressed canola oil, nuts - especially walnuts, avocados, seeds - including hemp seeds and freshly ground flax seeds) 3-4 a day

**WHOLE & CRACKED GRAINS** 3-5 a day

**PASTA** (al dente) 2-3 a week

**BEANS & LEGUMES** 1-2 a day

**VEGETABLES** (both raw and cooked, from all parts of the color spectrum, organic when possible) 4-5 a day minimum

**FRUITS** (fresh in season or frozen, organic when possible) 3-4 a day
Protect your bones by….

- Achieving and maintaining an optimal BMI
- Ensure adequate calcium intake
- Optimize vitamin D and K status
- Take enzymes as directed with all meals and snacks
- Exercise (weight bearing exercises when possible)
- Choose anti-inflammatory high calorie foods
got milk?