Prevention and Management of Osteoporosis-The Chiropractic Role

Palmer College of Chiropractic Florida
Homecoming 02/27/2022

Learning Objectives

• The learner will be able to:
  – Understand the significance of osteoporosis.
  – Review bone physiology and the impact of inflammation on bone health.
  – Summarize how to assess and diagnose osteoporosis.
  – Understand the complexity and the interrelationships of macro and micronutrients on bone health.
  – Discuss lifestyle and dietary habits that support bone health.
  – List the primary medications used for osteoporosis treatments.
  – Develop a bone-healthy lifestyle and diet plan for a simulated patient.

Meet Betty Bone!

• 80-year-old Caucasian female
• 64” tall, 130 lbs.
• Former smoker
• Early osteoporosis
• Chiropractic patient

Why Is Osteoporosis Important?

• Low bone mass
• Increased porosity
• Increased fragility
• Increased fracture risk
• Loss of independence
• Loss of life

Why Should Chiropractors Care?

• DCs see **10-14%** of the population (Bussieres & Stuber, 2013)
• **By 2030**, 20% of the population will be > 65 (Dougherty et al., 2012)
• Chiropractic one of most frequently-used alternative medicine types (Dougherty et al., 2012)
• **5% of older adults seek chiropractic care** (Dougherty et al., 2012)
• Early recognition of osteoporosis should be a mandate for health care providers (Cosman et al., 2014)
What Are the Clinical Repercussions?

- Most, maybe as much as 80%, of those with high risk of fracture AND 1 previous fracture are not diagnosed or managed.
- History of a prior OP fracture = 86% risk of subsequent fracture.
- Hip fractures have the most associated morbidity and mortality with mortality as high as 24% in the first year following the fracture.
- Scandinavia has the highest reported incidence of osteoporotic fracture.

Healthy People 2030 Objectives Targeting Osteoporosis

- Reduce the proportion of adults aged 50 and older with osteoporosis from 7.3% to 5.5%
- Reduce hip fractures among older adults.
  - Currently 5.7/1000 individuals
  - Goal 4.6/1000 individuals
- Increase the number of adults (65 and over) who get screened for osteoporosis
- Increase the proportion of older adults (65 and over) who get treated for osteoporosis following a fragility fracture.
**ANATOMY & PHYSIOLOGY OF BONE**

- **What is Bone Made Of?**
  - **Tough, organic matrix strengthened by calcium salts**
    - 30% matrix, 70% salts
  - **Organic matrix 90-95% collagen**
    - 5-10% ground substance
    - Extends along lines of tensional force and provides tensile strength
  - **Bone salts**
    - Crystalline salts deposited in the organic matrix
    - Principally calcium and phosphate
    - Hydroxyapatite
    - Compressional strength

- **Remodeling of Bone is Ongoing**
  - Bone formation is associated with osteoblast activity.
    - Osteoblast progenitors > mature osteoblasts
    - Bone is constantly being deposited (about 4% of bone normally)
  - Bone resorption is associated with osteoclast activity.
    - Monocytes are the precursors (bone marrow)
    - Osteoclasts are multinucleated, phagocytic cells
    - Normally active on less than 1% of the bone surfaces of adult
  - These processes are normally in equilibrium

- **When is Peak Bone Mass Attained?**

- **Factors That May Modulate Remodeling of Bone**
  - Vitamin D status
  - Parathyroid status
  - Hormonal status
    - Estrogen
    - Testosterone
    - Cortisol
    - Thyroid
  - Inflammation
Bone Remodeling Takes a Village

The Top 3 Regulators of Bone Remodeling

- Receptor activator of nuclear factor kappa B ligand (RANKL)
- Macrophage colony-stimulating factor (M-CSF)
- Osteoprotegerin (OPG)

Osteoporosis—the Most Common Bone Disease

- Osteoporosis is described as decreased bone matrix
- Differs from osteomalacia and rickets
  - Diminished organic bone matrix rather than from poor bone calcification
  - Osteoblastic activity is usually less than normal
  - Rate of bone osteoid deposition is depressed
  - Hyperparathyroidism, cause is excess osteoclastic activity

Most Common Causes of Osteoporosis

- Inactivity-lack of physical stress
- Malnutrition-preventing sufficient protein matrix formation
- Lack of vitamin C
  - Necessary for the secretion of intercellular substance, including formation of osteoid
- Postmenopausal
  - Lack of estrogen secretion, which decreases the number and activity of osteoclasts
  - Old age
  - Growth hormone and other growth factors diminish
  - Protein anabolic functions deteriorate, interfering with bone matrix deposition
- Cushing’s syndrome
  - Massive quantities of glucocorticoids decrease deposition of protein and depress osteoclastic activity

The Role of Inflammation in Bone Loss

- Osteoclasts are immune cells
  - Monocytes are the precursors for osteoclasts
- Chronic inflammation
- Auto-inflammation
- Hormonal changes
- Adiposity
- Disturb balance between bone building and bone breakdown

RISK FACTORS FOR OSTEOPOROSIS
Which Risk Factors Are Non-Modifiable?

- Age
- Female
- White
- Small-boned
- Certain diseases
  - Celiac
  - Prolonged cortisone use
  - Diabetes

Cosman et al., 2014

Which Risk Factors Are Modifiable?

- Tobacco use
- Excess alcohol
- Inactivity
- Low mineral intake
- Certain medications
  - Current and future cortisone use
- Low body mass

Cosman et al., 2014

Turn To Your Neighbor

Some Things Can Be Changed!

Risk Factors for Falling

-nion
- De-conditioning
- Muscle weakness
- Certain medication use
- Balance deficits
- Previous history of falling

Cosman et al., 2014; de Jong, van der Elst, & Hartholt, 2013

Risk Factors for Our Patient Betty Bone?

- BMI 24
- Taking inhaler (fluticasone) for COPD
- Previously active but has not returned to the YMCA x 12 months
- Former smoker

Which of these is a risk factor for osteoporosis?
DIAGNOSIS & SCREENING FOR OSTEOPOROSIS

National Osteoporosis Foundation Recommendations for Assessment of Fracture Risk

- Detailed history
- Physical examination
- Bone density
- Vertebral imaging
- World Health Organization 10-year fracture risk model (FRAX)

History As It Pertains to Osteoporosis

- Recent fracture in major skeletal site > 50
- Family history
- Risk Factors
- Diet
- Supplements
- Alcohol, tobacco, coffee use
- Medications

Physical Examination Is Important!!

- Annual measurement of height
- Loss of ½” in one year
- Loss of 1 ½” from original height
- Bone mineral density
- Women 65 and over
- Men 70 and over
- With risk factors 50 and over
- Adult fractures in 50 and over

Diagnostic Imaging For Assessment of Bone Health

- Dual-energy x-ray absorptiometry (DEXA) scan is the gold standard
  - World Health Organization has set the standards for diagnosis of osteoporosis and low bone mass/density using DEXA
- Plain film radiography
- Quantitative Ultrasound (QUS)
- Quantitative Computerized Tomography (QCT)

Dual-Energy X-ray Absorptiometry (DEXA)

- Gold standard by which the World Health Organization has established guidelines for diagnosis of osteoporosis
- Less than or equal to -2.5 below the young adult mean (t-score) is considered osteoporosis
### Diagnosis of Osteoporosis is Defined by the T-Score

<table>
<thead>
<tr>
<th>T-Score</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Normal</td>
<td>Bone density is within one standard deviation (SD) of the young adult mean (+1 or -1).</td>
</tr>
<tr>
<td>Low Bone Mass</td>
<td>Bone density is within -1 to -2.5 SD below the young adult mean (-1.0 to -2.5).</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>Bone density is -2.5 SD or more below the young adult mean (-2.5 or lower).</td>
</tr>
<tr>
<td>Severe (established) osteoporosis</td>
<td>Bone density is more than -2.5 SD below the young adult mean, and there have been one or more osteoporotic fractures.</td>
</tr>
</tbody>
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### World Health Definitions Based on Bone Density Levels

<table>
<thead>
<tr>
<th>Age</th>
<th>BMD Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women &gt;70</td>
<td>Less than or equal to -1.0</td>
</tr>
<tr>
<td>Men &gt;80</td>
<td>Less than or equal to -1.0</td>
</tr>
<tr>
<td>Women 65-69</td>
<td>Less than or equal to -1.5</td>
</tr>
<tr>
<td>Men 70-79</td>
<td>Less than or equal to -1.5</td>
</tr>
<tr>
<td>Postmenopausal women &amp; men &gt;50</td>
<td>Low-fracture trauma (weight loss 1.5&quot; or more, long-term or recent glucocorticoid treatment)</td>
</tr>
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### What Laboratory Tests Are Useful?

- Comprehensive Metabolic Profile (CMP)
- Complete Blood Count (CBC)
- Liver Function Tests
- Thyroid-stimulating hormone (TSH)
- Parathyroid hormone (PTH)
- 25-hydroxy vitamin D3
- Testosterone
- Bone-turnover markers
- Homocysteine

### Bone Turnover Markers

#### Bone Resorption
- N-terminal cross-linking telopeptides (NTX)
- C-terminal cross-linking telopeptides (CTX)
- Deoxypyridinoline (DPD)

#### Bone Formation
- Procollagen Type 1 propeptide (PINP)
- Procollagen type 1 C propeptide (PICP)
- Osteocalcin

Although these tests are not used for the diagnosis of osteoporosis or diminished bone mass, they are useful to assess risk of fracture and to monitor treatment. A bonus is that they change much more quickly than a DEXA, in 3-6 months, versus 1-2 years!

### What Laboratory Tests Are Useful?

- World Health Organization (WHO)
- Fracture Risk Algorithm (FRAX)

http://www.shef.ac.uk/FRAX/tool.jsp?locationValue=9

### Are there Questionnaires that would be Helpful?

- World Health Organization (WHO)
- Fracture Risk Algorithm (FRAX)

http://www.shef.ac.uk/FRAX/tool.jsp?locationValue=9
Pharmacologic Treatments

- Bisphosphonates
- RANKL inhibitors
- Estrogen hormonal therapy
- Calcitonin
- Parathyroid hormone

Common Medications Used for Osteoporosis.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Type of Drug</th>
<th>Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alendronate (Fosamax)</td>
<td>Bisphosphonate</td>
<td>GI problems, potency, renal dysfunction, increased risk of lower extremity fracture</td>
</tr>
<tr>
<td>Ibandronate (Boniva)</td>
<td>Bisphosphonate</td>
<td>Renal dysfunction, increased risk of lower extremity fracture</td>
</tr>
<tr>
<td>Risedronate</td>
<td>Bisphosphonate</td>
<td>Renal dysfunction, increased risk of lower extremity fracture</td>
</tr>
<tr>
<td>Zoledronic Acid</td>
<td>Bisphosphonate</td>
<td>Renal dysfunction, increased risk of lower extremity fracture</td>
</tr>
<tr>
<td>Denosumab</td>
<td>MAb, inhibitor</td>
<td>Hypercalcemia, urticaria, skin rash, ONJ, femur fractures</td>
</tr>
<tr>
<td>Estrogen</td>
<td>Hormone</td>
<td>Myocardial infarction, breast cancer, endometrial cancer</td>
</tr>
<tr>
<td>Calcitonin</td>
<td>Parathyroid hormone</td>
<td>In rats, increased incidence of osteosarcomas</td>
</tr>
<tr>
<td>Teriparatide</td>
<td>Parathyroid hormone</td>
<td>In rats, increased incidence of osteosarcomas</td>
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Non-pharmaceutical (natural) strategies

Exercise as prevention and treatment
Exercise Positively Affects Bone Building

- Osteoprotegerin (OPG) surrogate marker for bone-building potential
- OPG following exercise
  - Aerobic
  - Resistance-type
- Lowers inflammatory cytokines and promotes bone formation
- Increases osteoblastic activity

What is the Best Exercise Regimen?

- Aerobic
- Weightlifting
- Balance training
- Pilates
- Tai chi, yoga
- Combination?
- SAFE!

What Dosage and Frequency of Exercise?

- Weightlifting (Weaver et al., 2016)
  - Three days weekly
  - 100 loads per session
  - 7 months
- 60 minutes daily activity for children and adolescents (Weaver et al., 2016)
- Moderate to high intensity, resistance and impact, most beneficial (Kistler-Fischbacher et al., 2021).
- Free weights may be better than machines (Shojaa et al., 2020)

What About Swimming?

- Although swimming has been thought to not be ideal for improvement of bone density
- Su et al. found that swimming improved BMD at the lumbar spine

Tai chi and Yoga?

- A combination of yoga and Pilates maintained BMD, when detriment was expected (SR/MA-Fernandez-Rodriguez et al.)
- Tai chi showed some improvement in BMD (Zhang et al.)
- Balance improvement/fall risk may be another benefit
- ***avoidance of excessive forward flexion is important***
  - Compression fracture as a possible risk in at least one study

Whole-Body-Vibration Training for Osteoporosis

- Positive effects on bone formation
- Improves neuromuscular effectiveness
- Static or active
- Most studies on postmenopausal women
- Ideal dosage and frequency undetermined
NUTRITIONAL CONSIDERATIONS IN BONE HEALTH

Nutritional Considerations in Osteoporosis Management

- Protein
- Dietary fat
- Fruits and vegetables
- Fiber
- Micronutrients

The Three Bears of Protein Intake

- **Too much**: Elevated dietary potential renal acid load (PRAL) negative association with bone health
- **Too little**: Not enough protein is associated with increased fracture risk.
- **Just Right**: Adequate protein important for bone health in children and adults

- Decreased fracture risk with adequate intake

Alkaline salts in plant foods diminish PRAL

Which Diet is the BEST for Bone Health?

- Diet emphasizing fruit, vegetables, legumes, nuts, poultry, fish, and low-fat dairy and de-emphasizing soft drinks, fried foods, meat, processed foods, sweets and desserts.
  (Movassagh, 2017)
- No significant difference between soy protein or animal protein. (Shams-White, 2018)
- Vegetarian diets have been found to support bone health (Chuang, 2021; Knurick, 2015).
- Vegan diets are the most challenging.

What About Dietary Fats?

- Not extensively studied
- Omega-3 fatty acids positive association with bone health (Weaver et al., 2016)
- Anti-inflammatory effect
  - Inflammation and oxidative stress impact osteoclast activity and number (Gunn et al., 2015)

Fruits and Vegetables

- Total fruit and vegetable intake positively associated with bone health (Gunn, Weber, McGill & Kruger, 2015).
- Bone resorptive inhibitive properties (BRIP) of some F/V (Gunn et al., 2015)
- Nine servings daily positive impact on bone resorption markers and calcium excretion (Gunn et al., 2015).
Why Was it Called the Scarborough Fair Diet?

- Vegetables
  - Chinese cabbage, red cabbage, arugula
  - Onions, broccoli, tomatoes, mushrooms
  - Cucumbers, leeks, green beans
- Fruits
  - Dried plums (prunes)
- Herbs
  - Parsley, sage, rosemary, thyme, garlic

Does Fiber Intake Matter?

- Higher fiber intake associated with bone benefit in boys and girls
- Supports the microbiome
  - Improves calcium absorption
- Microbiota may have anti-inflammatory effect
  - Bone support via the immune system

Calcium is the Most Important Bone Health Nutrient

- Adequate intake has a high correlation with bone mass in all ages (Cosman et al., 2014; Weaver et al., 2016).
- Calcium supplementation positive effect in children (Weaver et al., 2016) & adults (Cosman et al., 2014)
- Combination of dietary and supplemental calcium found to reduce fracture risk (Cosman et al., 2014)
- Increased intake through dairy consumption also beneficial (Weaver et al., 2016)
- Many individuals have insufficient intake (Weaver et al., 2016)

Calcium Intake Recommendations

- Women 51 and older 1,200 mg daily
- Men 50-70 and 1,000 mg daily
- Men > 70 1,200 mg daily
- Additional recommendations

Estimating Daily Dietary Calcium Intake Workshop

- https://www.osteoporosis.foundation/educational-hub/topic/calcium-calculator
Workshop

- Pull out your 24-Hour Diet Recall form.
- To the best of your ability, recall your food and beverage intake in the last 24 hours.
- Using the link on the previous slide, estimate how much calcium you ate/drank in the last 24 hours.
- How many had more than 1,200 mg? 1,000? 800? How many had less than 800?

Calcium Supplementation is Not Without Risks

- Excess calcium > 1200-1500 mg daily has been associated with:
  - cardiovascular disease
  - kidney stones
  - stroke (Cosman et al., 2014)
- Bolland et al. (2011) and others found an association between high calcium supplementation and increased cardiovascular disease
- Heaney et al. (2012) argued that there were issues with the studies
- Point of contention in the literature (Chung et al., 2016)

What Do You Think Might Be a Solution?

Vitamin D is #1!

- Vitamin/hormone
- Instrumental in absorption of calcium from the intestines (Veldurthy et al., 2016)
- Primarily responsible for calcium homeostasis (Veldurthy et al., 2016)

Vitamin D Maintains Serum Calcium

What Are Some Food Sources of Vitamin D?

- Egg yolks (37 IU)
- Fatty fish and their oils
  - Pink salmon (canned, 3 oz) 465 IU
- Dairy products
  - low-fat, 8 oz fortified, 98 IU
- Fortified foods

Note: VDR stands for vitamin D receptor and PTHR is parathyroid hormone
**Vitamin D Synthesis in the Body**

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**How Important is Dietary Vitamin K?**

- Important in bone mineralization (Hamidi et al., 2013)
- Subclinical deficiencies associated with osteoporosis
- Diets low in vitamin K associated with increased fracture risk

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**Which Foods Are High in Vitamin K?**

- **K1 (phyloquinone)**
  - Leafy greens, brassica vegetables
  - Green fruits
  - Green & herbal teas
- **K2 (menaquinone)**
  - Manufactured by gut bacteria
  - Fish, eggs, liver, milk
  - Fermented foods including cheese

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**Other Micronutrients**

- **Magnesium**
  - 300 mg daily x one year improved bone mass in children
- **Vitamin C**
  - Improved bone mass in boys
- **Zinc**
  - With vitamin C improved bone mass in fourth-grade girls

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**Other Plants and Herbs in Healthy Bones?**

- Tea
- Coffee
- Herbs
- Isoflavones

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**LIFESTYLE CHOICES THAT CONTRIBUTE TO BONE LOSS**
Substances With a Negative Effect on Bone Health

- Tobacco
- Alcohol
- Carbonated beverages
- Caffeinated beverages
- High sodium intake

Weaver et al., 2016

Smoking Tobacco and Bone Health

- Smoking associated with decreased peak bone mass
- Passive smoking also has negative impact

Weaver et al., 2016

The Impact of Alcohol Intake on Bone Health

- Variable findings
- Some studies show a positive effect
  - Moderation
- > 2 drinks a day for women & 3/day for men negative effect

Cosman et al., 2014; Weaver et al., 2016

Carbonated Beverages

Caffeinated Beverages

High Sodium Intake
What is the Effect of Sedentary Behavior?

- Time spent sitting or reclining
- Children and young adults reported to spend > 40% day sitting
- Diminished bone mineral content with excessive sitting
- Compensated by vigorous activity 5 x weekly

Chastin, Mandrichenk, & Skelton, (2014)

Supplements as the Hero in Bone Health?

Calcium Supplementation Promotes Bone Health

- Most Americans consume 600-800 mg daily of calcium.
- Insufficient intake for bone health
- Supplementation recommended when diet insufficient.

Cosman et al., 2014

But-Calcium Supplements, Friend or Foe?

- High doses of calcium citrate & carbonate associated with slight increase in cardiovascular risk (Bolland et al., 2011)
- Other systematic reviews found methodological flaws (Heaney et al., 2012)
- Recent review found no increased risk (Chung et al., 2016)

Novel Sources of Calcium are an Alternative

- Alternate forms
  - Bone meal
  - Microcrystalline hydroxyapatite
- Do not raise serum calcium as much as carbonate or citrate
- Thus reducing the risk of vascular calcification and disease

Bristow et al., 2014

The Answer is Yes and Yes!

- Food first
- Identify need for additional supplementation
- Identify heart disease risk
- Consider bone meal or MCHC
- Carbonate or citrate last
  - No more than 800 mg.

Bolland et al., 2011; Skelton et al., 2014; Heaney et al., 2012
Adequate Vitamin D is Necessary for Healthy Bones

- Minimally, 400-800 IU recommended for bone health
- Vitamin D insufficiency common in the following:
  - Older adults
  - Chronic renal insufficiency
  - Chronically ill
  - Inflammatory bowel disease
  - Housebound
  - Dark-skinned
  - Obese individuals

Vitamin D Deficiency Depends Upon Definition

- IOM=less than 20 ng/ml
- Others (ES, IOD, NOF)=less than 30 ng/ml
- Endocrine Society recommends 40 ng/ml as a more optimal level

Many Americans are Low in Serum D

- 77% of Americans lower than 30 ng/ml in NHANES study 2001-2004 (LeBlanc et al., 2016)
- Necessary to supplement higher to achieve adequate levels (Cosman et al., 2014)
- 4,000 IU daily considered the tolerable upper limit (TUL; Cosman et al., 2014)

Workshop—What Will You Do In Practice?

- Turn to your partner
- Make a five-point plan for managing Betty Bone’s osteoporosis.
- Include the following:
  - Physical exam
  - Diagnosis
  - Diet
  - Lifestyle
  - Supplements

In Summary....

Osteoporosis is an important chronic health disease that chiropractors are likely to encounter.

Early diagnosis and intervention are important.

Diet and lifestyle play an important part in both prevention and management.

The chiropractor is in a unique position to educate patients as to prevention and natural management of osteoporosis.