THE SCHOOL OF
Applied Functional Medicine™

Powerful Practitioner Pearls on Bone Health

Today's Agenda

2

- Bone Basics
- Bone Balance: Strong *and* Flexible
- Suddenly Sexy Organs?
- Focus on the Falling
- Many Roots of What's Changed
- Hormone Symphony Effects
- Targeted Testing
- Supplement Considerations
- Calcium Cautions

The Skeletal System: Basics

3

- Bones, Ligaments, Tendons, Cartilage. Collagen and Calcium.
  - Intake, digestion, and absorption of protein is key! Glycine* and proline are Not most prevalent in animal muscle meats but rather connective tissue (of course!) in "tougher cuts" of meat. Legumes are a good plant source.
  - Consider dietary variety, eating hygiene, and stomach acid sufficiency (e.g. PPI/H2 receptor blocker drugs, H Pylori overgrowth, chronic stress, hypothyroid).
- Provides structure, movement, and Protection of organs and glands.
- About 200 bones in an adult (newborns ~280!). ~10% regenerates annually. Naturally porous: 5-90% depending on the specific bone.
- Bone volume is ~25% water, 35% collagen, and 35-40% minerals.
- Bone is the body's primary mineral storage (99% of the body's calcium).
  - But not the body's primary buffering system (bicarbonate is).
  - And bone tissue also stores growth factors, triglycerides, immune cells, hormones, and heavy metals!

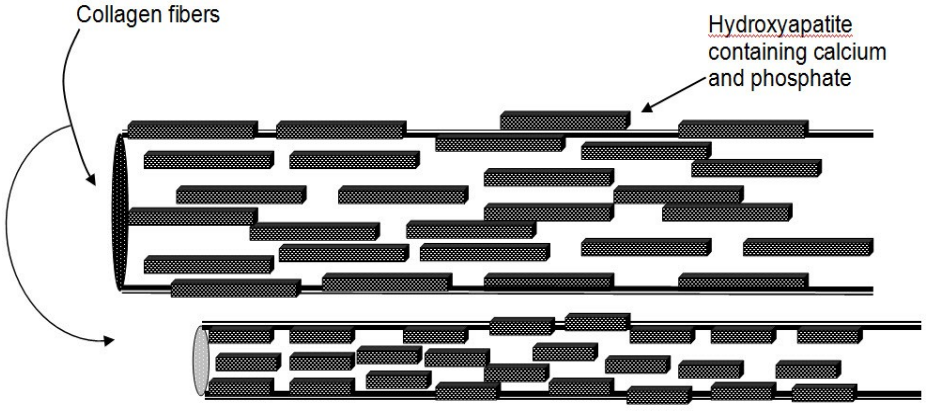
Excellent overviews of key bone concepts: https://www.hindawi.com/journals/bmri/2015/421746/ and https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3341892/ .
* A good article to share with clients about glycine sources/benefits (and also contains many references you may wish to explore): https://draxe.com/nutrition/glycine/ .
Remember too that glycine is essential for glutathione synthesis; supplementation with glycine and cysteine in elderly can restore age-related decline of glutathione synthesis: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3155927/

Strong AND Flexible

4

- Bone is a reinforced composite-like material made of minerals dispersed in a protein matrix of primarily collagen.
- Bone is both Strong and Flexible for optimal function.
  - Strong but not enough Flexibility = Brittle Bones
  - Flexible but not enough Strength = Weak Bones
  - Bones attach to muscle: Strength.
  - Bones attach to joints: Flexibility.

But #1 reason for fractures is falling.



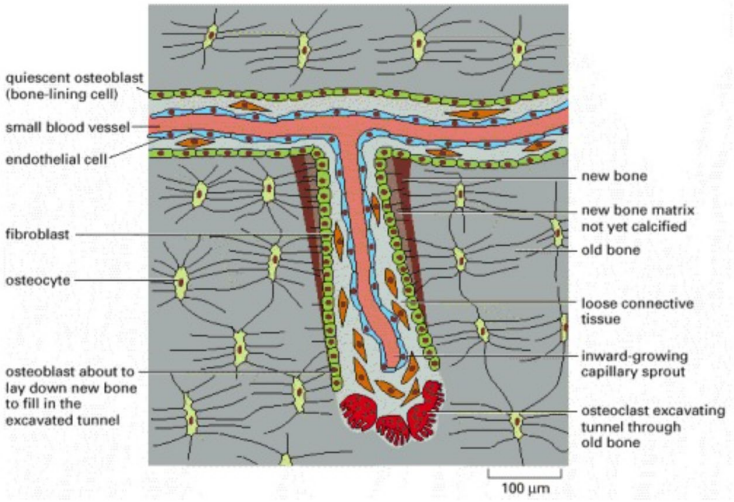
- **Crystal Hydroxyapatite** is formed from calcium phosphate and calcium hydroxide with magnesium, potassium, and other minerals.
- **Calcium and phosphorus** intake need to be well balanced.
- Peak bone mass density (BMD) is typically achieved near age 30 (childhood & young adult diet matters!)
- **Highly weakened bone may fracture from sudden, minor impact** e.g. stepping off a curb, reaching into a cabinet, coughing.

https://www.researchgate.net/publication/221915964_Bone_A_Composite_Natural_Material

Bones: Suddenly Sexy?

5

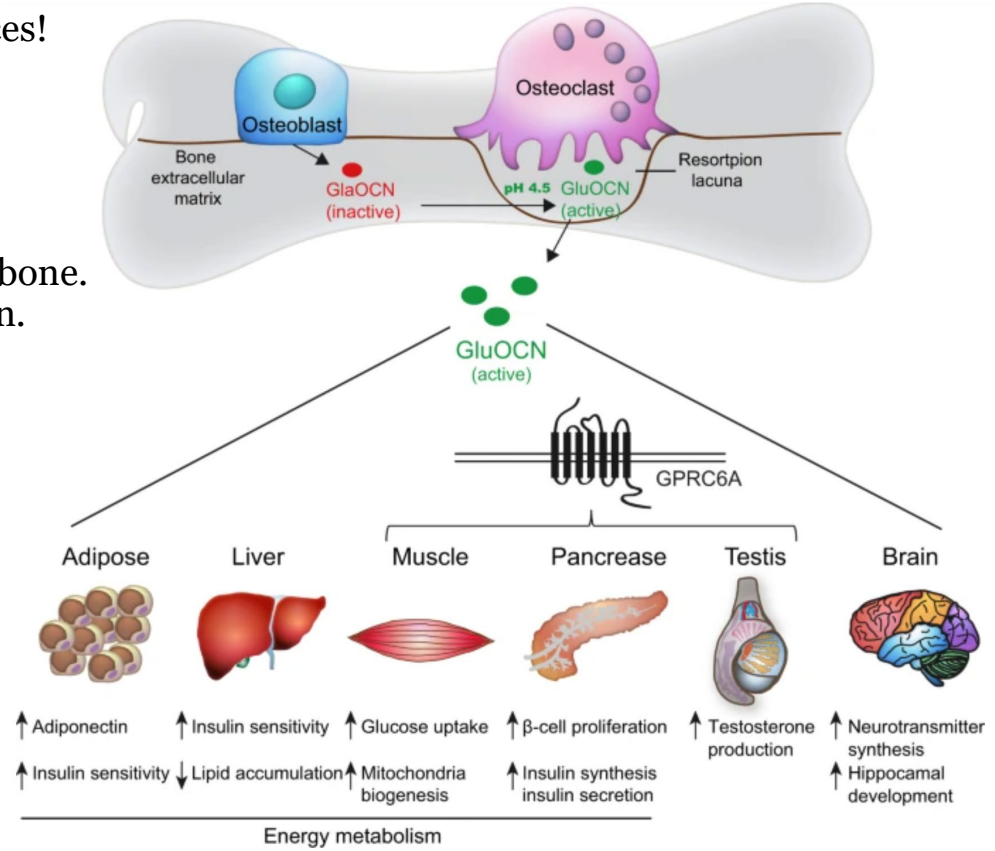
- A new perspective? **Bones are organs.**
- Red bone marrow produces red & white blood cells & platelets (hemopoiesis).
  - Read that again: the very lifeblood of the body begins (and is constantly replenished) in. the. Bones. **Producing ~500 billion blood cells, daily.**
  - Very active stem cells. Bone marrow stroma can differentiate into osteoblasts, chondroblasts, fibroblasts, & adipocytes.*
  - Blood cell synthesis requires nutrients e.g. iron, zinc, copper, Vitamin B12, Vitamin B9 (folate).
- Yellow bone marrow is adipose tissue that stores triglycerides.
  - **3rd largest fat depot in body,** after subcutaneous and visceral. Dynamic *and reversible* conversion from red BM.
  - Bones become fattier as we age, *impairing hemopoiesis*, and this adipose tissue both **reflects and affects whole body metabolic health**.**
- Keepin' it fresh! **Constantly remodeling itself.**
  - **Osteoblasts build new bone** and get trapped in their own secretions, becoming osteocytes. Osteocalcin requires Vit. K2.
  - **Osteocytes** must maintain their health (like all cells!) in order to be at optimal function and longevity e.g. circulation, cellular metabolism, antioxidant support. These secrete growth factors that influence behavior of osteoblast and osteoclasts.
  - **Osteoclasts** break down bone and are derived primarily from monocytes. Part of the immune system. Tunnel deep into bone, leaving a cavity which can be enriched again via osteoblasts.
  - **Osteocalcin** and growth factors released during remodeling have **whole body endocrine effects**, from insulin sensitivity to reproduction to cognitive function! ***



* Fibroblasts are truly fascinating cells e.g. https://www.ncbi.nlm.nih.gov/books/NBK26889/ (image found here too)
** https://www.frontiersin.org/articles/10.3389/fendo.2019.00069/full *** https://www.nature.com/articles/s41413-018-0019-6 (dense but skim and at least see figures)

Bones: Yes, Really Sexy!

- A particularly powerful example of interconnectedness. Even in unexpected places!
- Osteocalcin is a matrix protein in bone tissue (part of the 10% that is not collagen).
- Osteocalcin (OCN in the diagram) is produced by osteoblasts and is carboxylated (GlaOCN) by Vitamin K2 to form new, dense bone. This also contributes to circulating osteocalcin.
- Osteoclasts break down bone and uncarboxylate **osteocalcin, freeing it to create systemic endocrine effects.**
- Vitamin K2 must also carboxylate another protein called Matrix GLA protein (MGP) responsible for preventing and removing calcium from soft tissues e.g. arteries.*
- MK-7 and MK-4 are forms of Vitamin K2.** Vitamin K1 conversion to K2 by gut bacteria is highly variable.
- Vitamins D, A, and K have synergistic effects and can support (or deplete) one another. Balance is key! Of note, very high-dose Vitamin A alone is used in animal studies to *create* osteoporosis!*** Consider Vitamin K2 when supplementing with D3 esp. in patients over 40, with gut dysbiosis, or with K-deficient diets.



* https://schoolafm.com/ws_clinical_know/reversing-arterial-plaque/ ** https://chrismasterjohnphd.com/blog/2016/12/09/the-ultimate-vitamin-k2-resource#infographic2 and https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7353270/ *** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7530507/ Image: https://www.nature.com/articles/s41413-018-0019-6

Falls Cause Fractures!

7

- **#1 reason for age-related fracture is falling.**
- Frailty, poor balance, unsteady gait, and low muscle strength are key contributors.
- **Most fracture patients have fallen, but actually do not have osteoporosis.***
- Large population-based study of women aged 65 years or above showed that 85% of all low-trauma fractures were not attributable to osteoporosis.**
- Around one-third of generally healthy individuals aged 65 or above - and half of those aged 80 or above - will fall at least once a year.
- **Asking the simple question** 'Do you have impaired balance?' could potentially predict about 40% of all hip fractures.***
- Consider and prevent key related contributors:
  - **Muscle strength.** The weight of skeletal muscle after the age of 70 is about half of what it was at 21–30 years of age. Consider regular exercise, excess carbohydrate intake (insulin resistance contributing to low of lean muscle mass#), DHEA and testosterone sufficiency, magnesium sufficiency (seek RBC magnesium in upper third of RR or above it).
  - **Flexibility.** Consider yoga, tai chi, regular stretching, and chiropractic care.
  - **Vision.** Appropriate/updated corrective lens? Check Zinc, Vitamin A (esp. for night vision), & key phytonutrients.@
  - **Balance and unsteady gait.** May be associated with neuropathy (hyperglycemia?), insufficient B6, and/or insufficient levels of Vitamin B12 (consider hypochlorhydria?).##

"Although exercise has the potential to avert bone loss in older age, more important is its role in improving physical functioning, balance, and mobility and thus **decreasing the risk of falls**."###

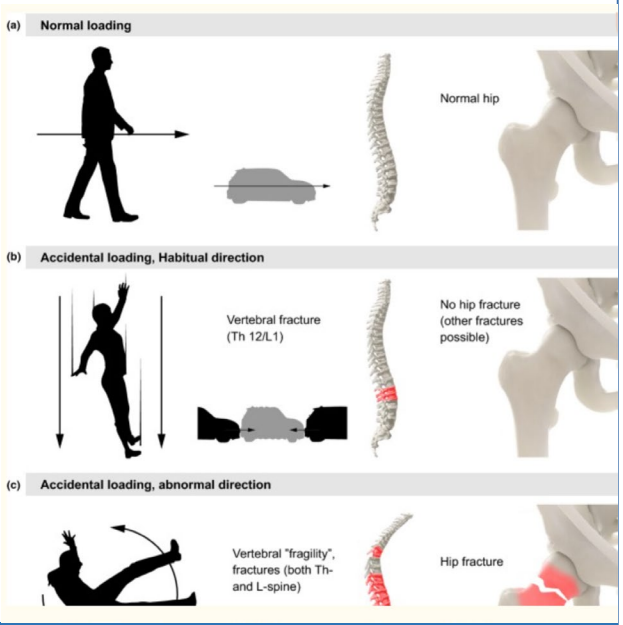
* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4497616/ ** https://asbmr.onlinelibrary.wiley.com/doi/10.1359/jbmr.2003.18.11.1947
*** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2727259/ # https://www.hindawi.com/journals/ije/2014/309570/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4002007/ ### https://www.hindawi.com/journals/jos/2019/5134690/
@ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3738983/

Falls Cause Fractures - and Death!

8

"Regrettably, bone-targeted pharmacotherapy has, at best, minimal effect on the incidence of fractures and on fracture-related mortality and is associated with adverse effects."*

- Most fracture patients have fallen, but actually *do not have osteoporosis*. **Bone density does not directly predict future fractures.**
- **Therapy that increases bone density (strength) does not increase bone toughness** (flexibility or resiliency in the face of a fall – remember the analogy of health bone like a tree trunk!)
- Consider and prevent key related contributors include muscle strength, flexibility, vision, and both balance and steady gait.
- The implications of falling and having a hip fracture are dramatic! Not because of the fracture but **due to lifestyle implications: mental, emotional, physical, spiritual, social, & economic**.
  - Relative risk of hip fracture increases 13-fold from 60 to 80 years of age *in both men and women*.*
  - **1-year mortality rate from first hip fracture is ~22-30%!**** By comparison, this datum for first heart attacks is ~32-37%.
  - Social/family isolation, loss of purpose/interests due to access, loneliness, guilt, shame… comprehensive health care must give individuals support in navigating these dramatic impacts AND positive, productive lifestyle changes.



* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4497616/ (and diagram)
** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6428998/ , https://www.medscape.com/answers/155919-15097/what-is-the-prognosis-of-acute-myocardial-infarction-mi-heart-attack

A New Epidemic

"As late as the end of the 19th century, pathologists recognized fragile and osteoporotic bone not as a frequent occurrence but rather as a medical curiosity."*

- Dr. Alan Gaby

- Skeletons dating from 1729 to 1852 were found to have significantly slower rate of bone loss at the hip than modern day women.**
- Age-adjusted rates of hip/wrist fractures doubled between 1950s and 1980 in several European countries.***
- The incidence of hip fractures in women and men increased, respectively, by 60% and 108% between 1970 and 1997 in Finland. ****
- Peak bone density typically occurs near age 30.
- **Compared to our forefathers, are we losing it faster?**
- **Or are we starting with less dense bones overall?**

Probably both.

* Gaby, "Nutritional Medicine" p. 636.
** https://www.researchgate.net/publication/15102833_Differences_in_proximal_femur_bone_density_over_two_centuries
*** http://www.ncbi.nlm.nih.gov/pubmed/6741475 , http://www.ncbi.nlm.nih.gov/pubmed/2857223 , http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1060513/
**** http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(98)04235-4/abstract

What's Changed?

10

"As late as the end of the 19th century, pathologists recognized fragile and osteoporotic bone not as a frequent occurrence but rather as a medical curiosity."

- Dr. Alan Gaby

- **High refined sugar intake?** (higher cortisol, higher calcium loss in urine)
- **High coffee/soda intake?** (caffeine & phosphoric acid, both higher calcium loss in urine)
- **Low stomach acid**? (widespread PPI use, affecting lower protein/minerals absorption)
- **"Acid-producing" diet**? (higher phosphorus, lower potassium)
- **Widespread low Vitamin D**? (increases calcium absorption and utilization)
- **Widespread low Vitamin K?** (required to make osteocalcin which binds calcium in bone tissue)
- **Poor methylation?** (high homocysteine interferes with collagen cross-linking in bone; consider sufficiency of Vitamin B6, B12, and/or Folate, potential SNPs e.g. MTHFR, MTRR)
- **General nutrient deficiency?** (e.g. magnesium, manganese, copper, zinc)
- **More sedentary lifestyle?** (less weight-bearing exertion, low muscle mass)
- Epidemic of **hypothyroid function** (poor digestion, autoimmune, poor T4 to T3 conv)

More of What's Changed?

- **Poor nutrient absorption?** (intestinal inflammation from gluten, frequent antibiotic use, prescription medications, NSAIDs, chemicals/pesticides in foods)
- **Chronically high stress?** (higher cortisol, impairs new bone growth, breaks down bone matrix)
- **Low progesterone?** (affect of chronic stress, perimenopause, PCOS)
- **High intake of dairy foods?** (lactose intolerance (2/3 world population) and/or dairy sensitivities can cause intestinal inflammation to impair mineral absorption)
- **General Inflammation?** (e.g. cytokines IL-1, IL-6, TNF-a; from a huge variety of sources e.g. food sensitivities, microbial imbalances, chemical toxicity)*
- **Metal toxicity?** (e.g. aluminum, lead)
  - Most lead is stored in bone tissue (as it readily replaces calcium) and is most highly freed to circulation when osteopenia begins, typically in the later perimenopausal years, potentially creating systemic inflammation, hypertension, cognitive impairments. Lead's half-life *after exposure* can exceed 20 years! **

"I don't understand why women are wrestling with bone health so much.
I mean, it's just a matter of doing two things regularly: Vitamin D and Calcium.
You just take a lot of them. How hard can it be?"

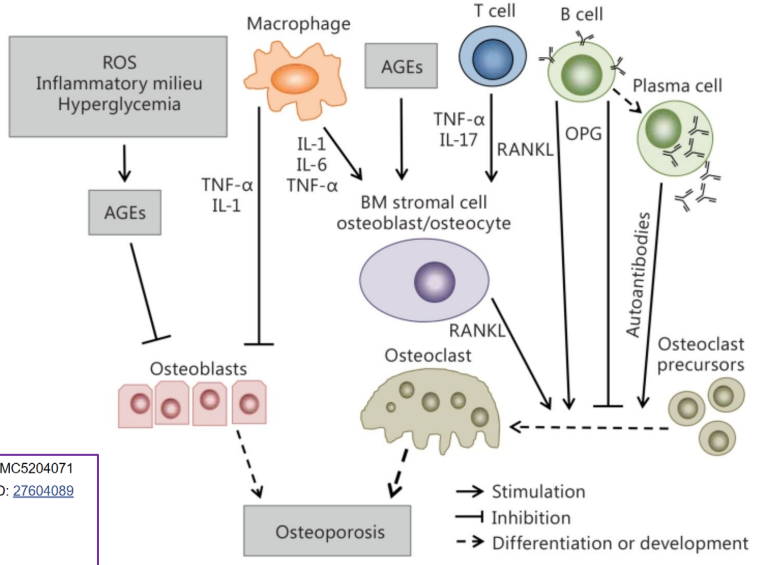
- My conventional PCP neighbor

Clearly, it's not that simple.

* http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3820310
** https://www.nature.com/articles/s41598-019-50654-7 , https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6372192/ , https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7454042/

Bone Loss as Inflammation in Action

- Osteoclasts are derived from the same myeloid precursor cells that give rise to immune cells. Osteoclasts are in fact specialized macrophages and highly sensitive and responsive to both local and systemic inflammatory cytokines.*
- **Inflammation stimulates more osteoclast activity** via a rich variety of inflammatory mediators e.g. IL-1, IL-6, IL-11, TNF-α, TNF-β.
- Drivers and mediators span the full spectrum of pro-inflammatory dynamics and diagnoses that we recognized today e.g. Type 2 diabetes, asthma/allergy, fibromyalgia, cardiovascular disease.
  We consider *progressive* bone density loss as a symptom – and mechanism! - of *chronic* inflammation.
- Osteoclasts regulate T-cell differentiation and activation. Creating a balance between T-helper and T-regulatory activity. *
- **Catabolic activity** supports survival!
  Released protein, calcium, and phosphorus.
  We see yet again the elegant orchestration of the body that has promoted survival of humans for so long!



Front Endocrinol (Lausanne). 2019; 10: 285. PMCID: PMC6527760
Published online 2019 May 14. doi: 10.3389/fendo.2019.00285 PMID: 31139147
The Role of Osteocytes in Inflammatory Bone Loss
Corinne E. Metzger[1,*] and S. Anand Narayanan[2]

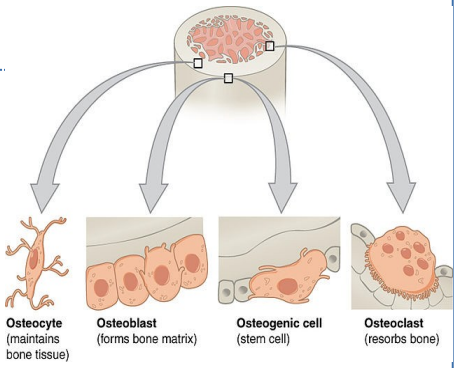
Bone Rep. 2017 Dec; 7: 121–131. PMCID: PMC5671387
Published online 2017 Oct 16. doi: 10.1016/j.bonr.2017.10.003 PMID: 29124082
Is osteoporosis an autoimmune mediated disorder?
Rosebella A. Iseme,[a,b,*] Mark Mcevoy,[b,c] Brian Kelly,[b,d] Lind

Curr Med Chem. 2016 Nov; 23(33): 3754–3774. PMCID: PMC5204071
Published online 2016 Nov. doi: 10.2174/0929867323666160907162546 PMID: 27604089
Osteoimmunology and Beyond
Lia Ginaldi* and Massimo De Martinis

* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4625766/ , https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3690642/ Diagram from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4821368/ ** https://nyulangone.org/news/calcium-signals-balance-bodys-response-infection-against-potential-self-attack

Hormone Symphony in Action on Bone#

13



- **Osteoblasts** make new bone tissue.
- **Osteoclasts** break down older bone tissue
- Hormones collectively direct balance in osteoblast/osteoclast activity.
  - **Paracrine signaling**: Osteoblasts & osteoclasts regulate each other.
  - **Growth hormone**: Stimulates bone growth and mineralization.
  - **Stress hormones:** Sufficiency required to prime other steroid receptors, but increased endogenous cortisol impairs osteoblasts and increases osteoclast activity.##
  - **Calcitonin** (a thyroid hormone): Reduces additional serum calcium by inhibiting bone resorption. Those *without* a thyroid are not making calcitonin. Synthetic T4/T3 meds do not include calcitonin; natural thyroid extracts do.*
  - **Parathyroid hormone**: Increases serum calcium by increasing bone resorption (also increasing kidney reabsorption of calcium; increasing excretion of phosphate).
  - **Thyroid hormone**: Hyperthyroid function increases bone resorption. Hypothyroid function leads to more brittle bone by impairing remodeling overall. **
  - **Estrogen / Testosterone**: Multi-factorial effect. Supports Vitamin D-mediated uptake of calcium in gut. Lengthens life of osteoblasts and inhibits bone resorption.***
  - **Progesterone**: Increases number of osteoblasts and their activity. ****

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7493450/ ## https://pubmed.ncbi.nlm.nih.gov/18401211/ , https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2911474/
* http://jeffreydach.com/2010/06/16/why-natural-thyroid-is-better-than-synthetic-by-jeffrey-dach-md.aspx
** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5754375/ and http://www.medscape.com/viewarticle/731899
*** (Testosterone) http://www.webmd.com/osteoporosis/living-with-osteoporosis-7/male-men and (Testosterone) http://www.ncbi.nlm.nih.gov/pubmed/10372695 and (Estrogen) http://www.sciencedaily.com/releases/2007/03/070323171448.htm and (Estrogen) http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1451218/
****http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2968416/ Image: https://commons.wikimedia.org/wiki/File:Bone_regeneration_-_Bone_remodeling_cycle_II_-_Pre-Osteoblast_Osteoblast_Bone-lining_cell_etc_--_Smart-Servier.jpg

Essential Estrogen Effects

14

Promotes and Prepares for the Body for Cell Growth

Preference for high-energy foods (sweets)

Calorie storage

Calorie conservation

Ovulation, endometrium preparation (monthly cycles)

Brain and emotional effects

Estrogen

Breast-feeding preparation

Intuition and mothering behavior

Resilient cardiovascular system

Skeletal support

Estrogen inhibits inflammation that would otherwise stimulate more osteoclast activity e.g. IL-1, IL-6, IL-11, TNF-α, TNF-β *

* https://www.hindawi.com/journals/bmri/2015/421746/#conclusions

Protective Progesterone

Excess Estrogen Effects	Progesterone Amelioration/Balance
Proliferates endometrium	Maintains endometrium
Stimulates breast cells	May protects against breast fibroids
Increases body fat	Helps use fat for energy
Salt and fluid retention	Natural diuretic
Higher risk of blood clots	Normalizes blood clotting
Restrains bone cell loss	Stimulates new bone cell growth
Anxiety, headaches	Natural antidepressant; calms anxiety
Reduces cellular oxygen	Restores cellular oxygen
Creates progesterone receptors	Normalizes tissue sensitivity to estrogen
Inhibits osteoclastic activity**	**Increases differentiation/activity of osteoblasts.***

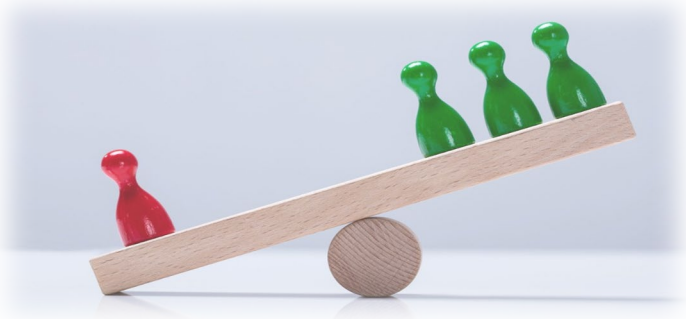
Progesterone primes Estrogen receptors (and vice versa)!
Thus, there is a coupling effect from progesterone to estrogen as well.

* https://www.researchgate.net/publication/326141848_Progesterone_for_the_prevention_and_treatment_of_osteoporosis_in_women
** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7371870/

Bone Health Balance

16

- Strength (minerals) and flexibility (amino acids) of bones.
- Balanced bone dissolution (osteoclast) and new bone growth (osteoblast).
- Estrogen and progesterone hormones.
- Premenopausal health and postmenopausal health**
- Pro-inflammatory and Anti-inflammatory immune function.
- Movement and rest.
- Discipline (nutrient-rich diet) and Relaxation (a little alcohol) vs. Excessive indulgence e.g. too much alcohol, fatty liver, insulin resistance*
- Intake and digestion/absorption.
- Calcium and K2/D3/Magnesium nutrition.
- Bone integrity and Environmental support (muscles, joints, balance, vision, gait)
- Strength (weighted exercise) and flexibility (yoga, stretching) of muscles/soft tissue.
- Assessment and prevention.
- Rapid Relief and Root Cause resolution.
- Education, Inspiration, and Empowerment



* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6761900/
** Remember peak bone mass is around age 30! And 80% of bone mass is formed by age 18.

Bone Health Targeted Testing

- DXA scan – perhaps every other year when driving improvement
- RBC Magnesium
- Serum and/or urinary Calcium
- Parathyroid hormone
- Serum Vitamin D (25-OH) – and also perhaps 1,25-OH, if chronic disease and 25-OH low
- Serum Vitamin A
- Serum Vitamin K - and uncarboxylated Osteocalcin (Genova)
- Kidney/Liver function (e.g. eGFR, ALT/AST, GGT, HbA1c) e.g. conversion of Vitamin D3 to 1,25-OH, detoxification.
- Urinary adrenal and sex hormones/metabolites (estrogens, progesterone, testosterone) e.g. DUTCH
- Full thyroid panel
- Bone-specific Alkaline Phosphatase (ALP) – part of an ALP isoenzyme panel
- Overall inflammatory markers e.g. CRP (caution, quite labile!), ESR, Ferritin
- Bone resorption markers e.g. NTX, CTX
- But also markers of ALL the major drivers of chronic inflammation and oxidative damage you suspect for this unique individual!
    - Metabolic: HbA1c, Fasting glucose, and Fasting insulin
    - Immune: CBC, CRP/Ferritin, autoimmune antibodies, globulin
    - Methylation: Histamine, homocysteine, amino acids, organic acids (esp. sufficiency of B vitamins)
    - Microbial/Digestive: Comprehensive stool test
    - Food sensitivity test (e.g. KBMO, Cyrex, Vibrant)

It's Not just about Calcium

Nutrient	Use	Sources	Considerations
Protein	To make collagen framework of bone	Wide variety of animal and plant	Requires intake & absorption. Total Protein >7.0 (RR 6-8.2 g/dl) is ideal. Stomach acid & digestive enzymes sufficiency are key.
Vitamin D**	Increase calcium absorption from intestines	Primarily from sun, supplement	Max benefit for calcium absorption is likely at ~35 ng/ml of 25(OH) Vitamin D*. Vitamin D intake increases body's need for Vit. A and Vit. K. Fat-soluble synergy!
Vitamin K2	Required to activate the binding protein osteocalcin to hold minerals in bone	K1 from leafy greens. K2 from cultured foods (natto, cheese, salami, sauerkraut) and grass-fed animal fat (e.g. egg yolk, butter, meat, liver)	Healthy body converts K1 to K2. K1 helps with natural blood clotting. K2 prevents arterial calcification. Serum Vitamin K lab marker only so useful and measures total. Can measure Uncarboxylated osteocalcin w/specialty labs (discussed in Part 2).
Calcium	Primary mineral contributing to bone density. Incorporated within protein fibrils.	Leafy greens, nuts, fish bones, dairy products	Max of ~500mg can be absorbed at once intestinally** Consider a maximum of 750mg/day via supplement and always divided doses. Carbonate form poorly absorbed with anything less than optimal stomach acid. Soft tissues can be calcified with too much intake.

* http://ajcn.nutrition.org/content/88/2/541S.full ** http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2912737/pdf/mayoclinproc_85_8_009.pdf

Nutrient	Use	Sources	Considerations
Magnesium	Key to incorporate phosphate into fibrils. Also, calcitonin to put calcium in blood back in bone.	Nuts and seeds (esp. almonds), fish (esp. halibut), legumes, dark leafy greens, buckwheat, artichoke, mussels.	Also, necessary to convert Vitamin D to its active form to enhance calcium absorption. Clinical tip: High intake Vitamin D with magnesium deficiency will drain muscle reserves.
Manganese *	Required for bone mineralization.	Tea, chocolate, whole grains. Over half dietary manganese lost when eating refined vs. whole grains. **	Deficiency uncommon but leads to less dense bones; can be hereditary.
Phosphorus	With calcium, part of hydroxyapatite in fibrils.	Abundant in American diet (e.g. meat, grains, dairy, processed foods)	Intake needs to be balanced with calcium. Inappropriately high-dose calcium will deplete phosphorus. High phosphoric intake (e.g. soda) may create an imbalance.
Zinc	Required for bone mineralization.	More common in animal foods.	Zinc and copper compete for absorption in the GI tract and into cells. Don't supplement one for longer than a couple of months without moving to a balanced formula Zn-Cu ratio near 15:1 unless there is lab data clarifying the need.
Copper	Required for collagen formation	More prevalent in vegetarian foods, esp. high in legumes	
Strontium	Incorporated into hydroxyapatite to give strength	Trace mineral in many foods.	In high does can stimulate osteoblasts dramatically.
Vitamin C, Silicon, Boron, etc.			

* http://www.ncbi.nlm.nih.gov/pubmed/427078

Killer Calcium?

- Necessary for bone strength (and muscle contractions and many other biochemical reactions actually), but it's not the only important player! **Vitamin D, Vitamin K2, and Magnesium are at least as important as calcium for long-term bone health.** Calcium intake does not correlate with lower fracture risk. # Yet there is rampant use of high-dose, poorly-absorbed Calcium.
- Especially without all cofactor nutrients, **supplemental calcium can do harm.**
  Up to 40% of arterial plaque is made up of calcium. This can include plaque in the brain (Alzheimers). Unlike dietary calcium, calcium *supplementation* may increase heart attack risk via multiple routes (e.g. blood pressure, coagulation, arteriosclerosis).##
- Studies with thousands of participants have repeatedly shown that supplemental calcium can be dangerous! However, dietary calcium is repeatedly shown to be safe re: cardiovascular disease – in a wide variety of sources and levels of intake.
  - A mix of pre- and post-menopausal women and men who used calcium supplements had a 140% higher risk of heart attack. Those getting calcium from food didn't have increased risk. 3rd vs. 1st quartile intake of dietary calcium had lower risk of CVD.**
  - More than 1000mg/day of calcium supplements was associated with a 20% increase in cardiovascular disease-related death in men. Dietary calcium was not a factor.**
  - Women had a 150% higher risk of heart attack if using 500mg/day supplement along with high dietary intake (for 1400mg/day or higher). *****
  - The large dose of calcium "suddenly" brought in via supplement may increase calcification of soft tissues because the body cannot make use of it at all once. This may be exacerbated in those with kidney challenges. ***
  - Calcium supplementation may increase incidence of kidney stones while dietary calcium does not. ****

http://www.ajcn.org/content/86/6/1780.full and https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4717874/ and http://www.nutritionalmagnesium.org/calcium-and-heart-health/ Helpful client article busting myths re: calcium/dairy and bone health: https://www.theglobeandmail.com/life/health-and-fitness/health/go-beyond-dairy-for-the-calcium-your-body-needs-for-good-bone-health/article27281822/

http://www.ncbi.nlm.nih.gov/pubmed/22626900 and https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3079822/ and https://www.ncbi.nlm.nih.gov/pmc/articles/pmid/21505219/ and https://www.ncbi.nlm.nih.gov/pubmed/26420590 .

** http://archinte.jamanetwork.com/article.aspx?articleid=1568523 *** http://heart.bmj.com/content/98/12/895.extract **** http://ajcn.nutrition.org/content/94/1/5.full ***** http://www.bmj.com/content/346/bmj.f228

All Things are Interconnected, Uniquely!

21

- Oxygen Intake and Spiritual Mindset
- Stress and Stress Management
- Toxins and Detoxification Ability
- Sensitivities and Allergies and Immune Health
- Energy Generation and Circulation
- Nourishment and Absorption Ability
- Genetic Predispositions and Infections
- Expectation, Association, History, Belief

Ask what kind of *Person* has this dis-ease vs. what kind of *Dis-ease* does this person have?

The SAFM Difference

Our Content

- Scientific **rigor**. Accredited continuing education. Referenced content. No "cliffs notes". Curated published research. Allows for a variable geek factor but the *authentic confidence* of rich learning.
- Practical **application** know-how of functional medicine science, the *"devil in the detail"*.
- Knowledge and tools about **both Rapid Relief and Root Cause** resolution.
- **Practice**, practice, practice via real-life, complex case exploration. Expanding your learning by Doing. *Into the pool!*
- **Repetition.** Creating rich, sustainable knowledge. Repetition breeds retention.
- **Flexible delivery** to meet your unique needs. Timing, formats, approach.
- **Continuous,** career-long learning and community

Our Practitioner Family

- Diverse, global (60+ countries), multi-modality (~20)
- Warm, supportive, engaged
- Respectful

In appreciation for your time and passion for learning, we offer you complimentary access to a rich, four-webinar series:

True Root Causes of Disease through the Functional Medicine Lens

https://safm.tips/fullscript

Thank you for joining us!

THE SCHOOL OF *Applied* Functional Medicine™

Thank You for Joining Us!

Powerful Practitioner Pearls on Bone Health