New Dietary Implications for Optimal Bone Health

The skeleton is well-designed to resist various types of mechanical stresses while providing shape and support to the body and its internal structures. It is comprised of various types of bones which possess mineral and protein components that optimize its rigidity and resistance to tension. The protein component is mostly collagen (and forms the attachment sites for muscle) which represents about 33% of bone, while the mineral components (calcium, magnesium, sodium, potassium, carbonate and phosphate) represent the structural component. The resilience of bone allows a functional platform for varying force vectors. It provides the foundation for the musculoskeletal system to be exceptionally capable at managing external/internal forces. The rigidity of bone is necessary to maintain segment structural integrity/alignment, and provides connective tissues the sturdy lever by which to produce torque. Bone tissue is hardened by calcium salts which represent nearly 98% of total calcium storage. However, bone is not simply a mineral storage unit, nor is it passive tissue; it possesses a fairly complex vascular system which is utilized to maintain extracellular/serum calcium concentrations for numerous other bodily functions. When extracellular calcium levels are too low, calcium is recruited from bone storage and mobilized to alternate physiological destinations based on the need. As is common knowledge for most health professionals, insufficient daily calcium intake for prolonged periods of time can compromise bone stores of calcium as the mineral density declines. Equally relevant is bone loading. Without adequate muscle force, calcium is lost at an alarming rate. A significant reduction in bone mineral density (BMD) leads to a pre-disease state known as osteopenia before progressing to osteoporosis, characterized by significant bone loss (2.5 standard deviations below the average BMD for a given age). Osteoporosis dramatically increases the risk for bone fractures, with the most common sites including the hip, vertebral column and wrist. Micro-fractures at the vertebrae are structurally debilitating and visible in forward flexion of the spine such as a Dowager's hump. Life expectancy associated with osteoporotic hip fractures can be as little as 12-18 months. In fact, more women die from osteoporotic-related disease than breast cancer.

To promote proper bone development/density as protection from these issues, adequate consumption of vitamin D and calcium along with regular participation in physical activity must be initiated during childhood. The need for proper nutritional support is clear when one considers the annual turnover rate in bone tissues among young adults is nearly 20% of total bone mass. As mentioned, bone is not an inert tissue but is actually extremely active; continually recycling and renewing the organic and mineral components via internal processes of remodeling. As it relates to activity one must understand that notable degenerative changes occur in a relatively short period of time when bones are inactive. In fact, an individual can lose about a year of bone mass in one week of bed confinement. Once bone tissues have fully matured, BMD is still subject to variations based upon diet and activity until about the age of 30; at which time genetics as well as behavioral, lifestyle, and environmental factors dictate the rate of decline. Research suggests that women may be lose up to 1% of their BMD each year after the age of 35 without appropriate dietary and activity support. This loss is aggravated by menopause, in which estrogen production is dramatically reduced and calcium absorption is decreased. These factors can expedite up to 3-6% losses in bone mass annually for five years following the beginning of menopause. Estrogen is a vital hormone in calcium regulation as it facilitates intestinal absorption, reduces excretion, and enhances retention by the bone in both men and women. Overall, women tend to lose about 8% of their bone mass (men 3%) per decade due to the natural the aging process. Males lose far less bone due to of the relatively high quantities of androgens produced later in life and greater muscular strength, a key correlate for BMD.

Research clearly demonstrates regular participation in resistance training that provides adequate weight-bearing stress to the axial skeleton as being critical to the maintenance of healthy bones throughout the lifespan. Specifically, there is a direct correlation between bone density as well as diameter and the strength of the attached musculature. Exercise-stimulated increases in bone diameter diminish the risk of fractures by mechanically counteracting the thinning of bones, and may even halt the development of porosity. Recommendations for lifting aimed at improving BMD or preventing porosity include selecting dynamic activities that incorporate ground reaction force (closed kinetic chain) and allow for the use of relatively heavy loads. Additionally, using unusual/unaccustomed loading patterns can contribute to improved bone adaptations by stimulating different variations of muscle group recruitment. These concepts are applicable for all populations and age ranges; in fact, age-appropriate weightlifting is a major component of programs aimed at maintaining independence among the elderly. Essentially, bones adapt and experience detraining symptoms in a manner somewhat similar to muscle, and must therefore be supported by appropriate nutrition and physical engagement. Unfortunately, the average adult female consumes about half of the recommended calcium per day (1000-1500 mg) and the majority of the adult US population is considered sedentary. This supports the trend of osteoporosis potentially reaching epidemic numbers in the future.

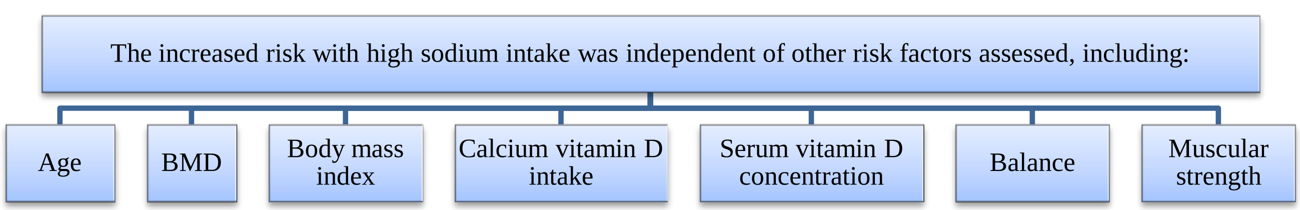
Further understanding the dynamics of bone health is a relevant health goal of the medical community. One novel study presented at The Endocrine Society's 95th Annual Meeting showed that a high-salt diet raises a woman's risk of breaking a bone following menopause, no matter what her current BMD value is. This is particularly concerning as salt intake in the U.S. represents a 4-5 fold over-consumption value on a daily basis. The Japanese study found that older women who consumed the highest quantity of sodium had more than four times the risk of suffering a non-vertebral fracture, even after adjustments for numerous additional variables that affect fracture risk. Kiyoko Nawata, PhD, the lead author and professor of health and nutrition at the University of Shimane in Matsue, Japan states, "Excessive sodium intake appears to be a risk factor for bone fragility. It is therefore important to consider excessive sodium intake in dietary therapy for osteoporosis." Non-vertebral fractures can cause substantial disability and even death (especially of the hip). Past research has shown a clear connection between excess sodium intake and decreased BMD; Nawata and her colleagues conducted the current study to connect these concepts with the direct risk for fractures.

The research team examined 213 post-menopausal women (average 63 years of age) who had previously undergone osteoporosis screening. The screening protocol included BMD scanning, use of a food questionnaire and blood work to test for markers of bone metabolism as well as rule out medical conditions that potentially increase the risk for any fractures. In addition, a physician determined the presence or absence of existing non-vertebral fractures. The participants also engaged in motor function tests to ascertain measures of balance and determine their fall risk as well as a test of handgrip strength. Low grip strength is a known risk factor for osteoporosis-related fractures. The average daily sodium intake among the study participants was reported to be 5,211 mg, which is consistent with intakes in American. The group with the highest sodium intake consumed an average of 7,561 mg/day. This high-intake group was 400% more likely to have an existing non-vertebral fracture, compared with the lower-intake groups who did not experience an increased risk for fractures.

The average American consumes far more sodium than the RDA of 2,300 mg. The 2010 Dietary Guidelines for Americans further recommend that individuals over the age of 51 should not consume more than 1,500 mg of sodium/day. While it is inconclusive that older adults will suffer from the current RDA, those at risk for bone disease and hypertension must monitor salt intake. Considering its widespread use as a preservative and flavor-enhancer, personal trainers should provide specific dietary recommendations related to consuming less processed foods among those at elevated risk for debilitating fractures due to these findings as well as many others that would serve to imply similar dietary modification.

In further support of nutrition for health, researchers examined how taking calcium and vitamin D before exercise may influence how bones adapt/respond to the bout. The data was also presented at The Endocrine Society's 95th Annual Meeting in San Francisco. According to the study lead author, Vanessa D. Sherk, PhD, postdoctoral research fellow at the University of Colorado Anschutz Medical Campus "The timing of calcium supplementation, and not just the amount of supplementation, may be an important factor in how the skeleton adapts to exercise training."

Previous research has shown that a year of intense training among competitive road cyclists is associated with a substantial decrease in BMD. Scientists believe that this kind of exercise-induced bone loss could be related to the loss of calcium during the bout via sweat. As blood calcium levels drop, the parathyroid gland produces excess parathyroid hormone, which can mobilize calcium from the skeleton. The investigators found that an exercise-induced decrease in blood calcium occurred whether calcium supplements were taken before or after exercising – but a pre-exercise dose resulted in less



of a diminution. Although not statistically significant, parathyroid hormone levels also increased to a slightly lesser degree among cyclists who took calcium before exercising. "These findings are relevant to individuals who engage in vigorous exercise and may lose a substantial amount of calcium through sweating," Sherk said. "Taking calcium before exercise may help keep blood levels more stable during exercise, compared to taking the supplement afterwards, but we do not yet know the long-term effects of this on bone density." Of interest, the timing of calcium supplementation did not cause a difference in serum concentration for a compound recognized to be a biological indicator of bone loss (collagen type-1 C-telopeptide (CTX)). Both the before- and after-exercise groups exhibited 50% increases in CTX.

The participants included 52 men aged 18-45 years. The research team randomly assigned these individuals to take 1,000 mg of calcium and 1,000 international units of vitamin D either 30 minutes before or 60 min after a bout of exercise. The exercise bout included a simulated 35-km time trial, and participants wore skin patches to absorb sweat. The investigators measured blood levels of calcium and parathyroid hormone before and immediately after the exercise, and CTX levels before and 30 min after the exercise. They used pre- and post-body weight, adjusted for fluid intake, combined with the calcium measured in the sweat from the skin patches, to estimate the amount of calcium lost through the skin during exercise.

These findings may warrant personal trainers providing specific recommendations for athletic clients who engage in high-volume cardiovascular training (especially in hot/humid environments) where excess quantities of calcium are lost via sweat. This is particularly relevant for aging athletes and fitness enthusiasts. Combined with the previous study, health professionals have an even clearer picture of the importance of endogenous mineral balance for bone health and should monitor both dietary and activity data to ensure adequacy is not displaced by insufficiency or excess.