OSTEOPOROSIS: NOTHING TO CRACK UP ABOUT

By John Clark M.D. NorthernLightsHealthEducation.com

WHAT IS OSTEOPOROSIS?

The National Institutes of Health defines it as, "Skeletal disorder characterized by compromised bone strength, leading to an increased risk of fracture."[1]

What does all that mean? Well, your bones get thin and start to break. Bone structure is much like the architecture of an old steel beam bridge, with girders crisscrossing for strength and stability. When you start across such a bridge, how many of the girders would you be willing to have missing or rusted through and still feel assured of safe passage? So it is with the bones. In the bones the "girders" are called trabecula. Osteoporosis is, "Osteo" meaning bone and "porosis" meaning opening or passage, literally holes in the bone. Osteoporosis is holes where trabecula once existed. This leaves the bone weak and susceptible to fractures.

EPIDEMIOLOGY OF OSTEOPOROSIS

Osteoporosis afflicts about 10 million Americans: 80% of victims are women. Another 34 million Americans have osteopenia, a milder thinning of the bones that will lead to osteoporosis if nothing is done to stop the dangerous process. Over 1.5 million osteoporotic fractures occur each year, 300,000 hip fractures, 700,000 vertebral fractures, 250,000 wrist fractures just to mention a few.[2,3]

FRACTURES

Wrist fractures increase with the onset of menarche. Hip fractures increase in the years following retirement when people become less active and quit engaging in weight bearing activities. Osteoporotic spine fractures increase with menopause and further increase with inactivity upon retirement.[4]

Wrist fractures are quite disabling. Besides being in a cast from 4 to 6 weeks, having surgery or needing rehabilitation,[5] people with wrist fractures are at high risk of developing painful arthritis in the years following injury.[6]

Spine fractures resulting from osteoporosis reduce the quality of life.[7,8] Spine fractures result in a hunchback appearance which medically we call kyphosis.[9] Kyphosis results in an overall loss of height. Spinal fractures are often painful.[10] As the posture becomes more stooped and the contents of the stomach and lungs become compressed, the abdomen starts to protrude, gastrointestinal reflux symptoms develop, and breathing becomes difficult.[11] If all this is not bad enough, depression can set in.[12]

Of all fractures resulting from osteoporosis, none are more devastating than hip fractures.

Of all fractures resulting from osteoporosis, none are more devastating than hip fractures. Thirty-five percent of post-menopausal white women have osteoporosis of the hip, spine, or wrist. Is osteoporosis improving in our nation? By the year 2020 it is estimated that nearly 50% of Americans over age 50 will have osteoporosis of the hip.[13] The cost of hip fracture care is prohibitive. In 2002 the costs were about $18 billion. [14] It is projected that by 2050, with the increase in osteoporosis and consequent fractures, that we could be spending $131.5 billion a year on hip fractures.[15] The bad news does not end there, up to 1/3 of hip fracture patients die within the first year following injury.[16] Now this is not necessarily because of something that happened with the fracture, but the health of the bones tends to be a reflection

of the health of the entire body.[17] These people die of blood clots, heart failure and heart attacks, or pneumonia, etc.

HOW OSTEOPOROSIS IS DIAGNOSES

Bone density is measured by a test we call the DEXA scan. DEXA stands for dual-energy x-ray absorptiometry. A DEXA is reported in standard deviations from the mean, how far a person's score differs from the normal. Osteoporosis, by definition, is two- and one-half standard deviations below the mean (≤ -2.5t score). For each standard deviation of bone loss there is a 40% increase in mortality from hip fracture.[18],[19] One fourth of hip fracture patients become disabled in the following year. [20] Two thirds never regain their former level of activity and independence[21] and one-fifth require long term nursing home care; accounting for about 140,000 nursing home admissions per year.[22]

And do not underestimate the emotional impact of a fracture:

- Sixty-eight percent worry that another fracture would put them in the nursing home.
- Seventy-three percent are concerned that they will have to reduce activities with family and friends.
- Eighty-nine percent live in fear of breaking another bone.

The bottom line is that you want to avoid osteoporosis at all costs.

WHY OSTEOPOROSIS?

"Disease is an effort of nature to free the system from conditions that result from a violation of the laws of health."[23] Let us look at some of the known causes of osteoporosis.

The first item that I will put on the list of things that cause osteoporosis may come as a surprise. Sugar! Sixteen teaspoons of sugar a day increases urinary calcium loss by 124%.[24] And most Americans get about twice that amount. Add Chocolate and the urine calcium increases to 147%.[25]

Salt (sodium chloride) causes fluid retention and increases kidney filtration of calcium. Sodium and calcium compete in the kidneys and calcium is sacrificed. Salt substitutes using potassium instead of sodium are actually helpful for preventing osteoporosis.[26]

Do not underestimate the emotional impact of a fracture.

Everyone talks about vitamin D and osteoporosis, and well they should. Vitamin D deficiency is rampant due to everyone hiding from the sun.[27] There are other nutrients whose deficiencies increase osteoporosis. These include vitamins K, B12, B6 and folic acid, magnesium, copper, and boron.[28]

Menopause has a profound effect on the bones. Bone turnover is increased by up to 55% in women with estrogen deficiency.[29]

Believe it or not, bones make electricity when stressed. It is this electricity that helps the body determine how much calcium to lay down in a given bone to meet the physical demands placed on it. When a bone is unused it is not maintained by the body with as much calcium and becomes osteoporotic. Osteoporosis of inactivity affects men and women equally. Decline in the physical activity level with age is an important risk factor for hip fracture.[30]

An apple a day may keep the doctor away, but a cup of caffeine certainly will not.
Caffeine increases the urinary excretion of calcium for at least 3 hours.[31] What is more, caffeine decreases bone-preserving testosterone.[32]

Drinking alcohol, particularly during adolescence and young adulthood, can dramatically compromise bone quality, increasing the risk of osteoporosis later in life. I'm not sure I know how to break this news, but some research indicates that the effects of alcohol on bone cannot be reversed, even if alcohol consumption is terminated.[33] In the process of bone remodelling, alcohol tends to poison the little cells that make new bone, leaving the trabecula thin and weak.[34]

Tobacco use decreases bone mass and quality, making it more susceptible to fractures.[35] Tobacco actually acts like a hormone and affects the hormonal system's action on calcium metabolism.[36]

What do people do when their stomach is "acid"? Many reach for a "Tum®"—a calcium anti-acid pill. When the body becomes "acid" it reaches for a calcium product as well; your bones. It is calcium from your bones that is used to buffer acid from your diet. A diet that makes your blood more acid significantly increases urinary loss of calcium from the bones.[37] Examples of acid forming foods include grains,[38] potatoes, and animal products—especially cheese.[39]

Animal protein, in contrast to vegetable protein, has a lot more sulphur and phosphorus which are made into sulfuric acid and phosphoric acid when digested. This elevated acid must be buffered by calcium from the bones, which leads to osteoporosis.[40,41,42]

Another source of acid comes from sodas, especially the brown ones with phosphoric acid in their ingredients.[43] Drinking such soda makes the whole body more acidic and increases calcium excretion in the urine.[44]

Psychological stress is a major obstacle in the fight to maintain bone mass. Chronic stress raises the stress hormones and inflames the body, both of which deplete calcium from the bones.[45] Elevated stress has been shown to increase osteoporosis.[46]

One particularly well-studied form of stress is depression.[47,48] Risk of hip fracture increases with depression. Older people with depression are particularly at increased risk of loss of bone mineral density,[49] and are more apt to fall and break bones.[50] Even the Bible makes reference to this association, "A merry heart doeth good like a medicine: but a broken spirit drieth the bones."[51]

SECONDARY CAUSES OF OSTEOPOROSIS

There are secondary causes of osteoporosis that are beyond the scope of this article to encompass. These include medications such as anticonvulsants, methotrexate, heparin, and steroids, etc., and conditions such as renal failure, hyperthyroid, hyperparathyroid, diabetes mellitus,[52] hypertension, hypercholesterolemia,[53] peptic ulcer disease,[54] and multiple myeloma, etc.

HOW SIGNIFICANT ARE EACH OF THESE RISK FACTORS?

To put these risk factors in perspective:

- Smoking - more than doubles your risk of hip fracture.
- Genetics - if your mother had osteoporosis and broke her hip, your risk of hip fracture doubles, not necessarily because you inherited bad bones, although there is some inheritability of bone structure. But the real problem lies in the lifestyle habits you inherit, or adopt, from your parents. You eat as they ate, you exercise, or do not exercise, as they did or did not exercise, etc.
- Inactivity - a resting pulse rate of greater than 80 beats per minute increases your risk by 80%. "What does a fast heart rate have to do with my bones?" you may be wondering. Athletes have very low heart rates. People in good cardiovascular shape have lower heart rates. Having a fast heart rate is really evidence that you may be a couch potato.
- Falls - any falls during the previous year has been shown to increase your risk of hip fracture by 60%.
- Caffeine - If you currently are using caffeine, (coffee, tea, cola, etc.,), 1½ cups of coffee per day will increase your risk by at least 30%.

Some lifestyle factors thought to be helpful actually have very little impact on bone health, and some of them may have other dangerous risks.

- Estrogen - for example current estrogen use has little or no effect, positive or negative as far as the bones are concerned, but as regards cancer, it has a significant detrimental effect.
- Calcium - daily calcium intake is of minimal help, about 10%.

- Obesity - carrying around an extra 20 pounds of weight may actually decrease osteoporosis by 20% but carries with it the negative risks of diabetes, arthritis and cancer.

The lifestyle factors making the biggest difference are:

- Exercise - walking for exercise, which decreases risk by 30% and being on one's feet more than 4 hrs per day, which drops the risk by 40%.[55] So, get up and get moving!

Osteoblasts never lay down thick calcium, like would sustain a hard-working athlete, on an inactive couch potato. That would be a waste.

BONE REMODELING

Bones are biologically active—always under construction, like the roads around where I currently live. In our town one crew goes around taking up the old pavement and a second crew goes around laying down new pavement. By the way, the paving crew never lays down thick pavement like would sustain a 4-lane freeway on a backwoods country road. That would be a waste. So it is with your bones. One set of cells, the osteoclasts, goes around taking up the old calcium, and another set of cells, the osteoblasts, goes around laying down the new. By the way, the osteoblasts never lay down thick calcium, like would sustain a hard-working athlete, on an inactive couch potato. That would be a waste.

By age 25 bones have reached maturity. By age 35 bones have achieved their peak bone mass. By age 40 the bones start to lose mass at about one half a percent per year. By age 45, in those perimenopausal years, bone loss can reach 3% per year, and if that continues for 10 years, a woman can lose 30% of her skeleton.

Urinary Calcium & Calcium Balance

Protein gm/day	Urinary Ca mg/day	Ca Balance mg/day
47	168	+31
95	240	-58
142	301	-120

THE CALCIUM BANK

Bones are the calcium bank. More than 99% of the calcium resides in the bones. The remaining 1% is in the blood and other fluids. The osteoclasts make withdrawals, from the "bone bank", and osteoblasts make deposits. The goal is to maintain a calcium balance where the deposits are at least as great as the withdrawals. It's like the good old saying about finances, "If a man's 'out-go' exceeds his income, then his upkeep will be his down fall."

DAILY CALCIUM ALLOWANCE

How much calcium should be included in the diet to maintain a positive calcium balance? According to the National Academy of Sciences a middle-aged person needs at least 1000 mg per day. The National Institutes of Health, believing osteoporosis to be epidemic, recommends 1500 mg of calcium daily.[56] The World Health Organization, monitoring the health of the entire world, finds osteoporosis rare. They state that 500 mg is more than adequate. Who is right?

CALCIUM BALANCE

Several things affect the overall calcium balance of the body. We get calcium in food and drink to supply our body's needs. Some of this calcium is absorbed and some of it passes on and is lost in the stool. That which is adsorbed is transferred to the blood and bones and some of it is excreted in the urine through the kidneys. If

our calcium absorption exceeds our losses than we have a positive calcium balance. Of the four components of calcium balance, intake, absorption, stool loss and urine excretion, the only one we can significantly influence is urinary loss. Here is where we need to focus our efforts on tipping the calcium balance in our favor.

To illustrate—someone on a diet consisting of 47 grams of protein and a urinary calcium excretion of 168 mg/day would be in a 31 mg positive calcium balance, (meaning that by the end of that day the total calcium in their body actually increased by 31 mg.) This is good. Double the protein intake to 95 grams and the urinary calcium excretion will jump to 240 mg and the balance at the end of the day will now be -58 mg. Triple the protein (142 mg/day) and the urinary calcium loss will climb to 300 mg/day and the balance will be a -120 mg/day.[57]

"But," you may say, "How do you know that calcium is coming from the bones? Maybe you just consumed more calcium with that extra protein and it turned up in the urine."

To further test this question a molecule called N-telopeptide was studied. When calcium is taken from the bone so is N-telopeptide. When calcium appears in the urine along with N-telopeptide we know exactly where the calcium came from—the bones. When the protein in a person's diet is increased from 49 gm/day to just 70 gm/day, (not even doubled or tripled), the urinary excretion N-telopeptide increases by 33%! The only place that the calcium appearing in the urine could have come from is the bones.[58]

The message? You cannot eat enough calcium to offset the effect of other poor lifestyle choices on your bones.

Can the problem be solved by simply taking more calcium? What about 1400 mg of calcium a day? An experiment was done in which subjects were divided in to three groups. Each group was given 1400 mg of calcium per day, but different levels of protein (48 gm/day, 95 gm/day, 142 gm/day). The group on the 48 gm/day protein diet maintained a positive calcium balance of 20 mg/day. The other two groups had negative calcium balances, -30 mg/day and -70 mg/day, respectively.

The message? You cannot eat enough calcium to offset the effect of other poor lifestyle choices on your bones.[59,60]

Let us put this in perspective. If you lost 50 mg of calcium a day for 20 years you could lose 365 grams of your skeletal mass. How much did you start out with? The average female has around 821 grams.[61] That would mean that you could lose 44% of your skeletal calcium in 20 years.

HOW MUCH PROTEIN DO YOU NEED?

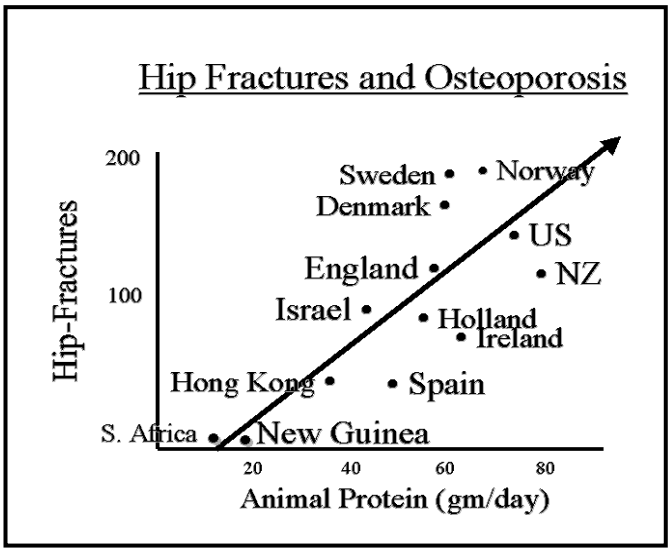
During World War I, Denmark was cut off from the rest of the world. Consequently, they instituted a food-rationing program to monitor the distribution of nutritional resources. Their principal foods were bran bread, barley porridge, potatoes, greens, cabbage, some milk, and some butter. The people of the cities and towns got little or no pork. Beef was so costly that only the rich could afford to buy it in sufficient amount. And they ate less than before, and often lost weight. No attention was paid to protein requirements. While fat was regarded as a very valuable addition to the diet, it was not considered as being a necessity. Bran was considered to be a very valuable food that was well-digested by man. Alcoholic beverages were nearly eliminated, as raw material was not rationed to distilleries. While the rest of the world saw death rates skyrocket from the "Spanish Influenza," the death rate for Denmark for the year October, 1917, to October, 1918, dropped to 10.4 per thousand. Dr. Hindhede, observing the health improvements on this forced low protein vegetarian diet, put himself on a low protein diet, and finding that he did quite well, published that 40 grams of protein a day is sufficient to maintain good health.[62]

It was not until the mid-1900's that researcher William C. Rose described the requirements of the 8 essential acids and determined the total protein requirements to maintain the body's nitrogen balance. In his work it was revealed that if the perfect protein

were eaten, one that supplied the optimal proportion of each of the 8 essential amino acids, only 12.7 gm of protein per day were necessary.[63]

Has such a diet been tried with success? In Somalia there is a group called the Bantus. The Bantu women get around 350 mg of calcium a day and their protein intake is only 10% of their diet. They have no calcium deficiency, and they have almost no hip fractures.[64] On the other hand are the Eskimos. Eskimos consume between 2000 mg and 2500 mg of calcium a day and have high level of weightbearing activity, yet they have the highest rates of osteoporosis in the world! Their protein intake averages 250-400 gm/day.[65,66]

One of the most telling studies on the effects of a high protein diet on osteoporosis was published by Abelow, et. al. in which they compared the rate of hip fracture in different countries to their per-capita animal protein consumption. Countries like South Africa, with low animal protein consumption, had a low rate



of hip fracture. Countries like the United States and England, with high animal protein consumption, had high hip fracture rates. The relationship between animal protein consumption and hip fracture rate for 13 countries maintained a linear relationship, which could send the message, "Need hip fracture? Eat animal protein."[67]

Animal protein is rich in phosphorus and sulphur as are processed foods.[68] (Animal products supply about 64% of the phosphorus in the American diet and grains another 19%.) Phosphorus and sulphur are metabolized by the body into sulfuric acid[69] and phosphoric acid. These acids are then buffered with calcium from your bones. What is more, as protein is metabolized; excess urea is produced, which acts like a diuretic to hasten the loss of calcium in the urine.[70]

The drawbacks to a high animal protein diet are not confined to calcium loss in the urine. Excess protein consumption has been linked to progressive loss of renal function,[71,72] kidney stones,[73,74] gouty arthritis from uric acid,[75] elevated cholesterol,[76,77] and increased cancer risk.[78]

Does animal protein include milk protein? Does the consumption of dairy products carry the same level of risk for osteoporosis as other animal products? In a 12-year study of 77 thousand woman, the daily consumption of dairy products increased hip fracture risk by 45%.[79] In another study of men and women aged 65 years old and older, dairy product consumption, particularly during their 20s, increased their risk of hip fracture later in life by 190%-240%. And why would a high calcium food like milk be such a poor protection against osteoporosis. Typically, only about 20-40% of milk calcium is absorbed, depending on the calcium status of the person. Calcium is absorbed better from most vegetable sources than from dairy foods.[80] What is more, once milk is digested, it has such high protein[81] and phosphorus[82] that it causes calcium loss.[83] Another factor is the sulphur content. Milk protein has twice as much of the sulphur containing amino acid methionine as soy or wheat protein.[84] Methionine breaks down to sulfuric acid which must be buffered with calcium from the bones.[85]

There are other benefits to plant protein that go beyond their lower sulphur content. Some plant proteins, such as those coming from soy or turmeric, actually have helpful weak hormonal activity. Studies suggest that dietary soybean protein is effective in preventing bone loss due to ovarian hormone deficiency.[86] What is more, soy contains genistein, which has been shown to

increase bone mineral density by 6% over a two-year period.[87]

WHERE DO WE GET OUR CALCIUM?

"Okay. So, if I eat something with calcium, which is also high in sulphur or phosphorus, I lose the benefit. So, what can I eat to get my calcium?" you may be asking. The absorptive efficiency of calcium from most vegetable sources is very good.[88] Some vegetarian foods high in calcium are dandelion greens, kale, turnip greens, mustard greens, collard greens, lambs quarters, baked beans, sesame seeds, blackstrap molasses, hazelnuts, green soybeans, dried figs, amaranth grain, and carob flour. By the way, lambs-quarters have one and a half times as much calcium as milk, without the protein, sulphur and phosphorus problems.

EXERCISE

Exercise provides mechanical stress to the skeleton. Calcium is added to the stressed skeleton to strengthen it to meet the demands put on it. As they say, "If you don't use it, you lose it."

If you do not find time to exercise you will have to find time to be sick.

Recall that perimenopausal women lose bone mass at a rate of 3% per year. Researchers wanting to study the effect of exercise on bone mass took two groups of women--one who did not exercise and one which was trained in daily exercise. As expected, the ones who did not exercise lost 3% of their bone mass every year. On the other hand, the exercise group not only cut losses, but also gained a little bone mass each year.[89] Exercise is one of the main ways of increasing or maintaining bone mass. In another study that looked at woman's ongoing activity level, women who were the most active had a 55% lower risk of hip fracture.[90]

VITAMIN D

Vitamin D works on the small intestine and the kidney. In the small intestine, vitamin D increases absorption of calcium. In the kidney, vitamin D increases the reabsorption of calcium. Thus, vitamin D increases the available calcium for the bones.

An 18-month study of women in their 80s revealed that the addition of 800 units of vitamin D to their diets increased their bone mass by 2.7% in just 18 months. What is more, they had 43% fewer hip fractures than expected.[91]

Sunlight is the natural source of vitamin D.[92] Twenty minutes a day out in the sun with at least 25% of your skin exposed to the sun, without the use of sunblock, should be sufficient.

BANKING ON YOUR BONES: RECOMMENDATIONS FOR BONE HEALTH

1. Weight bearing exercise. Thirty minutes a day of weight bearing exercise such as walking, out in the open air and sunshine.
2. Reduce protein and grain consumption. Eat foods that will not produce acid that has to be buffered by calcium from the bones.
3. Choose to abandon the calcium thieves. Thieves include sugar, chocolate, salt, caffeine, alcohol, tobacco, sodas, chronic stress, and depression.
4. Get at least 20 minutes of sunshine a day on 25% of your body.
5. Eat a plant-based diet rich in naturally occurring calcium. In one study increasing the intake of fruit and vegetables from 3.6 servings per day to 9.5 reduced calcium loss in the urine by 30%.[93] The biggest animals that walk our earth are vegetarian, and they have strong bones and teeth.

SO, WHAT SHOULD WE EAT?

An unrefined plant-based diet! The original diet!

Then God said, "I give you every seed-bearing plant on the face of the whole earth and every tree that has fruit with seed in it. They will be yours for food." "And you will eat the plants of the field."[94]

What is more, God has promises for those who reach out to serve others.

"The Lord will guide you continually, and satisfy your soul in drought, and strengthen your bones; you shall be like a watered garden, and like a spring of water, whose waters do not fail."[95]

Best wishes in your quest for stronger bones.

For further ideas on how to incorporate what you have just learned into your daily life, see the chapter entitled, "How Can I Apply Healthy Principles in My Daily Life". Or Lifestyles Choices.

---

[1] National Arthritis and Musculoskeletal and Skin Diseases Advisory Council was held on January 17, 2006, at the National Institutes of Health.
[2] National Osteoporosis Foundation http://www.nof.org/osteoporosis/diseasefacts.htm
[3] Gass M, Dawson-Hughes B. Preventing osteoporosis-related fractures: an overview. Am J Med. 2006 Apr;119(4 Suppl 1):S3-S11.
[4] Wasnich RD, Primer on the Metabolic Bone Diseases and Disorders of Mineral Metabolism. 4th edition, 1999.
[5] Bone Health and Osteoporosis: A Report of the Surgeon General http://www.surgeongeneral.gov/library/bonehealth/chapter_5.html
[6] Weiss KE, Rodner CM. Osteoarthritis of the wrist. J Hand Surg (Am). 2007 May-Jun;32(5):725-46.
[7] Chang SF. The silent disease: the quality of life of women with osteoporotic fracture. Hu Li Za Zhi. 2004 Oct;51(5):72-7.
[8] Crans GG, Silverman SL, Genant HK, et. al. Association of severe vertebral fractures with reduced quality of life: reduction in the incidence of severe vertebral fractures by teriparatide. Arthritis Rheum. 2004 Dec;50(12):4028-34.
[9] Osteoporos Int. 1999;9(3):206-13. Number and type of vertebral deformities: epidemiological characteristics and relation to back pain and height loss. European Vertebral Osteoporosis Study Group. Ismail AA, Cooper C, Felsenberg D, et. al.
[10] Melton LJ 3rd. Adverse outcomes of osteoporotic fractures in the general population. J Bone Miner Res. 2003 Jun;18(6):1139-41.
[11] Fujimoto K. Review article: prevalence and epidemiology of gastro-oesophageal reflux disease in Japan. Aliment Pharmacol Ther. 2004 Dec;20 Suppl 8:5-8.
[12] Bianchi ML, Orsini MR, Saraifoger S, et. al. Quality of life in post-menopausal osteoporosis. Health Qual Life Outcomes. 2005 Dec 1;3:78.
[13] National Osteoporosis Foundation http://www.nof.org
[14] Gass M, Dawson-Hughes B. Preventing osteoporosis-related fractures: an overview. Am J Med. 2006 Apr;119(4 Suppl 1):S3-S11.
[15] Johnell O. The socioeconomic burden of fractures: today and in the 21st century .Am J Med. 1997 Aug 18;103(2A):20S-25S.
[16] Roche JJ, Wenn RT, Sahota O, Moran CG. Effect of comorbidities and postoperative complications on mortality after hip fracture in elderly people: prospective observational cohort study. BMJ. 2005 Dec 10;331(7529):1374.
[17] From AM, Hyder JA, Kearns AM, Bailey KR, Pellikka PA. Relationship between low bone mineral density and exercise-induced myocardial ischemia. Mayo Clin Proc. 2007 Jun;82(6):679-85.
[18] Johansson C, Black D, Johnell O, et. al. Bone mineral density is a predictor of survival. Calcif Tissue Int. 1998 Sep;63(3):190-6.
[19] Trivedi DP, Khaw KT. Bone mineral density at the hip predicts mortality in elderly men. Osteoporos Int. 2001;12(4):259-65.
[20] Magaziner J, Fredman L, Hawkes W, et. al. Changes in functional status attributable to hip fracture: a comparison of hip fracture patients to community-dwelling aged. Am J Epidemiol. 2003 Jun 1;157(11):1023-31.
[21] Willig R, Keinänen-Kiukaaniemi S, Jalovaara P. Mortality and quality of life after trochanteric hip fracture. Public Health. 2001 Sep;115(5):323-7.
[22] Melton LJ 3rd. Adverse outcomes of osteoporotic fractures in the general population. J Bone Miner Res. 2003 Jun;18(6):1139-41.
[23] White EG. The Ministry of Healing. Mountain View, CA: Pacific Press Publishing Association, 1942 p.127.
[24] Nguyen UN, Dumoulin G, Henriet MT, Regnard J. Aspartame ingestion increases urinary calcium, but not oxalate excretion, in healthy subjects. J Clin Endocrinol Metab. 1998 Jan;83(1):165-8.
[25] Nguyen NU, Henriet MT, Dumoulin G, et. al.Increase in calciuria and oxaluria after a single chocolate bar load. Horm Metab Res. 1994 Aug;26(8):383-6.
[26] Heaney RP. Role of dietary sodium in osteoporosis. J Am Coll Nutr. 2006 Jun;25(3 Suppl):271S-276S.
[27] Vieth R. The role of vitamin D in the prevention of osteoporosis. Ann Med. 2005;37(4):278-85.
[28] Bunker VW. The role of nutrition in osteoporosis. Br J Biomed Sci. 1994 Sep;51(3):228-40.
[29] Riggs BL, Khosla S, Atkinson EJ, et. al. Evidence that type I osteoporosis results from enhanced responsiveness of bone to estrogen deficiency. Osteoporos Int. 2003 Sep;14(9):728-33.
[30] Hoidrup S, Sorensen TI, Stroger U, et. al. Leisure-time physical activity levels and changes in relation to risk of hip fracture in men and women. Am J Epidemiol. 2001 Jul 1;154(1):60-8.
[31] Massey LK, Whiting SJ. Caffeine, urinary calcium, calcium metabolism and bone. J Nutr. 1993 Sep;123(9):1611-4.
[32] Ferrini RL, Barrett-Connor E. Caffeine intake and endogenous sex steroid levels in postmenopausal women. The Rancho Bernardo Study. Am J Epidemiol. 1996 Oct 1;144(7):642-4.
[33] Sampson HW. Alcohol and other factors affecting osteoporosis risk in women. Alcohol Res Health. 2002;26(4):292-8.
[34] de Vernejoul MC, Bielakoff J, Herve M, et.al. Evidence for defective osteoblastic function. A role for alcohol and tobacco consumption in osteoporosis in middle-aged men. Clin Orthop Relat Res. 1983 Oct;(179):107-15.
[35] Meszaros S, Ferencz V, Deli M, et. al. Effect of cigarette smoking on bone quality parameters in women. Orv Hetil. 2006 Mar 19;147(11):495-9.
[36] Kapoor D, Jones TH. Smoking and hormones in health and endocrine disorders. Eur J Endocrinol. 2005 Apr;152(4):491-9.
[37] Macleay JM, Olson JD, Turner AS. Effect of dietary-induced metabolic acidosis and ovariectomy on bone mineral density and markers of bone turnover. J Bone Miner Metab. 2004;22(6):561-8.
[38] Krapf R. Partial neutralization of the acidogenic Western diet with potassium citrate increases bone mass in postmenopausal women with osteopenia. Interview by Nicola Zitzmann. Int J Prosthodont. 2007 Mar-Apr;20(2):113-4.
[39] Remer T, Manz F. Potential renal acid load of foods and its influence on urine pH. J Am Diet Assoc. 1995 Jul;95(7):791-7.
[40] Abelow BJ, Holford TR, Insogna KL. Cross-cultural association between dietary animal protein and hip fracture: a hypothesis. Calcif Tissue Int. 1992 Jan;50(1):14-8.
[41] Rotily M, Leonetti F, Iovanna C, et. al. Effects of low animal protein or high-fiber diets on urine composition in calcium nephrolithiasis. Kidney Int. 2000 Mar;57(3):1115-23.
[42] Giannini S, Nobile M, Sartori L, et. al. Acute effects of moderate dietary protein restriction in patients with idiopathic hypercalciuria and calcium nephrolithiasis. Am J Clin Nutr. 1999 Feb;69(2):267-71.

[43] Kristensen M, Jensen M, Kudsk J, et. al. Short-term effects on bone turnover of replacing milk with cola beverages: a 10-day interventional study in young men. Osteoporos Int. 2005 Dec;16(12):1803-8.
[44] Fettman MJ, Coble JM, Hamar DW, et. al. Effect of dietary phosphoric acid supplementation on acid-base balance and mineral and bone metabolism in adult cats. Am J Vet Res. 1992 Nov;53(11):2125-35.
[45] Kumano H. Osteoporosis and stress. Clin Calcium. 2005 Sep;15(9):1544-7.
[46] Kiecolt-Glaser JK, Preacher KJ, MacCallum RC, et. al. Chronic stress and age-related increases in the proinflammatory cytokine IL-6. Proc Natl Acad Sci U S A. 2003 Jul 22;100(15):9090-5.
[47] Mussolino ME. Depression and hip fracture risk: the NHANES I epidemiologic follow-up study. Public Health Rep. 2005 Jan-Feb;120(1):71-5.
[48] Yirmiya R, Goshen I, Bajayo A, et. al. Depression induces bone loss through stimulation of the sympathetic nervous system. Proc Natl Acad Sci U S A. 2006 Nov 7;103(45):16876-81.
[49] Robbins J, Hirsch C, Whitmer R, et. al. The association of bone mineral density and depression in an older population. J Am Geriatr Soc. 2001 Jun;49(6):732-6.
[50] Whooley MA, Kip KE, Cauley JA, et. al. Depression, falls, and risk of fracture in older women. Study of Osteoporotic Fractures Research Group. Arch Intern Med. 1999 Mar 8;159(5):484-90.
[51] Holy Bible, Proverbs 17:22, King James Version.
[52] Janghorbani M, Feskanich D, Willett WC, Hu F. Prospective study of diabetes and risk of hip fracture: the Nurses' Health Study. Diabetes Care. 2006 Jul;29(7):1573-8.
[53] McFarlane SI. Bone Metabolism and the Cardiometabolic Syndrome: Pathophysiologic Insights. J Cardiometab Syndr. 2006 Winter;1(1):53-57.
[54] Sawicki A, Regula A, Godwod K, Debinski A. Peptic ulcer disease and calcium intake as risk factors of osteoporosis in women. Osteoporos Int. 2003 Dec;14(12):983-6. Epub 2003 Oct 3.
[55] Cummings SR, Nevitt MC, Browner WS, et. al. Risk factors for hip fracture in white women. Study of Osteoporotic Fractures Research Group. N Engl J Med. 1995 Mar 23;332(12):767-73.
[56] National Institute of Health. Osteoporosis: consensus conference. JAMA 1984;254:799-802.
[57] Anand CR, Linkswiler HM. Effect of protein intake on calcium balance of young men given 500 mg calcium daily. J Nutr. 1974 Jun;104(6):695-700.
[58] Kerstetter JE, Mitnick ME, Gundberg CM, et. al. Changes in bone turnover in young women consuming different levels of dietary protein. J Clin Endocrinol Metab. 1999 Mar;84(3):1052-5.
[59] Linkswiler HM, Zemel MB, Hegsted M, Schuette S. Protein-induced hypercalciuria. Fed Proc. 1981 Jul;40(9):2429-33.
[60] Allen LH, Oddoye EA, Margen S. Protein-induced hypercalciuria: a longer term study. Am J Clin Nutr. 1979 Apr;32(4):741-9.
[61] Reid DM. Measurement of bone mass by total body calcium: a review. J R Soc Med. 1986 Jan;79(1):33-7.
[62] Hindhede M. The effect of food restriction during war on mortality in Copenhagen. JAMA 1920;76(6):381–2.
[63] Rose WC. II. The sequence of events leading to the establishment of the amino acid needs of man. Am J Public Health Nations Health. 1968 Nov;58(11):2020-7.
[64] Solomon L. Osteoporosis and fracture of the femoral neck in the South African Bantu. J Bone Joint Surg Br. 1968 Feb;50(1):2-13.
[65] Mazess RB, Mather W. Bone mineral content of North Alaskan Eskimos. Am J Clin Nutr. 1974 Sep;27(9):916-25.
[66] Mazess RB, Mather WE. Bone mineral content in Canadian Eskimos. Hum Biol. 1975 Feb;47(1):44-63.
[67] Abelow BJ, Holford TR, Insogna KL. Cross-cultural association between dietary animal protein and hip fracture: a hypothesis. Calcif Tissue Int. 1992 Jan;50(1):14-8.
[68] Uribarri J. Phosphorus homeostasis in normal health and in chronic kidney disease patients with special emphasis on dietary phosphorus intake. Semin Dial. 2007 Jul-Aug;20(4):295-301.
[69] Zemel MB, Schuette SA, Hegsted M, Linkswiler HM. Role of the sulfur-containing amino acids in protein-induced hypercalciuria in men. J Nutr. 1981 Mar;111(3):545-52.
[70] Lemann J Jr. Relationship between urinary calcium and net acid excretion as determined by dietary protein and potassium: a review. Nephron. 1999;81 Suppl 1:18-25.
[71] Ihle BU, Becker GJ, Whitworth JA, et. al. The effect of protein restriction on the progression of renal insufficiency. N Engl J Med. 1989 Dec 28;321(26):1773-7.
[72] Pedrini MT, Levey AS, Lau J, et. al. The effect of dietary protein restriction on the progression of diabetic and nondiabetic renal diseases: a meta-analysis. Ann Intern Med. 1996 Apr 1;124(7):627-32.
[73] Robertson WG, Peacock M, Heyburn PJ, et. al. Should recurrent calcium oxalate stone formers become vegetarians? Br J Urol. 1979 Dec;51(6):427-31.
[74] Giannini S, Nobile M, Sartori L, et. al. Acute effects of moderate dietary protein restriction in patients with idiopathic hypercalciuria and calcium nephrolithiasis. Am J Clin Nutr. 1999 Feb;69(2):267-71.
[75] Choi HK, Atkinson K, Karlson EW, et. al. Purine-rich foods, dairy and protein intake, and the risk of gout in men. N Engl J Med. 2004 Mar 11;350(11):1093-103.
[76] Sirtori CR, Agradi E, Conti F, et. al. Soybean-protein diet in the treatment of type-II hyperlipoproteinaemia. Lancet. 1977 Feb 5;1(8006):275-7.
[77] Anderson JW, Johnstone BM, Cook-Newell ME. Meta-analysis of the effects of soy protein intake on serum lipids. N Engl J Med. 1995 Aug 3;333(5):276-82
[78] Li C, Bai X, Wang S, Tomiyama-Miyaji C, et. al. Immunopotentiation of NKT cells by low-protein diet and the suppressive effect on tumor metastasis. Cell Immunol. 2004 Sep-Oct;231(1-2):96-102.
[79] Feskanich D, Willett WC, Stampfer MJ, Colditz GA. Milk, dietary calcium, and bone fractures in women: a 12-year prospective study. Am J Public Health. 1997 Jun;87(6):992-7.
[80] Weaver CM. Calcium bioavailability and its relation to osteoporosis. Proc Soc Exp Biol Med. 1992 Jun;200(2):157-60.
[81] Margen S, Chu JY, Kaufmann NA, Calloway DH. Studies in calcium metabolism. I. The calciuretic effect of dietary protein. Am J Clin Nutr. 1974 Jun;27(6):584-9.
[82] Reiss E, Canterbury JM, Bercovitz MA, Kaplan EL. The role of phosphate in the secretion of parathyroid hormone in man. J Clin Invest. 1970 Nov;49(11):2146-9.
[83] van Beresteijn EC, Brussaard JH, van Schaik M. Relationship between the calcium-to-protein ratio in milk and the urinary calcium excretion in healthy adults--a controlled crossover study. Am J Clin Nutr. 1990 Jul;52(1):142-6.
[84] Ellinger GM, Duncan A. The determination of methionine in proteins by gas-liquid chromatography. Biochem J. 1976 Jun 1;155(3):615-21.
[85] Zwart SR, Davis-Street JE, Paddon-Jones D, et.al. Amino acid supplementation alters bone metabolism during simulated weightlessness. J Appl Physiol. 2005 Jul;99(1):134-40.
[86] Arjmandi BH, Alekel L, Hollis BW, et. al. Dietary soybean protein prevents bone loss in an ovariectomized rat model of osteoporosis. J Nutr. 1996 Jan;126(1):161-7.
[87] Marini H, Minutoli L, Polito F, et. al. Effects of the phytoestrogen genistein on bone metabolism in osteopenic postmenopausal women: a randomized trial. Ann Intern Med. 2007 Jun 19;146(12):839-47.
[88] Weaver CM. Calcium bioavailability and its relation to osteoporosis. Proc Soc Exp Biol Med. 1992 Jun;200(2):157-60.
[89] Kemmler W, Lauber D, Weineck J, et. al. Benefits of 2 years of intense exercise on bone density, physical fitness, and blood lipids in early postmenopausal osteopenic women: results of the Erlangen Fitness Osteoporosis Prevention Study (EFOPS). Arch Intern Med. 2004 May 24;164(10):1084-91.
[90] Feskanich D, Willett W, Colditz G. Walking and leisure-time activity and risk of hip fracture in postmenopausal women. JAMA. 2002 Nov 13;288(18):2300-6.
[91] Chapuy MC, Arlot ME, Duboeuf F, et. al. Vitamin D3 and calcium to prevent hip fractures in the elderly women. N Engl J Med. 1992 Dec 3;327(23):1637-42.
[92] Holick MF. McCollum Award Lecture, 1994: vitamin D--new horizons for the 21st century. Am J Clin Nutr. 1994 Oct;60(4):619-30.
[93] Appel LJ, Moore TJ, Obarzanek E, et. al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. N Engl J Med. 1997 Apr 17;336(16):1117-24.
[94] Genesis 1:29; 3:18 (NIV). Scripture taken from the HOLY BIBLE, NEW INTERNATIONAL VERSION®. Copyright © 1973, 1978, 1984 International Bible Society. Used by permission of Zondervan. All rights reserved. The "NIV" and "New International Version" trademarks are registered in the United States Patent and Trademark Office by International Bible Society. Use of either trademark requires the permission of International Bible Society.
[95] Holy Bible, Isaiah 58:11, King James Version.