

Dietary protein: is a large intake related to osteoporosis (thin bones)? It's probably the lack of neutralizing effect of vegetable alkali rather than the protein per se.

The puzzle of the relationship between protein consumption and bone health. There appears to be two bodies of evidence which give diametrically opposed results as to whether protein intake, particularly animal protein, leads to osteoporosis. On the one hand there are some quite reasonable studies (Hannan 02) and not-so-clear studies (Dawson-Hughes 02) that show a relationship between lower protein intake and osteoporotic fracture (Heaney 01). In the setting of the standard American diet, those with the lowest protein intake have greater losses of bone mineral density. There is clear evidence in such a setting that by increasing the protein intake especially with supplementary calcium and vitamin D, this process can be reversed.

However, there are also an equal number of studies which show the reverse (Sellmeyer 01). How can these results be reconciled? Where does the truth lie? A clue to this puzzle was provided in the 1970s when it was noted that the Inuit who have traditionally had the highest animal-based food intake in the world, close to 100% of diet, had bone mineral densities 10 to 15% lower than the average US levels, despite very high levels of calcium intake from fish bones (Mazess 74). This finding was confirmed in 2001 by a study of hip fracture rate in Inuit men and women which was higher than the US population and had increased in incidence over a 20 year period (Pratt 01). These people have almost no vegetable intake and this is probably the vital clue.

People with high vegetable intake don't have a higher incidence of osteoporosis and fracture. In the vegetarian community, osteoporosis is not more common. Likewise in areas consuming the Mediterranean diet which is rich in vegetables, low in animal protein with a moderate overall protein intake, osteoporosis and fractures rates are lower than elsewhere in Europe (Ismail 02). Contrast this with the situation in the US. It has probably the highest per capita intake of animal protein in the world, yet osteoporosis is a major

problem. There tends to be an inverse relationship between consumption of animal protein and vegetables: high meat consumption is usually associated with a much lower vegetable consumption and vice versa. This can be very clearly seen in data derived from FAO sources quoted in the paper by Frassetto (Frassetto 00).

The further story: one of balance between acid generating dietary protein and neutralizing potassium containing alkalis from plant-based foods. It had been known from studies of human kidney function that acid excretion in the urine increases in proportion with animal protein content of diet (Abelow 92). It should also be noted that all protein will add to acid load but those with the highest content of sulphur containing amino acids methionine and cysteine, will have a bigger effect. Animal protein tends to have a higher content of these amino acids than does fruit and vegetable derived protein. As example cheese or red meat have 6-10 mg/100g of methionine compared to 0.48mg/100g for peas (Ginty 03).

Hence plant-based proteins do contribute to this load but to a lesser degree. The acid load from protein can be offset by increasing the amount of potassium containing alkalis found particularly in vegetables. (See below) As examples of foods contributing acid load, most meats generate around 8 to 10mEq/100g and hard cheeses around 20 of acid load. In contrast, most vegetables have an acid neutralizing effect of between -0.5 to -5.0 mEq/100g. (An extensive list can be found in the reference Remer 95.)

The body does not store excess dietary protein but breaks it down adding to the acid load. It is important to understand that excess protein in the diet is simply broken down to its component elements, with the energy generated being stored as fat. The body does not store excess protein and having a diet high in protein, even in people who exercise a lot, is no advantage despite a lot of myth. All the extra protein does in for example athletes is add to the energy supply since they have only a marginal increase in need for protein in muscle maintenance. Excess dietary protein is essentially no different from carbohydrates as an energy supply.

Where it does differ is in production of acid which rises proportionally with the protein intake as noted above. The mechanism is that proteins are broken down into their constituent amino acids which are then further broken down into more simple molecules. The sulphur from the sulphur containing amino acids is converted to

sulphuric acid.

How does the body handle this acid load? This increased acid load in the body, causing what is known as a metabolic acidosis, has to be controlled since the acidity/alkalinity, i.e. the pH, of the blood has to be held within a very narrow range. Outside this range, the body's biochemical functions rapidly fail leading to severe illness and sometimes death. An acid load is produced from amino acid breakdown from dietary protein, whether it be from plant or animal origin. The amount of acid produced is proportional to mainly to the protein load but also to the proportion of S amino acids in that protein load.

By and large, higher levels of protein intake are only possible by the consumption of animal based protein. If there is not a matching alkaline load from plant-based foods, most of this acid is neutralized against the calcium phosphate in bone, leading to a progressive loss of calcium in the urine. (Calcium phosphate is the main mineral of bone.) Further evidence of this is shown by tests where urinary acid load was increased with ammonium chloride resulting in increasing loss of calcium (Abelow 92). A diet rich in animal-protein and lower in fruit and vegetables will cause a low grade metabolic acidosis which over time will lead to a progressive erosion of the bone mineral, causing osteoporosis (Krapf 06).

What is important is the balance between acid producing dietary protein and alkali containing plant-based foods to maintain healthy bones. Perhaps dietary protein has been unfairly blamed but it indirectly carries part of the blame. As the dietary protein intake rises, more vegetable derived potassium containing alkali is needed to neutralize this effect. It has been noted that giving potassium bicarbonate (alkali) without dietary change to reverse the acid loading, abolishes the calcium loss in the urine. A recent study has shown that potassium citrate, an organic alkali, will improve bone mineral density (Krapf 06). However, such a therapeutic approach is impractical as a form of prophylaxis.

Another approach would be to simply increase the amount of plant-based foods without reducing animal protein intake. This again would be difficult to achieve since the amount of plant-based food that would be needed to neutralize the acidosis produced by current excess protein intake would be unacceptably large. In fact, observations around the world show that there appears to be an inverse relationship between animal protein consumption and plant-

based food consumption.

As predicted countries that have a high vegetable to animal-based foods have a low rate of osteoporosis as assessed by hip fracture, and vice versa (Frassetto 01). A study by Tucker et al showed that bone mineral density in elderly men and women was positively related to fruit and vegetable intake, in particular with potassium and magnesium intakes (Tucker 99). Sellmeyer et al study found almost identical findings (Sellmeyer 01). A discussion of the pros and cons of this debate can be found in (Sebastian 01).

Protein in excess is just another form of energy. There is nothing to be gained from a high protein diet. Even in Olympic athletes, the amount of extra protein required to build new muscle is minimal compared to that required for maintenance which is not particularly increased. Growing children are much the same as the amount of amino acid going to new protein is small compared to that required for body maintenance. The benefit from a high protein diet is nil and is quite possibly deleterious to bone health especially where there is a limited intake of fruit and vegetables. See the section on [proteins](#).

In summary. With the progressive increase of animal protein and decrease in plant-based foods in western diets over past few decades, the subsequent acid load has been greater, leading to a progressive increase in osteoporosis. This has been in spite of a progressive increase in calcium recommended daily intake to the current level of more than 1000mg/day in the US. The clear message in all this is to increase your intake of fruit and vegetables and reduce your intake of protein if it is high. However, if you don't eat much, especially if you are very old, a low protein intake can damage your bones and in this setting additional calcium and vitamin D are also important. On the latter point, it is now apparent that vitamin D deficiency is becoming more common in most western societies, partly coupled with sun avoidance. It is important the older people and those who have little sun exposure should have their vitamin D levels checked and be treated with supplementation if required.

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