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Editorial

# Effect of Dietary Protein Sources on Bone Health

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## Editorial

Bone is a dynamic tissue as reflected by continuous remodeling, including bone formation and resorption.The balance between both processes is vital to maintain the integrity of the skeleton. Understanding the critical events responsible for bone formation is important to identify the factors that affect bone metabolism. These events include osteoblast differentiation, formation of a collagenous bone matrix and ultimately the mineralization of this bone matrix. On the other hand, activation of osteoclasts is primarily implicated in bone resorption [1].

Osteoporosis has become a major health problem characterized by an increased risk of fractures due to a reduction in both bone quantity and quality. It arises when the bone resorption occurs in a greater rate than the bone formation. Most of the current pharmacological approaches focus on inhibiting bone resorption in those who already have the disease or in those who are at risk of developing the disease [2]. On the contrary, recent insight has been shed into dietary components that may optimize bone mass and stimulate bone formation [3].

Although there are many dietary components that affect bone mass, protein remains a very essential nutrient to maintain bone health. This is simply because proteins form up to one third of bone mass. Since cross-linking of collagen fibers in bone matrix requires post-translational modification of amino acids (such as hydroxylation of lysine and proline residues), a lot of collagen fragments cannot be reconsumed to form a new bone matrix. Therefore, a daily supply of dietary protein is required for bone maintenance [4].

The prevalence of osteoporosis is continuously increasing, which seems to be associated with adopting modern lifestyle, including consumption of unhealthy food and intake of large amounts of soft drink, along with low physical activity. Western diet and fast food, rich in animal proteins, have been considered risk factors for osteoporosis and bone fracture [5]. Conversely, accumulating evidence suggests that consumption of fruit and vegetables was found to be beneficial in increasing bone mass in postmenopausal women [6,7]. These findings stimulate an intriguing question whether different sources of dietary protein may affect bone metabolism in a different manner. In other terms, would the dietary proteins of plant origin may be more beneficial to bone health than that of animal sources?

Emerging data indicate that various sources of dietary protein may exhibit different effects on bone homeostasis. Animal protein-based diets have been suggested to have a greater negative effect on bones than plant protein-based diets do, because animal proteins *e.g.*beef, chicken, fish and eggs are acid forming food, due to the metabolic oxidation of the sulfur-containing amino acids (methionine and cysteine) to sulfate moiety leading to shifting of blood pH to acidic side.This in turn affects the overall dietary acid-base balance and ultimately contributes to buffering response by the skeleton in the form of mobilization of carbonate and citrate salts from bone matrix in order to balance the endogenous acids generated from animal proteins [8]. Small decreases in blood pH have been reported to activate bone resorption [9]. Furthermore, *in vitro* study has indicated that acidosis can directly stimulate osteoclastic activity and inhibit osteoblastic activity [10].

Dietary acid load associated with excessive intake of animal protein can adversely affect bone metabolism indirectly *via* inducing alterations of endocrine function. The hypercorticoid response to metabolic acidosis has been reported in rats [11]. Moreover, *Maurer et al* demonstrated that western diet-induced mild acidosis was accompanied with increased excretion of cortisol leading to higher plasma levels in young human adults [12]. Evidence showed that even a mild increase in cortisol levels would contribute to increased fracture risk [13].

Another consequence of protein-induced acidosis is the urinary calcium excretion which is strongly related to the net renal acid excretion.Overconsumption of animal proteins was associated with urinary calcium loss [9]. Earlier study has demonstrated that urinary excretion of calcium was positively correlated with animal protein intake in middle aged and elderly Japanese population [14]. Interestingly, short term-neutralization of acid load associated with western diet by carbonate salt significantly attenuated the urinary calcium excretion and suppressed the biochemical markers of bone resorption in young adult subjects [12].

More importantly, the effect of dietary protein on calcium homeostasis also includes the amount of calcium absorbed. It has been suggested that animal protein intake induced calcium urinary excretion only when calcium intake is simultaneously inadequate, implying that the continuous supplementation of calcium may attenuate the negative influence of animal protein on bones [15]. This may explain some of conflicting results of previous studies that demonstrated low or no association between animal protein and bone health. *Spencer et al* performed extensive studies on the long term consumption of meat and milk and found no adverse effects on calcium balance, which may be attributed to phosphorus and calcium contents, respectively [16]. It is likely seems that the adverse impact of animal protein on calcium excretion can be modified by other nutrients on diet.

On the other hand, plant based diets are good source of potassium and base precursors, which have alkalizing effects, so reduced urinary calcium excretion. This may provide a reasonable explanation for the beneficial influence of vegetables and fruits on bone health [7].


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Consistently, *Sellmeyer et al* reported that a high dietary ratio of animal to vegetable protein intake greatly increased femoral neck bone loss and risk of hip fracture in postmenopausal women than those with a low ratio[17]. Furthermore, Soybean, as a vegetable protein has received a considerable attention for its role in enhancing bone health. It has been shown that soy protein when substituted for animal protein may indirectly enhance bone strength. Several studies have demonstrated that in comparison with animal protein, soy protein decreases urinary calcium loss, due to lower sulfur-containing amino acid and higher potassium content of soy protein [18]. The favorable effects of soybeans on bones may be related also to its isoflavones, which exhibit mild estrogenic activity [19]. In this context, a clinical study has shown that soy protein/isoflavones intake significantly increased bone mineral density and content in early postmenopausal Chinese women [20].

Overall, dietary protein intake appears to be anabolic for bones within the recommended daily allowance. However, increasing the protein intake, especially that originating from animal sources, may be associated with negative impact on bones.Introducing the vegetable proteins as alkalizing nutrients in diet may be helpful in terms of attenuating the urinary calcium loss and maintaining bone health. Although there is considerable debate regarding the effect of animal protein on bone health, we seriously recommend a combination of animal proteins with vegetables and fruits as a dietary regimen, along with adequate calcium intake, to maintain healthy bones. Certainly, future studies are warranted for further evaluation of the influences of different protein sources on bone metabolism. More research should be directed to explore additional dietary approaches to ensure an appropriate bone health.

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