Acid-base dietary components, bone mineral density, and fracture risk in the Framingham Osteoporosis Study.

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Diets high in acid forming components, including several amino acids in protein foods, phosphorus and chlorine; and low in base forming components, including fruit and vegetables, potassium, calcium, magnesium and vitamin C, are hypothesized to lead to lower bone mineral density (BMD) and higher fracture risk. Some studies have shown that high animal to plant protein intake ratio may be associated with fracture. Magnesium and potassium have been shown to improve calcium and bone mineral retention. In recent years there has also been accumulating evidence of the positive effect of fruits and vegetables on BMD. We have recently shown that cola intake is associated with lower BMD, perhaps due to its phosphoric acid content. In contrast to the original hypothesis, however, we and others have found that higher rather than lower protein intake is associated with BMD. The apparent anabolic effects of the protein itself, and through increased IGF-1, appear to outweigh the negative acidic effect in typical US diets. We have recently extended our analyses from BMD to incident fracture risk in the original Framingham cohort. Of the original Heart Study subjects, 976, aged 67-95 y, completed valid food frequency questionnaires at the 20th examination. During 15 years of follow-up, there were 92 incident hip fractures. Cox-proportional hazards models were used to determine associations between magnesium, potassium, fruit and vegetables, total protein, animal protein, NEAP (net rate of endogenous non-carbonic acid production), PRAL (potential renal acid load) and dietary PRAL and hip fracture. The models were adjusted for age at exam 20, sex, BMI, height, physical activity score for the elderly (PASE), smoking status, alcohol use and total energy intake. Due, perhaps, to limitations in power, none of these variables reached statistical significance in relation to fracture risk. However, comparison of the highest versus lowest quartiles of magnesium intake and of fruit and vegetable intake resulted in non-significant Hazard Ratios (HR) in the expected direction: 0.80 (0.4-1.8) and 0.70 (0.4-1.3), respectively; and vitamin C approached significance, 0.49 (0.2-1.0), but in women only. In contrast with the original hypothesis, but consistent with our findings on protein and BMD, HRs for total protein and animal protein were also in the protective direction: 0.50 (0.2-1.2) and 0.65 (0.3-1.4), respectively. Given these results, it is, perhaps, not surprising that the NEAP, PRAL and dietary PRAL also followed this pattern: 0.67 (0.4-1.2), 0.89 (0.5-1.6) and 0.90 (0.5-1.7). Further analysis is needed with larger numbers of incident fracture. However, it appears that existing measures of acid load may need rethinking in their relation to bone, due to the apparent importance of the anabolic effects of protein that work in opposition to the negative acidic contribution.