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Role of dairy beverages in the diet

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ABSTRACT

The U.S. Dietary Guidelines for Americans recommends 3 cups of low fat milk or equivalent daily for most calorie levels [1]. Milk provides over 10% of the requirement for calcium, vitamin D, magnesium, phosphorus, potassium, riboflavin, protein, and carbohydrates for most people. Obtaining adequate intakes of calcium, potassium, and magnesium without milk in the diet requires effort. Milk has bioactive ingredients that may play unique roles in health. Benefits of dairy consumption are associated with reduced risk of low bone mass, stroke, metabolic syndrome, and some cancers. Concerns over milk consumption have focused on saturated fats historically. More research is needed to resolve potential concerns of milk consumption and risk of several disorders including ovarian cancer and soft tissue calcification.

Milk and milk products have a prominent role in dietary recommendations in western countries. They have comprised a food group for all of the iterations of the Dietary Guidelines for Americans. Yet, milk consumption is often maligned or deemphasized in the media and by some health professionals [2,3]. Worldwide consumption of milk is low, especially in eastern cultures.

The prominence of milk in public policy recommendations in western countries is largely because of its concentrated source of nutrients in a convenient and economical form. Milk is the principal nourishment of all mammalian species during early life. Prior to the agricultural revolution, early man foraged for plant foods that were high in calcium and other minerals. It is estimated that calcium intakes in diets of early man exceeded 3 g per day [4]. However, when cereal crops became the staple of the diets of man, calcium intakes fell dramatically because the fruit (seeds) of the plant accumulate the lowest concentrations of calcium. With domestication of animals, milk became the dominant source of calcium in the diet of most populations. If milk consumption is not maintained post weaning, intestinal lactase does not persist and many individuals become maldigesters of milk sugar lactose. In a nationally representative sample, self reported lactose intolerance was 12% [5].

In recent history, populations are living well beyond reproductive years and chronic diseases receive more attention. The relationships of milk consumption to chronic disease are debated with some evidence that chronic diseases are ameliorated by inclusion of milk in the diet, whereas some observational studies suggest that risk of certain chronic disease is increased with milk consumption. The benefits may largely relate to nutrients and/or bioactive constituents of milk. The risks are often associated with the fat found in high fat dairy products and/or increased hormone exposure.

1. Meeting shortfalls nutrients

Shortfall nutrients of concern in the American diet identified by the 2005 Dietary guidelines for Americans Advisory Committee [6] reflects on the literature including Foote et al. [7] using Continuing Survey of Food Intake by Individuals (CSFII) were calcium, magnesium, potassium, vitamins A,C, and E, and fiber for adults and calcium, magnesium, potassium, vitamin E and fiber for children . The 2005 Dietary Guidelines for Americans advisory committee further noted difficulties in meeting vitamin D, iron, and B_{12} for vulnerable populations [6].

According to a secondary analysis of data from the 1999 to 2004 National Health and Nutrition Examination Survey (NHANES), less than 3% of the U.S. population consumes the recommended level of potassium, 30% of those aged 2 years and older consumed the recommended intakes for calcium, and 55% consumed less than the Estimated Average Requirement for magnesium [8]. Only the youngest children meet the My Pyramid dairy recommendations and the proportion who meet them decreases with increased age [9].

Milk is a good source of most of these shortfall nutrients except for fiber, vitamin D (unless fortified), and iron. Three cups of milk and low fat dairy products are included in most patterns in the food guidance system of My Pyramid.gov in order to meet the Dietary Reference Intakes for several nutrients and calcium and potassium in particular. Dairy foods contribute 70.3% of calcium, 16% of magnesium almost all of the vitamin D, 18.2% of vitamin B12, 15% of zinc, and 25% of riboflavin in the U.S. diet [6].

Milk consumption has been called a marker for an overall healthy diet because of its association with increased nutrient intake [10–12].

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Several studies have demonstrated the difficulty in meeting requirements of calcium, potassium, and several other nutrients when milk is largely excluded from the diet. An analysis of data on adolescents in the NHANES 2001 to 2002 survey showed that those who excluded dairy could not meet calcium recommendations within the current dietary consumption patterns because of not choosing alternative calcium-fortified foods [13]. For the 2005 Dietary Guidelines for Americans advisory committee report, it was determined that without milk products, 19–50 year old women would reach only 44% of calcium recommendations, 57% of magnesium recommendations and 57% of potassium recommendations, as an example [6]. African Americans achieve the lowest proportion of those meeting calcium recommendations of any ethnic group in the U.S. [11]. In a 20-country comparison, only young men were likely to have calcium intakes that met or exceeded their country-specific calcium recommendation [14]. Women of all ages from adolescent years met less than 60% of their country-specific calcium recommendations on average.

2. Relation to bone health

Dairy consumption has been positively linked to bone health in observational, retrospective, and intervention studies. Two reviews of the literature found that 25 out of 32 observational studies and 11 out of 11 randomized controlled trials showed a significantly positive association between dairy food intake and bone mineral density (BMD) or bone mineral content (BMC) [6,15]. The advantages of dairy consumption to bone health are strongest during growth. A retrospective study using NHANES data showed that low milk consumption during childhood was associated with a doubling of hip fracture in American postmenopausal women [16]. A meta-analysis of trials of dairy products and dietary calcium on BMC in children showed significantly higher total body and lumbar spine BMC with higher intakes, but it depended on having low calcium comparison groups [17]. Although there are no RCTs of dairy on fracture risks in adults, calcium and vitamin D supplementation reduced fracture risk by about 20% in pooled estimates [18].

Individuals avoid consuming recommended intakes of milk and other dairy products for a variety of cultural, philosophical, religious, health and preference reasons. Both children [19,20] and adults [21–23] who avoid milk or perceive they have lactose intolerance or where milk is not readily available have lower BMC or BMD. A recent meta-analysis of 9 studies of 2749 subjects compared BMD of vegans, lactoovovegetarians, and omnivores [24]. Compared to omnivores, vegans had 6% lower BMD and lactoovovegetarians had 2% lower BMD at the lower lumbar spine. The effect size was similar at the femoral neck. In a corresponding editorial, Lanham-New [25] concluded vegetarianism was not a serious risk factor for osteoporosis (particularly in lactoovovegetarians), but only about 3% of Americans and British are vegetarians. Nevertheless, fracture risk was found to be higher in vegans (incidence rate ratio 1.3, 95% CI 1.02–1.66) in a 5.2 year follow up of 34, 696 adults in the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford) [26].

Milk constituents thought to influence bone health include calcium, protein, potassium, phosphorus, magnesium, zinc, vitamin B_{12}, and vitamin D when fortified. Calcium, phosphorus, magnesium, and zinc play a structural role in formation of hydroxyapatite crystals that comprise bone mineral content. Calcium also reduces bone remodeling rates through PTH suppression [27]. Zinc is also involved in bone turnover as a co-factor in alkaline phosphatase. The role of vitamin D in bone health is through activating calcium transport proteins important for active calcium absorption and controlling urinary calcium excretion and bone resorption. Collagen proteins and minor others form the organic matrix and occupy half of the bone volume. Vitamin K is involved in carboxylation of matrix proteins. Potassium may influence urinary calcium loss as an alkaline element, although this is controversial [28]. Vitamin B_{12} may influence osteoblast proliferation of homocysteine metabolism which may influence fractures [15].

A relevant question is whether substituting milk with other sources of these milk constituents can provide comparable nourishment for bone health and protection against fracture. Practically speaking, most individuals who avoid milk do not attempt to adjust their diets to meet the nutrients found in milk [11,13]. Those that do concentrate on only one or two nutrients provided milk, i.e. calcium and vitamin D (fortified). The most common alternative source of calcium is calcium carbonate used in fortified foods and supplements. Fig. 1 shows some of the advantages to bone of milk as a source of calcium compared to calcium carbonate in a growing rat model as part of a diet that met the nutrient requirements of the rat [29]. The figure also shows residual advantages to bone in rats fed milk as a source of calcium compared to calcium carbonate during growth after switching to a diet deficient in calcium as calcium carbonate. The deficient period was half of the calcium requirements for a rat which is similar to calcium consumption in adult women [11]. The potential value of dietary enhancement of supplements for bone health was recently reviewed [30].

3. Relation to diseases other than osteoporosis

Milk consumption and other dairy products have been positively associated with protection against insulin resistance syndrome (IRS), coronary heart disease, blood pressure, and some cancers. A meta-analysis of cross-sectional studies showed that the odds ratio for prevalence of IRS for those who consume 3–4 servings of dairy vs. 0.9–1.7 daily was 0.71 (95% CI 0.57–0.89) [31]. In the Nurses' Health Study, consuming 3 or more servings of dairy daily compared to less than one serving daily lowered risk of type 2 diabetes by 11% (CI 0.81–0.99) [32]. However, other studies show no relationship between dairy intake and IRS or type 2 diabetes [33,34]. RCTs of dairy on IRS and type 2 diabetes are lacking.

Highest intakes of milk consumption decreased vascular events and ischemic heart disease by 16% (CI 0.78–0.90) in a pooled estimate of relative risk of heart disease from 10 prospective cohort studies [35]. Similarly, milk consumption lowered risk of ischemic stroke, especially in those who had experienced a prior vascular event, in a 20 year prospective study of 2403 men [36]. High fat dairy products have been associated with increased risk of CHD in contrast to skim milk [37]. Similarly, low fat more than high fat dairy products were inversely associated with risk of hypertension in women [38].

Because many chronic diseases are at increased risk with obesity, the potential satiating effects of milk are of interest. Skim milk has greater satiating effect and led to subsequent lower energy intake 4 h after receiving a controlled portion than for a fruit drink, presumably because of its protein content [39]. The influence of dietary protein on

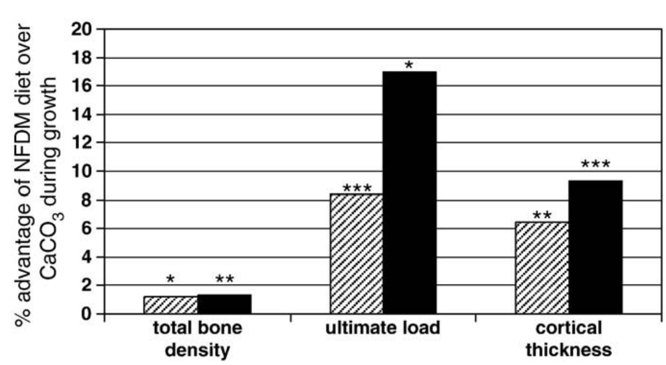

Fig. 1. Percent increase in bone properties for femurs of young rats fed 0.4% Ca as nonfat dry milk (NFDM) diets over rats fed 0.4% Ca a $CaCO_3$ for 10 wk (Slashed bars) and in rats switched to 0.2% Ca as $CaCO_3$ after an additional 10 weeks (Solid bars) ($n = 50$/group). *$p<0.01$, **$p<0.001$, ***$p<0.0001$. Data taken from Weaver et al. [29].