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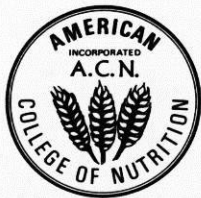


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Original Research

The Role of Dairy in Meeting the Recommendations for Shortfall Nutrients in the American Diet

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Key words: dairy intake, calcium, potassium, magnesium, NHANES, DRI, short fall nutrients

Background: The 2005 Dietary Guidelines Advisory Committee (DGAC) recognized calcium, potassium and magnesium, all found in high levels in dairy foods, among the shortfall nutrients in both children and adults' diets.

Objective: The objectives were to determine: 1) the percentage of the population with intakes greater than the Adequate Intakes (AI) for calcium and potassium and the percentage of the population with inadequate magnesium intake (based on Estimated Average Requirement [EAR]) and 2) the impact of various levels of dairy consumption on intake of calcium, potassium and magnesium.

Design: Secondary analysis of data from the 1999-2004 NHANES.

Subjects/Setting: Participants 2 years of age and older.

Main Outcome Measures: Percentage of the population meeting current recommendations for calcium, potassium and magnesium.

Statistical Analyses Performed: Percentage of EAR/AI for nutrients was calculated based on age/gender specific values. All analyses were weighted using the NHANES six-year sample weights and adjusted for the complex sample design of NHANES with the statistical package SUDAAN.

Results: The most recent NHANES data demonstrated that a significant proportion of the American population did not meet recommendations for calcium, potassium, and magnesium. Less than 3% of the population consumed the recommended level or more of potassium. Only 30% of the US population 2 years of age and older obtained the recommended level of calcium or more and 55% consumed less than the EAR for magnesium. Recommending 3-4 servings from the dairy group for all people greater than 9 years of age may be necessary in order to ensure adequate intake of calcium and magnesium, assuming the current diet remains the same. More than 4 servings of dairy would be needed to meet the potassium recommendation at all ages.

Conclusions: For those individuals who do not consume dairy products, we need to better understand the barriers to consuming specific dairy products. In addition, more research is needed to examine whether food-based recommendations are practical, feasible and cost effective to meet nutrient needs.

Key teaching points

- A significant proportion of the population does not meet recommendations for calcium, potassium and magnesium.
- Individuals that met or exceeded the dairy recommendations are more likely to have a mean calcium intake above the AI for calcium.
- Recommending 3-4 servings from the dairy group for all people greater than 9 years of age may be necessary in order to ensure adequate intake of calcium and magnesium, assuming the current diet remains the same.
- More than 4 servings of dairy may be needed to meet the potassium recommendation at all ages, in addition to an increased fruit and vegetable intake.
- For those individuals who do not consume dairy products, we need to better understand the barriers to consuming specific dairy products.
- More research is needed to examine whether food-based recommendations are practical, feasible and cost effective to meet nutrient needs.

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INTRODUCTION

Intake of dairy products improves overall diet quality [1,2]. Specifically, intakes of calcium, potassium, magnesium, zinc, vitamins A and D, riboflavin, and folate were improved as dairy product intake increased [3–5]. Groups that met or exceeded food recommendations for dairy were more likely to have a mean calcium intake above the Adequate Intake (AI) for calcium [6]. In adolescents, calcium recommendations [7] could not be met in dairy free diets without supplementation [8]. Data from National Health and Nutrition Examination Survey (NHANES) “What We Eat in America” show that a large percentage of Americans, one year and older, are not meeting the nutrient standards for calcium, potassium and magnesium [9], all abundant in dairy products [10]. Approximately 70% are not getting the recommended amounts of calcium, 97% are not meeting the potassium AI, and 56% have a magnesium intake below the Estimated Average Requirement (EAR).

In addition to improving diet quality, consumption of dairy products has traditionally been associated with increased bone mineral density [11], a strong predictor of fractures [12], and reduced risk of osteoporosis [13]. Approximately 10 million Americans have osteoporosis, with costs estimated at \$17.9 billion per year [14] this suggests this disease has major public health implications. More than 90% of the bone mass is achieved by age 20 [15]; however, bone formation requires an adequate and constant supply of nutrients, notably calcium, magnesium, phosphorus, potassium, and fluoride; vitamins D, A, C, and K; and protein [16–18]. Thus, it is important to continue to consume nutrient rich foods throughout the life-cycle to maintain skeletal integrity.

The effect of dairy product consumption on health is not limited to bone health. Some epidemiologic [19–21] and intervention [22,23] studies have suggested that dairy products have favorable effects on body weight and composition; however, other studies did not [24–27]. Dairy components— including milk peptides [28], calcium, potassium, magnesium, and vitamin D have also been associated with reducing the risk of hypertension [29,30]. The impact of dairy foods on hypertension appears to be greater in African Americans (AA) than European Americans (EA) [31]. Other health benefits from consuming dairy products may include reduced risk of type 2 diabetes [32], metabolic syndrome [32,33], stroke mortality [34], and colorectal cancer [35].

In 2004, the Institute of Medicine (IOM) increased the recommendation for potassium to 4.7g per day for all adults [36]. This level of dietary intake should maintain blood pressure levels, blunt the adverse effects of sodium intake on blood pressure, and possibly decrease bone loss. Because of the lack of data from dose response trials demonstrating these possible effects, an EAR could not be established; thus, a Recommended Dietary Allowance could not be derived, and AI levels were determined. Similarly, AI levels were established for

calcium, despite the relatively large number of calcium studies that have been conducted.

Despite the recognized health advantages of consuming dairy products, intake by children [2,37,38] and adults is low [1,2,39–41], and as many as 75% of women fail to meet the recommendations [42] for calcium intake [7,10]. The 2005 Dietary Guidelines Advisory Committee (DGAC) recognized calcium, potassium and magnesium, all found in high levels in dairy foods, among the shortfall nutrients in the diets of both children and adults. To help assuage this problem, the DGAC recommended consumption of two servings of milk and milk products for children 2 to 8 years of age, and three servings for those 8 and older [10]. Additionally, the DGAC concluded that calcium and potassium intakes were compromised if milk products were not included in the diet and that replacement of milk products with other foods would necessitate enormous deviations from current food choices to provide equivalent nutrients provided by milk products [10]. One limitation of most studies done to date is that they have assessed mean intake rather than the percentage of individuals at risk of having inadequate intakes. For nutrients with an EAR/RDA we can now estimate the actual prevalence of inadequate intakes. However, for nutrients with AIs, we still do not have the tools to assess the prevalence of inadequacy.

As the science advances in the area of nutrient intake recommendations, the USDA food patterns should be reassessed in 2010 to ensure that they are evidence-based and can be effectively translated into appropriate nutritional guidance for consumers. The aim of this study was to examine nutrient adequacy in Americans and define the role of dairy in helping individuals meet recommendations for these shortfall nutrients using the most current nationally representative food consumption data. Specifically the goals were to determine: 1) the percentage of the population with intakes greater than the AI for calcium and potassium and the percentage of the population with inadequate magnesium intake (based on EAR) and 2) the impact of various levels of dairy consumption on intakes of calcium, potassium and magnesium.

METHODS

Subjects

This is a secondary analysis of data from the 1999–2004 NHANES participants 2 years of age and older with a reliable 24-hour dietary recall meeting minimum criteria. Detailed descriptions of the dietary interview methods are provided in the NHANES Dietary Interviewer’s Training Manual, which includes pictures of the Computer-Assisted Dietary Interview system screens, measurement guides, and charts used to collect dietary information [43]. Pregnant or lactating females were excluded from the sample. The focus of this paper is limited to intakes of calcium, potassium, and magnesium. Estimates of

nutrient intake were based on food alone, and did not include contributions from supplements. These three nutrients were identified as shortfall nutrients in both children and adults by the 2005 DGAC [44].

Determination of Usual Intake

To determine usual intake requires multiple days of nutrient intake for at least a representative subsample of the individuals in order to estimate within-individual variances. Software for Intake Distribution Estimation (SIDE; Iowa State University; [45] was used with the 2 days of intake provided in NHANES 2003-2004 using two-day sampling weights to obtain needed variances (two days of intake are not available for 1999-2000 and 2001-2002 data releases). SIDE was then re-run using the first day intake of NHANES 2003-2004 with one-day sampling weights and the within-individual variances computed using two days of intake. The Dietary Reference Intake (DRI) age groups were used to present usual mean intake for calcium, potassium, and magnesium [7]. A weighted average approach was used to estimate overall population usual intake and probabilities above/below certain levels similar to that used by Moshfegh, *et al.* [44].

Only intakes greater than the AI were used to determine the prevalence of inadequate intakes in the population for calcium and potassium [46]. We did not estimate the percentages of people with intakes below a standard based on the AI. Groups with mean intakes at or above the AI can generally be assumed to have a low prevalence of inadequate intake for the defined criterion of nutritional status [46]. To assess the extent of inadequate intake of magnesium, the EAR cut-point method proposed by the IOM [46] was used. The EAR is the appropriate DRI to use when assessing the adequacy of group intakes [46]. The EAR cut-point method provides an estimate of the proportion of individuals in the group with inadequate intakes for age and gender [7,46]. With the cut-point method, there are a number of assumptions made regarding the data on intakes and requirements [46]. This method estimates the proportion of the usual intake distribution of magnesium that falls below the EAR [7] for age and gender. The use of EAR for assessing inadequate intake of magnesium is consistent with what has been reported using previous NHANES data on nutrient intakes from food compared to DRIs [9].

Determination of Dairy Servings and Nutrient Intake

Data from NHANES 1999-2000, 2001-2002, and 2003-2004 were combined and pregnant and/or lactating women were excluded; using six years of data allows for a more reliable estimate of intake. Dairy servings were determined using the Pyramid Servings Database [47] for the 1999-2000 data and the MyPyramid Servings Database [48] for the 2002-2002 and 2003-2004 data. Participants were separated into four age groups: 1) children two to eight years; 2) children nine to 18 years; 3) adults 19 to 50 years and 4) adults 51 years or

older. Within each age group, participants were further separated into groups depending on dairy serving intake (including milk, cheese and yogurt): 1) < 1 servings/day; 2) 1-1.5 servings/day; 3) 1.5-2.5 servings/day; 4) 2.5-3.5 servings/day; 5) 3.5-4.5 servings/day; and 6) > 4.5 servings/day. These dairy serving intake groups were selected based on a recent study using NHANES data [49].

Percentage of EAR/AI for nutrients was calculated based on age/gender specific values [46]. All analyses were weighted using the NHANES examination six-year sample weights and adjusted for the complex sample design of NHANES with the statistical package SUDAAN version 8 (RTI, Research Triangle Park, NC).

RESULTS

Sample Demographics

The sample consisted of 25,380 people 2 years of age and older. The sample included 51% females, 32% Hispanic-American, 39% European-American, 25% African-American, and 4% other (data not shown).

Usual Mean Intake for Calcium, Potassium and Magnesium from Food

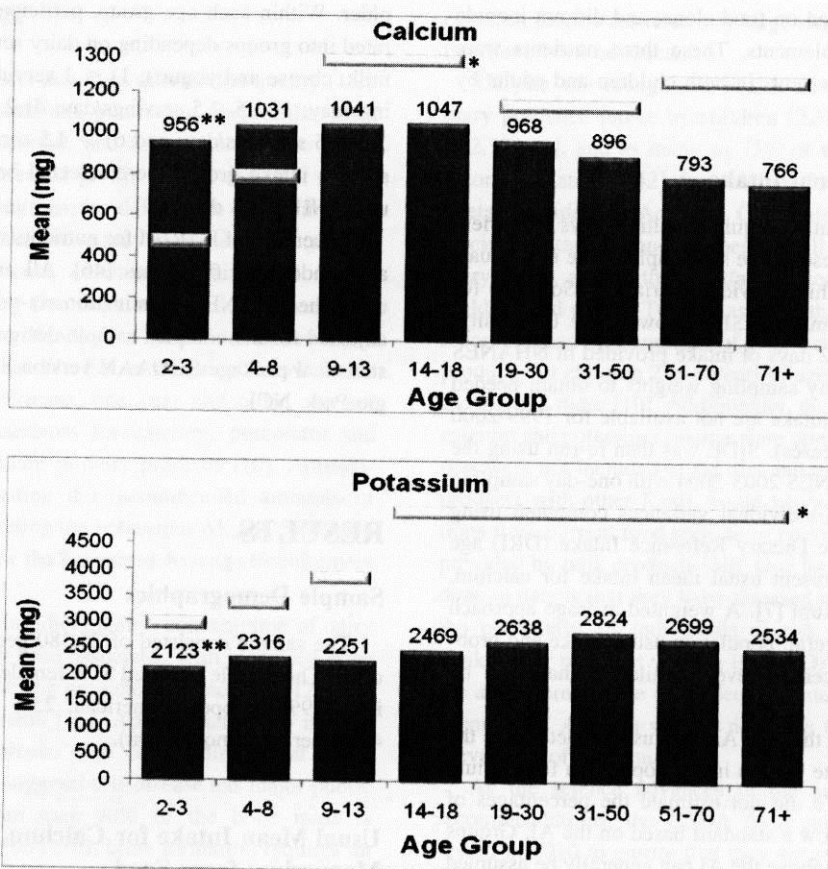
Fig. 1 shows the usual mean intake of calcium and potassium compared to the recommended AI for the various age groups. Children had mean calcium intakes above the recommended AI until 9 years of age. After 9 years of age usual mean calcium intakes declined with mean intakes not meeting the age-specific AI recommendation. Mean usual intake for potassium did not meet the AI recommendations at all ages.

Fig. 2 shows the usual mean intake for magnesium compared to the EAR for the various age groups. By 14 years of age, the usual mean intake of magnesium does not meet the EAR and this continues with the older age groups.

Population above the AI for Calcium and Potassium

Only 32.3% (21.3% for females and 43.7% for males) of the total population had usual intakes of calcium above the AI (Table 1). A large majority of children 2-8 years of age had usual intakes of calcium that were above 100% of the AI. Similarly, a large percentage of individuals 9 years of age and older (ranging from 5.7%-61.2%) had intakes above the AI for calcium.

Only 24% (5.5% females; 4.2% males) of the total population had intakes of potassium above 100% the AI (Table 2). The percentages above 100% AI for potassium did not vary by age or gender (range: 9.0-0.2%).



* The bar indicates the recommended AI for that age group.
 ** Mean intake.

Fig. 1. Usual mean intake for calcium and potassium for individuals 2+ years-old.

Probability of the Population below EAR for Magnesium

Table 3 shows the percent of participants whose magnesium intake from food did not meet the EAR by age and gender. The prevalence of inadequacy for the total population was 56.6% (52.8% for males; 60.3% for females). The prevalence of inadequacy was low for 2-8 year olds. In contrast, the prevalence of inadequacy for magnesium intake was substantial for individuals 14 years of age and older (range: 60.4%-82.5%). More than 90% of females 14-18 years of age had intakes below the EAR for magnesium.

Impact of Dairy Consumption on Intakes

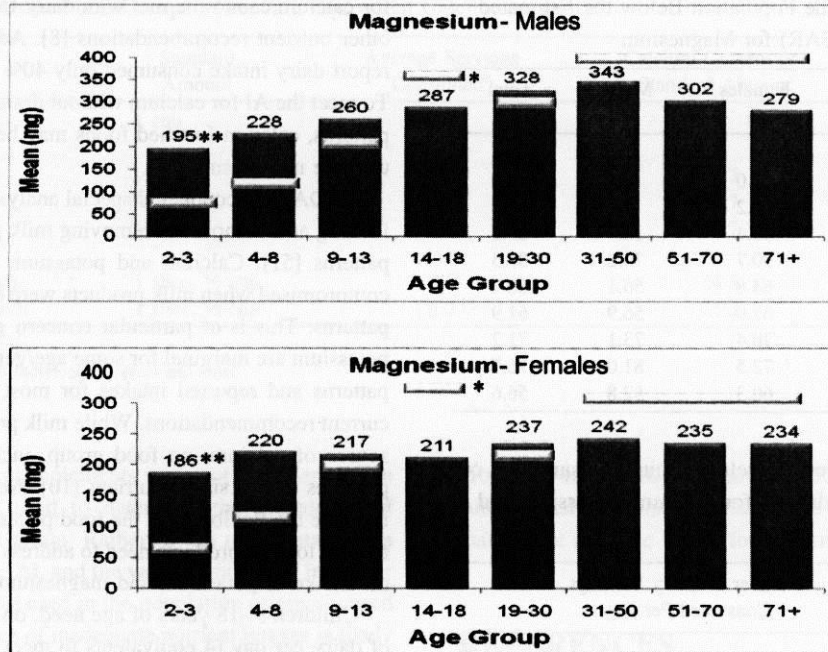
The impact of various levels of dairy consumption on intake of calcium, potassium and magnesium is presented in Table 4. The number of daily dairy servings needed to meet 100% of the AI for calcium varied by age. People 2-8 and 19-50 years of age would need to consume 2.0 servings of dairy to meet 100% AI for calcium. People age 51+ would need 3.0 daily servings of dairy and ages 9-18 would need 4.0 daily servings of dairy

to meet 100% AI for calcium. In all age groups, consuming more than 4.5 daily servings of dairy did not result in meeting 100% of the AI for potassium.

The number of dairy servings that would need to be consumed daily to meet 100% EAR for magnesium varied by age. Children ages 2-8 years consuming < 1 serving of dairy per day, meet 160% of the EAR for magnesium. In contrast, people ages 9-18 and 51+ years would need to consume 3.0 servings of dairy per day and ages 19-50 years would need to consume 2.0 servings per day to meet 100% of the EAR for magnesium.

Substitution of Other Food Groups

The amounts of other food groups that would be needed to provide equivalent calcium as dairy is presented in Table 5. For a person to obtain 300mg calcium (equivalent to 1 cup milk), he or she would need to consume 5.3 servings of dark-green leafy vegetables, 6.2 servings of legumes, 53 servings from the meat and bean group, or 12 servings of whole grains.



* The bar indicates the recommended EAR for that age group.
 ** Mean intake.

Fig. 2. Usual mean intake for magnesium for individuals 2+ years-old.

Table 1. Proportion of the Population Above the Adequate Intake (AI) for Calcium

Nutrient/Age Group (yrs)	Females	Males	Total
Calcium			
2-3	96.2	94.9	95.6
4-8	73.4	81.1	77.2
9-13	17.4	24.1	20.7
14-18	8.4	39.6	24.0
19-30	16.3	61.2	38.8
31-50	19.9	46.0	33.0
51-70	6.9	16.1	11.5
71+	5.7	11.6	8.7
Total	21.3	43.7	32.3

Table 2. Proportion of the Population Above the Adequate Intake (AI) for Potassium

Nutrient/Age Group (yrs)	Females %	Males %	Total %
Potassium			
2-3	5.1	12.8	9.0
4-8	1.3	0.3	0.8
9-13	0.0	0.4	0.2
14-18	0.2	3.8	2.0
19-30	0.2	3.9	2.1
31-50	0.3	6.0	3.1
51-70	0.5	3.8	2.2
71+	0.3	1.4	0.8
Total	5.54	4.22	2.35

DISCUSSION

The most recent NHANES data demonstrated that a significant proportion of the American population is not meeting recommendations for calcium, potassium, and magnesium. Less than 3% of the population consumed the recommended level or more of potassium. Only 30% of the US population 2 years of age and older obtained the recommended level of calcium or more and 55% consumed less than the EAR for magnesium.

Few Americans met either the dietary recommendations for calcium [6] and or dairy intake [37]. Only the youngest age group met the MyPyramid dairy recommendations [37].

The percentage decreased among older children [37], which is consistent with our findings. People that met or exceeded the dairy recommendations (2-3 equivalents/day) are more likely to have a mean calcium intake above the AI for calcium. However, the groups that met or exceeded the dairy recommendations had an average dairy serving intake about one serving higher (3-4 equivalents/day) than the current recommendation.

Increased consumption of dairy products had a positive impact on potassium intake for all age groups. However, given the increased potassium recommendation recently issued by the IOM, mean potassium intakes did not meet the potassium AI for any of the age groups analyzed in this study.

Table 3. Proportion of the Population Below the Estimated Average Requirement (EAR) for Magnesium

Nutrient/Age Group (yrs)	Females %	Males %	Total %
Magnesium			
2-3	0.0	0.0	0.0
4-8	0.2	0.1	0.2
9-13	40.4	18.7	29.5
14-18	90.7	74.2	82.5
19-30	64.8	56.1	60.4
31-50	67.0	56.9	61.9
51-70	70.4	73.1	71.7
71+	72.5	81.0	76.7
Total	60.3	52.8	56.6

Table 4. Impact of Various Levels of Dairy Consumption on Meeting the Recommendations for Calcium, Potassium and Magnesium

Nutrient/ Age Group	Number of Dairy Servings Consumed Per Day					
	< 1	1-1.5	1.5-2.5	2.5-3.5	3.5-4.5	> 4.5
Calcium (% AI)						
2-8	54	81	108	146	183	252
9-18	32	53	71	97	121	180
19-50	47	75	101	134	167	247
51+	38	61	81	107	133	186
Potassium (% AI)						
2-8	43	52	58	70	77	97
9-18	38	43	49	59	65	89
19-50	48	55	62	68	78	97
51+	49	57	62	71	79	98
Magnesium (% EAR)						
2-8	160	187	214	254	280	355
9-18	69	83	96	114	120	158
19-50	79	91	101	112	124	149
51+	75	89	98	109	123	145

Similar findings were found in an earlier study using Continuing Survey of Food Intakes by Individuals (CSFII) (1994-1996) and NHANES (1999-2000) [6]. Increasing the number of dairy servings to 3-4 could more than double the percentage of Americans meeting potassium recommendations [49]. Nearly 20% of Americans (ages 9+) meet the potassium AI when they consume 3-4 servings of dairy foods. Although 20% is not a large portion of the population, dairy foods improve potassium intake. Dairy also contributes to magnesium intakes. This is important given that a large proportion of the population also have inadequate intakes of magnesium [50].

Inadequate intake of calcium is a particularly important nutritional concern among adolescents who do not consume dairy products. A study conducted with a nationally representative sample of adolescents 9 to 18 years showed that the AI

for calcium cannot be met with dairy-free diets while meeting other nutrient recommendations [8]. Adolescents who did not report dairy intake consumed only 40% of the AI for calcium. To meet the AI for calcium without dramatic changes in dietary patterns, calcium fortified foods may be needed if dairy products are not consumed.

USDA staff conducted special analyses for the 2005 DGAC looking at the impact of removing milk products from the food patterns [51]. Calcium and potassium intakes were severely compromised when milk products were excluded from the food patterns. This is of particular concern given that calcium and potassium are marginal for some age/gender groups in the food patterns and reported intakes for most groups are below the current recommendations. While milk products are an excellent source of calcium, no food group, including the milk group provides only a single nutrient [10]. Any recommendations to increase the flexibility in the food patterns by suggesting alternatives to milk products need to address the possible impact on the intake of potassium and magnesium.

Children 9-18 years of age need, on average, 4 equivalents of dairy per day (4 equivalents to meet calcium recommendation and at least 3 equivalents to meet magnesium recommendation). An equivalent of dairy is 300mg of calcium. Adults 19-50 years need at least 2 equivalents of dairy per day (2 equivalents to meet calcium recommendation and at least 2 equivalents to meet the magnesium recommendation). Adults 51+ years of age need 3 equivalents of dairy per day (3 equivalents to meet calcium recommendation and at least 3 equivalents to meet the magnesium recommendation). More than 4 equivalents of dairy would be needed to meet the potassium recommendation at all ages. Thus, consuming 4 equivalents of dairy in addition to increased intakes of fruits and vegetables may be needed to meet the potassium recommendation. These data indicated that recommending 3-4 equivalents from the dairy group for all people greater than 9 years of age may be necessary in order to meet the DRIs and to ensure adequate intakes of calcium and magnesium, assuming the current diet remains the same.

Our data also indicated that dairy products are more widely consumed than non-dairy calcium sources. Emphasis should be placed on recommending higher levels of dairy consumption rather than trying to incorporate foods that consumers apparently do not prefer or consume, at best, infrequently. A problem with this recommendation is that if the dairy recommendation is increased, energy intake may increase, or other foods/beverages in the diet will decrease potentially resulting in the compromise of other nutrients. As the science advances in the area of nutrient intake recommendations, the USDA food patterns need to be assessed in 2010 to ensure that they are current with the existing science and effectively translate nutritional guidance to consumers.

There are several limitations to this study. The data are cross-sectional and based on two 24-hour dietary recalls. One could challenge whether these data reflect usual intake

Table 5. Amounts of Other Food Groups to Provide Equivalent Calcium as Dairy^a

Food Group or Subgroup	Standard Amount	Average Servings Consumed ^b	Calcium Content per Standard Amount	Servings for 300 Mg Ca
Milk Group	1 cup	1.7	302	1
Vegetables				
Dark-green leafy	½ cup	0.2	56.7	5.3
Legumes	½ cup	NA	48.7	6.2
Meat and Beans	1 ounce	5.3	5.7	52.6
Grain Group				
Whole grain foods	1 slice; ½ cup	0.6	24.3	12.3
Refined grain foods	1 slice; ½ cup	6.0	25.2	11.9

^a Adapted from [USDA tables].

^b Source: [FGP tables] for all individuals 2 years and older.

NA = Not applicable.

[9,52,53]. Intakes from supplements were not considered. The use of AI cannot be used to determine the prevalence of inadequate intake in a group. Rather, if the mean intake of a group is at or above the AI, and the variance of intake is similar to the variance of intake used in the population originally used to set the AI, prevalence of inadequate nutrient intakes is likely to be low [46].

The optimal number of dairy servings for the various age groups to ensure the lowest prevalence of inadequate intake of calcium, potassium and magnesium is based on the assumption that nothing else in the diet changes. However, it appears to be more realistic and practical to add an additional serving of dairy products to help Americans come closer to nutrient recommendations, specifically calcium, potassium and magnesium, rather than recommending 6–15 servings of other food sources that Americans consume considerably less than the amounts recommended [10]. For example, for Americans (31–50 years of age) to meet the 2005 Dietary Guidelines they would need to increase fruit and vegetable consumption by 159%, vegetable consumption by 52%, and whole grains by 251% [10].

For those individuals who do not consume dairy products, we need to better understand the barriers to consuming specific dairy products. In addition, more research is needed to examine whether food-based recommendations are practical, feasible and cost effective to meet nutrient needs.

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