

**Role of Dairy Foods in a Healthy Diet:  
A Focus on Food Guide Pyramid Dairy Servings  
Recommendations**

**National Dairy Council**

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## EXECUTIVE SUMMARY:

The Food Guide Pyramid (FGP) is the primary science-based nutrition education tool that translates dietary standards into simple food guidelines that are useful to consumers to meet nutrient needs and to help prevent chronic disease. The FGP, released in 1992, should be reassessed from time to time to ensure that it is current with the existing science and effectively translates nutritional guidance to consumers. The aim of this paper is to examine the implications of the current Dietary Reference Intakes (DRI) for calcium and magnesium on dairy food guidance and to explore potential changes in the number of FGP defined servings of dairy that may be required to meet the DRI for these nutrients. Alternative dietary guidance using marketplace servings of dairy is also examined based on the most current nationwide food consumption data.

Using an approach developed by USDA, **we have shown that at least 3 servings of FGP dairy servings per day are needed for the majority of the population** (those greater than 9 years of age) to meet calcium recommendations. This is especially evident when we factor in *actual* non-dairy calcium intake (this adjusts for the fact that few Americans are consuming the recommended levels of grains, fruits, and vegetables, some of which are significant sources of calcium). **We have also shown that 4 FGP servings of dairy are necessary to ensure adequate intake of magnesium for most Americans.** We conclude from this analysis that **FGP recommendations for dairy products should be 3-4 servings for all individuals greater than 9 years of age.**

In reference to the above USDA approach, however, the DRI panel has made it clear that it is inappropriate to use mean intakes as a basis for nutrient intake assessment. Hence, we have adopted an alternative approach that is consistent with DRI panel recommendations for dietary assessment. We examined current nutrient intake data from the Continuing Survey of Food Intake by Individuals (CSFII) and the National Health And Nutrition Examination Survey 1999-2000 (NH4) to show that **groups which met or exceeded the FGP dairy recommendations (2-3 servings/day) were more likely to have a mean calcium intake above the Adequate Intake (AI) for calcium, which means the likelihood of inadequate calcium intake in these groups is low. However, the groups that met or exceeded the FGP dairy recommendations had an average dairy serving intake about one serving higher than current recommendations (i.e., 3-4 servings/day).** When we estimated the ideal number of dairy servings required to meet the DRI for both calcium and magnesium for various age groups, we concluded the following:

- 1) **Children 2-8 years of age need at least 2 servings of dairy per day;**
- 2) **Children 9-18 years of age need on average 4 servings of dairy per day;**
- 3) **Adults aged 19-50 years of age need at least 3 servings of dairy per day;**
- 4) **Adults older than 51 years of age need 3-4 servings of dairy per day (3 servings to meet calcium recommendations and at least 4 servings to meet the Estimated Average requirement (EAR) for magnesium).**

Serving sizes used in the FGP for dairy foods are, in many cases, different and substantially larger than those encountered by consumers in the marketplace on the Nutrition Facts panel for the same food. Mandatory nutrition labeling of food products, including labeling of serving size, has been in place since 1993. American consumers have become accustomed to reading the Nutrition Facts panel. We've termed the serving sizes used on the Nutrition Facts panel "marketplace" serving sizes. In order to help consumers make healthy food choices and to avoid consumer confusion between FGP serving sizes and marketplace serving sizes, we urge the USDA to consider harmonizing serving sizes such that servings used in the FGP agree with those used on the Nutrition Facts panels of food packages. Changing FGP recommendations to marketplace serving sizes for dairy products **would require the dairy serving recommendation to increase from 2-4 servings per day to at 3-4 servings per day, assuming meeting 100% of the Adequate Intake for calcium is an acceptable standard. Four servings of dairy products are particularly necessary for those 9-18 years of age and those 50+ years of age when we factor in actual non-dairy calcium intake.**

**Milk and other dairy foods are the major source of calcium in the US diet, providing over 70% of the calcium available in the food supply, and also contribute substantial amounts of other essential nutrients to the US diet including, phosphorus (33%), riboflavin (27%), Vitamin B<sub>12</sub> (22%), protein (20%), potassium (19%), zinc (16%), magnesium (17%) and vitamin A (16%).** The Dietary Guidelines have suggested that certain non-dairy sources (e.g., canned fish with bones, fortified orange juice, fortified soy beverage, tofu, and some dark green leafy vegetables [greens]) could be consumed to increase calcium in the diet. We have shown these foods are not commonly consumed (<0.2% of food occasions for canned fish, fortified orange juice, fortified soy beverage, tofu, and greens combined as compared to milk, cheese and yogurt accounting for about 10% of all food occasions). We examined the nutritional impact when these non-dairy calcium sources replaced 1-2 dairy servings in the diet. While in general calcium intake was maintained (except for greens and soy beverage, primarily due to the level of fortification in the marketplace) with replacing dairy products with non-dairy calcium sources, careful consideration of the impact on the intake of other nutrients is warranted when recommending non-dairy sources. When two servings of dairy products were replaced with these non-dairy calcium sources we report significant decreases in calcium, vitamin D, riboflavin, and vitamin B<sub>12</sub>. **Given the nutritional density of dairy products, particularly low-fat dairy products, emphasis should be placed on consumption of more dairy products rather than trying to add other non-dairy calcium sources to the diet.**

## INTRODUCTION

Milk and other dairy foods are the major source of calcium in the US diet, providing over 70% of the calcium available in the food supply [1]. In an analysis of food sources of calcium, milk and milk products provided 83% of the calcium in the diets of young children, 77% of the calcium in adolescent females' diets, and between 65% and 72% of the calcium in adults' diets [2]. Pragmatically, it is difficult to achieve dietary calcium recommendations without consuming dairy products [2-8]. Milk and other dairy foods also contribute substantial amounts of other essential nutrients to the US diet including (**Table 1**): phosphorus (32%), riboflavin (26%), Vitamin B<sub>12</sub> (21%), protein (19%), potassium (18.9), zinc (16%), magnesium (16%) and vitamin A (15%) [2]. Vitamin D fortified milk products provide virtually all of the US dietary intake of vitamin D. Numerous studies have reported that the intake of milk and other dairy products improve the overall nutrient density and quality of the diet in women [8-11], older adults [10], children, and adolescents [2,12]. The importance of calcium in reducing the risk of chronic diseases such as osteoporosis was a key factor in setting higher dietary recommendations for this nutrient by the IOM in 1997 for children, adolescents, adults (19–50 yrs) and older adults ( $\geq 51$  yrs) compared to the 1989 RDA [13]. These higher recommendations coincide with peak calcium accretion rates in bone that occurs in teenage girls and boys and the age-related decline in calcium absorption among older adults [14-17]. Numerous randomized clinical trials in adults and children have demonstrated that dairy products, as the principal source of calcium, had significant positive effects on bone mass development [18-23]. Beyond bone health benefits, low-fat dairy product consumption, by virtue of their calcium content and possibly other nutrients including potassium and magnesium, have also been shown to help reduce the risk of hypertension and other chronic disorders [24-28]. For example, recent studies have reported that calorically restricted diets high in calcium and, in particular, calcium-rich low fat dairy foods are more effective in reducing body weight and body fat than low calcium diets [29-35].

There is little disagreement about the public health benefits of calcium. The major concern in the US is how to best meet calcium needs. Unfortunately, most Americans are not meeting the dietary recommendations for calcium, particularly young and adolescent girls and older adults. Americans' low calcium intake and the gap between recommended dietary intakes and typical intakes are recognized as a major public health problem. The calcium crisis may be attributed, at least in part, to changes in the food consumption patterns of the US population over the past century, in particular the trend toward consuming less milk and more soft drinks [36-42]. After age 8, the intake of soft drinks increases dramatically and by age 18, adolescents drink approximately 19 oz/day whereas milk consumption decreases to less than 1 serving per day [43]. USDA's Healthy Eating Index surveys indicate that Americans two years of age and over consumed an average of 1.5 servings/day of dairy foods instead of the 2 to 3 servings/day currently recommended by the USDA's Food Guide Pyramid (FGP) [44]. The USDA FGP is the primary nutrition education tool that translates dietary standards into simple food guidelines that are useful to consumers to meet nutrient needs and to help prevent chronic disease. The research foundation for the FGP is well documented and is based on current nutrition

**TABLE 1. Percent Nutrient Contribution of Dairy Foods, Excluding Butter, to the U.S. Food Supply, 1999**

Nutrient	1999 %
Energy	9.5
Protein	20.0
Fat	12.3
Saturated Fat	24.3
Cholesterol	16.4
Carbohydrate	4.9
Minerals	
Calcium	72.9
Phosphorus	33.5
Zinc	16.6
Magnesium	16.7
Iron	1.8
Potassium	18.9
Sodium	31.5
Vitamins	
Riboflavin	27.2
Vitamin B <sub>12</sub>	21.6
Vitamin A	16.3
Vitamin B <sub>6</sub>	9.0
Folate	5.9
Thiamin	5.1
Vitamin E	2.7
Ascorbic Acid	2.8
Niacin	1.3

Source: [2]

recommendations, food consumption data by target populations, and the nutrient composition of those foods [45, 46]. As the science advances for nutrient intake recommendations the FGP should be reassessed to ensure that it is current with the existing science and effectively translates nutritional guidance to consumers.

The aims of this paper are:

1. To examine the implications of the current Dietary Reference Intakes (DRI) for calcium and magnesium on dairy food guidance and to explore potential changes in the number of FGP defined servings of dairy that may be required to meet the DRI for these nutrients. Alternative dietary guidance using marketplace servings of dairy is also examined based on the most current nationwide food consumption data.
2. To review the impact of dairy food consumption on chronic disease risk.

## **PART I**

### **REASSESSMENT OF THE DAILY RECOMMENDED SERVINGS OF DAIRY: IMPACT OF NEW DIETARY REFERENCE INTAKES ON FGP RECOMMENDATIONS FOR CALCIUM AND MAGNESIUM**

Recently the Institute of Medicine (IOM), a division of the National Academy of Sciences, has been reevaluating nutrient requirements for macro- and micronutrients, including vitamins and minerals. This process has led to the development of new Dietary Reference Intakes (DRI) for many nutrients for various age/gender groups (47-51). **Table 2** shows the DRI for calcium and magnesium for various groups of the U.S. population.

The USDA has developed a process to reassess the FGP to ensure dietary recommendations still lead to nutrient intakes that meet current DRI for calcium and magnesium. Shaw et al. [52] described a six-step process for any reassessment of FGP:

1. Identify proposed change in dietary standard – determine if there is consensus on the recommendation; if yes then proceed
2. Assess whether survey data indicate if current diets meet the new standards; if no then proceed
3. Assess whether FGP recommendations meet the new standards; if not then proceed
4. Determine if proposed standards can be met with changes in the FGP recommendations; if yes, proceed;
5. Explore modifications to FGP recommendations that lead to meeting the new standards; confirm changes are consistent with FGP goals; if no, proceed
6. If there is no dietary solution to meeting the new standards or any change required to meet the new standard is not consistent with FGP goals, consider other options

**TABLE 2. Dietary Reference Intakes For Calcium And Magnesium**

Ages	Calcium AI <sup>1</sup> mg/day	Magnesium EAR <sup>2</sup> mg/day	Magnesium RDA <sup>3</sup> mg/day
<b>Females</b>			
1-3 years	500	65	80
4-8 years	800	110	130
9-13 years	1300	200	240
14-18 years	1300	300	360
19-30 years	1000	255	310
31-50 years	1000	265	320
51-70 years	1200	265	320
>70 years	1200	265	320
<b>Males</b>			
1-3 years	500	65	80
4-8 years	800	110	130
9-13 years	1300	200	240
14-18 years	1300	340	410
19-30 years	1000	330	400
31-50 years	1000	350	420
51-70 years	1200	350	420
>70 years	1200	350	420

<sup>1</sup>Adequate Intake

<sup>2</sup>Estimated Average Requirement

<sup>3</sup>Recommended Dietary Allowance

This process has considerable strengths, including documentation of decisions during each step. Shaw et al. [52] report how this process led to changes in the number of dairy servings recommended for various population groups to help meet the new DRI for calcium and magnesium [13]. Prior to the new DRI report, the number of dairy servings recommended via the FGP for individuals aged 11-24 years were three servings a day. Two servings of dairy products per day were recommended for individuals of all other ages. With the new DRI raising recommended intakes of calcium for children 9 years and older (to 1300 mg calcium per day) and for adults older than 50 years of age (to 1200 mg calcium per day), Shaw et al. [52] suggested that an additional dairy serving per day for individuals in these age groups would, in general, help most population groups meet the new DRI for calcium.

### **REASSESSMENT OF FGP DAIRY RECOMMENDATIONS – EXTENSION OF SHAW ET AL. ANALYSIS [52]**

We support all the steps reported by Shaw et al. [52], however, we believe it is important to consider an additional step when reassessing the FGP recommendations. The actual intake of the nutrient(s) in question should be considered in the reassessment process to provide a real world assessment of FGP recommendations and to aid in development of modifications to the FGP recommendations. Thus, we have replicated the approach of Shaw and colleagues and extended the analysis to evaluate the impact of including actual non-dairy calcium intake in the reassessment of the number of FGP dairy servings required to meet the DRI for calcium and magnesium. Briefly, first we used data presented in Shaw et al. [52] regarding calcium content of non-dairy foods to estimate the non-dairy calcium intake from recommended FGP dietary patterns (i.e. patterns A, B, and C). We then modeled the impact of adding 2-4 dairy servings to these non-dairy calcium and magnesium intakes and compared the values to the DRI for calcium (Adequate Intake) and magnesium (Recommended Dietary Allowance). Next we estimated actual non-dairy calcium intake from NHANES 1999-2000 (NH4) [53] by determining the number of dairy product servings consumed by linking the Food Guide Pyramid Servings database to NH4. Given that each dairy serving in the FGP provides approximately 302 mg/serving we subtracted this amount of calcium/dairy serving from total calcium intake to estimate actual non-dairy calcium intake. We used the same approach to calculate non-dairy magnesium intake (using 28 mg magnesium/dairy serving). We then added the calcium and magnesium expected from 2-4 dairy servings to the estimated actual non-dairy calcium and magnesium intake and compared the results to the current DRI for these nutrients.

To ascertain the percent of the population consuming FGP patterns (patterns A, B, and C with 1600, 2200 and 2800 calories/day, respectively), we used NH4 data and defined Pattern A (1600 calories/day) as less than 1900 kcals, the mid-point between Pattern A and Pattern B (2200 calories per day). We defined Pattern B as 1901-2500 calories per day and Pattern C (2800 calories per day) as greater than 2500 calories per day. With these data we could provide an estimate of the number of Americans consuming each of the three dietary patterns.

**Table 3** presents the current mean intake of calcium and magnesium by various age/gender groups from NH4. The overall mean calcium intake for all ages ( $863 \pm 12.0$  mg/day) agreed with that recently released as Advanced Data from the Center for Disease Control and Prevention [54]. Only in children 2-8 years of age and in males 19-50 years of age does the mean calcium intake exceed the Adequate Intake (AI) for calcium. In older adults (50+ years of age) and in females 19-50 years of age, the mean magnesium intake was below the Estimated Average Requirement (EAR). We also present the percentage of the population meeting the DRI for calcium and magnesium. These data, from NH4, show the vast majority of the population needs to consume more calcium and magnesium to meet recommended consumption levels. About 85% of girls 9-18 years of age are not meeting the AI for calcium; over 70% of the boys of the same age are also not meeting the AI for calcium. Fewer than thirty percent of females and about 41% of males aged 19-50 years met the AI for calcium. In older adults (51+ years), over 80% of both men and women are not consuming enough calcium to meet the AI. While most children aged 2-8 years met the EAR for magnesium, only 33-47% of children aged 9-18 years of age met the EAR for magnesium. Over 50% of adults 19-50 years of age did not obtain the EAR for magnesium and only one-third of older adults (greater than 51 years) met the EAR for magnesium (thus, two-thirds of older adults are not consuming the minimally recommended amount of magnesium each day). These data are consistent with previous reports concerned about low calcium and magnesium intake in the US. We conclude that continued efforts are necessary to help Americans consume more calcium and magnesium.

In order to show the impact of incorporating *actual* non-dairy calcium and magnesium intake on the additional calcium and magnesium needed from dairy products, in **Table 4a and 4b** we recreate data of Shaw and colleagues [52] for calcium and magnesium, respectively. These authors used a calculated approach to determine non-dairy calcium based on recommended FGP food patterns. As expected, the data in these tables are in very good agreement with data in Shaw and colleagues. There were only minor changes in results and these changes were most likely due to assumptions we used to calculate non-dairy calcium via food composites. We assumed 50% of grain consumption was whole grain, and 1/3 of vegetable consumption was from dark green/deep yellow vegetables, 1/3 of was from starchy vegetables or legumes and that 1/3 was from other vegetables. We also assumed 20% of meat group calcium came from eggs (eggs have a six-fold higher calcium and comparable magnesium content as meat). Our composite calculations for non-dairy calcium and magnesium intake are presented in **Table 5a and 5b**, respectively.

From examination of **Table 4a**, given the assumption of Shaw et al. [52] that when the mean calcium intake met the AI for calcium for a particular age/gender group within a dietary pattern (value in the table was equal or greater than 100%) then calcium needs of that group will probably be met, we conclude that 3 servings of dairy products are required for virtually all of the population to meet the DRI for calcium if they are consuming Pattern A. With Patterns B & C, three dairy servings are necessary for over 40% of the population since 9-18 year olds and 50+ year olds represent 41.8% of the

**TABLE 3. Mean Intake of Calcium and Magnesium and Percentage of Age/Gender Group Meeting DRI -- NHANES 1999-2000**

	Average Intake, mg/day		Percentage Meeting DRI <sup>1</sup> , %	
	Male	Female	Male	Female
<b>CHILDREN 2-8 YEARS</b>				
Calcium <sup>2</sup>	919.7 ± 39.3	797.6 ± 26.5	59.8	54.8
Magnesium	221.3 ± 7.4	194.4 ± 5.4	93.8	91.4
<b>CHILDREN 9-18 YEARS</b>				
Calcium	1032.1 ± 28.2	818.6 ± 25.9	28.5	15.2
Magnesium	269.8 ± 7.2	214.0 ± 5.0	46.8	32.8
<b>ADULTS 19-50 YEARS</b>				
Calcium	1027.5 ± 28.2	779.0 ± 25.2	41.4	27.1
Magnesium	341.2 ± 5.2	249.0 ± 7.2	42.0	37.5
<b>ADULTS 51+ YEARS</b>				
Calcium	832.3 ± 25.0	689.7 ± 23.4	19.7	11.3
Magnesium	326.9 ± 7.1	239.9 ± 5.4	35.8	34.8

<sup>1</sup>Adequate Intake for calcium and Estimated Average Requirement for magnesium

<sup>2</sup>Mean +/- standard error

**TABLE 4a. Calcium Provided by Food Guide Pyramid Patterns with Food Guide Pyramid Based Dairy Servings<sup>1</sup>**

Percentage of DRI

Ages	Calcium DRI, mg/d	Mean Calories/d <sup>2</sup>	Percent Pattern A <sup>3</sup>	Child 2-6 years (2 dairy)	Pattern A			Pattern B			Pattern C		
					(2 dairy)	(3 dairy)	(4 dairy)	(2 dairy)	(3 dairy)	(4 dairy)	(2 dairy)	(3 dairy)	(4 dairy)
1-3 years	500	1548	77.0	150									
4-8 years	800	1845	59.7	131	111	149	187	130	168	206	143	181	219
9-13 years	1300	2107	47.8		<b>69</b>	<b>92</b>	115	<b>80</b>	103	127	<b>88</b>	111	135
<b>Females</b>													
14-18 years	1300	1958	50.8		<b>69</b>	<b>92</b>	115	<b>80</b>	103	127	<b>88</b>	111	135
19-30 years	1000	2040	51.2		<b>89</b>	119	150	104	134	164	115	145	175
31-50 years	1000	1939	54.5		<b>89</b>	119	150	104	134	164	115	145	175
51-70 years	1200	1697	68.5		<b>74</b>	<b>99</b>	125	<b>87</b>	112	137	<b>95</b>	121	146
>70 years	1200	1440	80.6		<b>74</b>	<b>99</b>	125	<b>87</b>	112	137	<b>95</b>	121	146
<b>Males</b>													
14-18 years	1300	2806	24.6					<b>80</b>	103	127	<b>88</b>	111	135
19-30 years	1000	2867	22.8					104	134	164	115	145	175
31-50 years	1000	2713	22.9					104	134	164	115	145	175
51-70 years	1200	2354	33.0		<b>74</b>	<b>99</b>	125	<b>87</b>	112	137	<b>95</b>	121	146
>70 years	1200	1930	50.3		<b>74</b>	<b>99</b>	125	<b>87</b>	112	137	<b>95</b>	121	121

<sup>1</sup> Non-dairy calcium intake calculated from food patterns and calcium composites from Shaw, et al., 2000 -- Pattern A: 287 mg/d; Pattern B : 437 mg/day and Pattern C: 541mg/d. Food Guide Pyramid dairy serving was 302 mg.

<sup>2</sup>Calories from NHANES IV.

<sup>3</sup>Pattern A defined as less than 1900 kcal/day in NHANES IV; the midpoint between Pattern A and B.

**TABLE 4b. Magnesium Provided by Food Guide Pyramid Patterns with Food Guide Pyramid Based Dairy Servings<sup>1</sup>**

Ages	Magnesium DRI, mg/d	Mean Calories/d <sup>2</sup>	Percent Pattern A <sup>3</sup>	Percentage of DRI									
				Child 2-6 years	Pattern A			Pattern B			Pattern C		
				(2 dairy)	(2 dairy)	(3 dairy)	(4 dairy)	(2 dairy)	(3 dairy)	(4 dairy)	(2 dairy)	(3 dairy)	(4 dairy)
1-3 years	80	1548	77.0	182									
4-8 years	130	1845	59.7	191	200	221	243	258	280	301	305	327	348
9-13 years	240	2107	47.8		108	120	131	140	152	163	165	177	189
Females													
14-18 years	360	1958	50.8		72	80	88	93	101	109	110	118	126
19-30 years	310	2040	51.2		84	93	102	108	117	126	128	137	146
31-50 years	320	1939	54.5		81	90	99	105	114	122	124	133	141
51-70 years	320	1697	68.5		81	90	99	105	114	122	124	133	141
>70 years	320	1440	80.6		81	90	99	105	114	122	124	133	141
Males													
			Percent Pattern A & B <sup>3</sup>										
14-18 years	410	2806	45.3					82	89	96	97	104	110
19-30 years	400	2867	43.7					84	91	98	99	106	113
31-50 years	420	2713	46.3					80	87	93	94	101	108
51-70 years	420	2354	59.9		62	68	75	80	87	93	94	101	108
>70 years	420	1930	80.9		62	68	75	80	87	93	94	101	108

<sup>1</sup> Non-dairy magnesium intake calculated from food patterns and calcium composites from Shaw, et al., 2000 -- Pattern A: 203 mg magnesium per day; Pattern B: 280 mg magnesium per day and Pattern C: 341mg magnesium per day. Food Guide Pyramid dairy serving contains 28 mg of magnesium.

<sup>2</sup>Calories from NHANES IV.

<sup>3</sup>Pattern A defined as less than 1900 kcal/day in NHANES IV; the midpoint between Pattern A and B. Pattern B defined as greater than 1900 kcal/day and less than or equal to 2500 kcal/day.

**TABLE 5a. Non-dairy Calcium Consumption<sup>1</sup>**

Food Group Composite	Pattern A		Pattern B		Pattern C		Pattern for Children 2-6 Years of Age	
	Servings per day	Calcium mg	Servings per day	Calcium mg	Servings per day	Calcium mg	Servings per day	Calcium mg
Grains <sup>2</sup>	6	147	9	221	11	270	2	49
Vegetables <sup>3</sup>	3	73.35	4	97.8	5	122.25	1	24.45
Fruit	2	26	3	69	4	92	0.66	15
Meat <sup>4</sup>	5 oz	41	6 oz	49.2	7 oz	57.4	1.7 oz	57.4
<b>Total</b>		<b>287</b>		<b>437</b>		<b>541</b>		<b>146</b>

<sup>1</sup>Composites and servings from Shaw, et al. 2000; Non-dairy calcium for children 2-6 years would be 1300 kcal and all serving sizes reduced by 1/3

<sup>2</sup>Assumes 50% of grains whole grain and 50% enriched grain products

<sup>3</sup>Assumes 1/3 vegetables are deep green or yellow, 1/3 are starchy or legumes and 1/3 are others

<sup>4</sup>Assumes 20% of meat group comes from eggs

**TABLE 5b. Non-dairy Magnesium Consumption<sup>1</sup>**

Food Group Composite	Pattern A		Pattern B		Pattern C		Pattern for Children 2-6 Years of Age	
	Servings per day	Magnesium mg	Servings per day	Magnesium mg	Servings per day	Magnesium Mg	Servings per day	Magnesium mg
Grains <sup>2</sup>	6	90	9	135	11	165	2	30
Vegetables <sup>3</sup>	3	54.45	4	72.6	5	90.75	1	18.15
Fruit	2	26	3	39	4	52	0.66	8.58
Meat <sup>4</sup>	5 oz	33	6 oz	33	7 oz	33	1.7 oz	33
<b>Total</b>		<b>203</b>		<b>280</b>		<b>341</b>		<b>90</b>

<sup>1</sup>Composites and servings from Shaw, et al. 2000; Non-dairy calcium for children 2-6 years would be 1300 kcal and all serving sizes reduced by 1/3

<sup>2</sup>Assumes 50% of grains whole grain and 50% enriched grain products

<sup>3</sup>Assumes 1/3 vegetables are deep green or yellow, 1/3 are starchy or legumes and 1/3 are others

<sup>4</sup>Assumes 20% of meat group comes from eggs

population [55]. Over 50% of the female population 14-50 years of age consumed a diet similar to Pattern A, and over 20% of males of this age consumed a diet similar to Pattern A. When we factor in the percentage of the population consuming dietary Pattern A, we conclude over 55% of the population [i.e.  $41.8 + [7.42 (.246)] + [15.3 (.229)] + 7.67 (.512) + 15.2 (.545) = 56.6$  – population data from U.S. Census (2000)] [55] needs 3 servings of dairy products per day using the methods of Shaw et al. [52]. Thus, for a very large percentage of the US population at least three servings of dairy products are required to meet the AI for calcium.

key

From **Table 4b**, we conclude that at least 4 servings of dairy would be required for a large percentage of the population (~45%) to approach meeting the RDA for magnesium. However, for some older adults even four dairy servings per day may not be enough to meet the RDA for magnesium. These conclusions were similar to those reached by Shaw and colleagues [52]. It is important to recall there are two major assumptions with these conclusions: 1) meeting the AI for calcium and the RDA for magnesium will provide adequate levels of these nutrients (although, as we'll discuss later, this may not always be correct); and 2) these data assume that Americans would consume the recommended number of servings of grains, fruits, and vegetables. However, data from USDA [56] show that Americans do not consume the recommended number of grains, fruits, and vegetables and as such non-dairy calcium may be even lower than that concluded from the calculations of Shaw et al. [52] and those described above.

To assess the impact of non-dairy calcium intake, we estimated *actual* non-dairy calcium intake from NH4 by subtracting dairy calcium from total calcium intake (calculated using USDA Food Guide Pyramid servings database and assuming 302 mg calcium per serving of dairy). Non-dairy calcium intake (**Table 6a**) ranged from 192-313 mg/day in females and from 217-424 mg/day in males and typically represented less than 40% of the AI for the respective age/gender group. Shaw et al. [52] assumed non-dairy intake was 270 mg/day in Pattern A, 390 mg/day in Pattern B and 486 mg/day in Pattern C. It is hard to make a direct comparison of the non-dairy calcium intake from Shaw et al. [52] to our calculations, but it appears non-dairy calcium intake from NH4 was 50-100 mg/day lower than the values used by Shaw et al. Non-dairy magnesium intake (**Table 6b**) ranged from 126-214 mg/day in females and from 151-298 mg/day in males, which typically represented about 70% of the RDA for magnesium (for young children non-dairy magnesium exceeded the RDA). In general, these data stress the key role of dairy products in providing calcium and magnesium to the US population; without appropriate levels of dairy products in the diet it is virtually impossible to meet the DRI for calcium and magnesium.

When we add 2-4 FGP servings of dairy products to the *actual* non-dairy calcium intake (**Table 6a**) and use the same assumptions of Shaw et al. [52], we show that all individuals greater than 9 years of age need at least 3 FGP servings of dairy products to meet the AI for calcium, whereas 9-18 year old females and 9-13 year old males need 4 servings of dairy products to meet at least 100% of the AI for calcium. When we add 2-4 FGP servings of dairy products to the non-dairy magnesium intake (**Table 6b**), we show that 4 servings of dairy products help most groups approach the DRI for magnesium. Certain

groups (e.g., children 14-18 years of age, adults over the age of 70, and possibly adults 19-30 years of age) require even more than 4 servings of FGP dairy products to meet the RDA for magnesium.

### **Summary**

**We have shown that at least 3 servings of FGP dairy servings are needed for the majority of the population (those greater than 9 years of age) to meet calcium recommended intakes and 4 servings are needed by adolescent girls and boys. This is especially evident when we factor in *actual* non-dairy calcium intake. This adjusts for the fact that few Americans are consuming the recommended levels of grains, fruits, and vegetables, some of which are significant sources of calcium. We have also shown that 4 FGP servings of dairy are necessary to ensure adequate intake of magnesium for most Americans. We conclude that FGP recommendations for dairy products should be 3-4 servings for all individuals greater than 9 years of age.**

**TABLE 6a. Calcium Provided by Non-dairy plus Food Guide Pyramid Based Dairy Servings<sup>1</sup>**

Ages	Calcium DRI mg/day	Non-Dairy Calcium, mg/day <sup>2</sup>	Percentage of DRI		
			(2 dairy)	(3 dairy)	(4 dairy)
<b>Females</b>					
1-3 years	500	191.6	159	220	280
4-8 years	800	226.3	104	142	179
9-13 years	1300	273.5	68	91	114
14-18 years	1300	273.9	68	91	114
19-30 years	1000	296.2	90	120	150
31-50 years	1000	312.5	92	122	152
51-70 years	1200	283.5	74	99	124
>70 years	1200	238.7	70	95	121
<b>Males</b>					
1-3 years	500	216.7	164	225	285
4-8 years	800	286.1	111	149	187
9-13 years	1300	283.6	68	92	115
14-18 years	1300	381.9	76	99	122
19-30 years	1000	404.7	101	131	161
31-50 years	1000	423.5	103	133	163
51-70 years	1200	377.2	82	107	132
>70 years	1200	312.3	76	102	127

<sup>1</sup>Food Guide Pyramid dairy serving defined as 302 mg/serving.

<sup>2</sup>Non-dairy calcium intake calculated from NHANES IV.

**TABLE 6b. Magnesium Provided by Non-dairy plus Food Guide Pyramid Based Dairy Servings<sup>1</sup>**

Ages	Magnesium DRI mg/day	Non-Dairy Magnesium, mg/day <sup>2</sup>	NEW Percentage of DRI		
			(2 dairy)	(3 dairy)	(4 dairy)
<b>Females</b>					
1-3 years	80	126.4	228	263	298
4-8 years	130	143.7	154	175	197
9-13 years	240	162.1	<b>91</b>	103	114
14-18 years	360	165	<b>61</b>	<b>69</b>	<b>77</b>
19-30 years	310	189.2	<b>79</b>	<b>88</b>	<b>97</b>
31-50 years	320	214.2	<b>84</b>	<b>93</b>	102
51-70 years	320	208.4	<b>83</b>	<b>91</b>	100
>70 years	320	184.1	<b>75</b>	<b>84</b>	<b>93</b>
<b>Males</b>					
1-3 years	80	151	259	294	329
4-8 years	130	161.2	167	189	210
9-13 years	240	182	<b>99</b>	111	123
14-18 years	410	228.2	<b>69</b>	<b>76</b>	<b>83</b>
19-30 years	400	261.6	<b>79</b>	<b>86</b>	<b>93</b>
31-50 years	420	298	<b>84</b>	<b>91</b>	<b>98</b>
51-70 years	420	291	<b>83</b>	<b>89</b>	<b>96</b>
>70 years	420	257.6	<b>75</b>	<b>81</b>	<b>88</b>

<sup>1</sup>Food Guide Pyramid dairy serving defined as 28 mg magnesium per serving (Shaw et al., 2000).

<sup>2</sup>Non-dairy magnesium intake calculated from NHANES IV.

## ASSESSMENT OF CURRENT FGP DAIRY INTAKE RECOMMENDATIONS ON MEETING CALCIUM AND MAGNESIUM DRIs

In this section, we first examine the impact of the recently released Dietary Reference Intakes (DRI) on assessing calcium and magnesium intake from recent dietary surveys. Then, using dietary intake data from the Continuing Survey of Food Intake by Individuals, 1994-96, 1998 (CSFII) [57] and National Health and Examination Survey, 1999-2000 (NH4) [53] we apply dietary assessment methodologies suggested by the Dietary Reference Intakes (DRI) panel to: 1) assess the impact of consuming the FGP dairy recommendation on calcium and magnesium intake, and 2) estimate the ideal number of dairy servings to meet calcium and magnesium recommendations.

The recently released Dietary Reference Intakes (DRI's) were developed via a new approach to dietary recommendations [47]. Four types of DRI were established, namely:

“The **Adequate Intake (AI)** is a recommended average daily nutrient intake level, based on experimentally derived intake levels or approximations of observed mean nutrient intake by a group of apparently healthy people that are assumed to be adequate.”

The **Estimated Average Requirement (EAR)** is “the intake that meets the estimated nutrient need of 50% of the individuals in that group” (median of nutrient requirement).

The **Recommended Dietary Allowance (RDA)** is “the intake that meets the nutrient need of almost all (97 to 98 percent) individuals in that group.”

The **Upper Tolerable Level (UL)** “is the highest level of continuing daily nutrient intake that is likely to pose no risk of adverse health effects in almost all individuals in a specific life stage group.”

With the release of the new DRI's, there has been considerable effort by the Institute of Medicine (IOM) to ensure that the health and nutrition community uses the new DRI's appropriately [47]. For example, in recent DRI reports there has been considerable discussion regarding the use of comparing mean nutrient intakes to the RDA:

“Some of the most common mistakes in evaluating dietary survey data arise from inappropriate conclusions drawn from comparing mean nutrient intakes with Recommended Dietary Allowances (RDAs). When mean nutrient intake exceeds the RDA, researchers often conclude (inappropriately) that diets meet or even exceed recommended nutritional standards.”

“Some of the most common mistakes in evaluating dietary data arise from comparisons of mean intakes with RDAs. In particular, when studies find group mean intakes equal to or exceeding the RDA, the conclusion has often been that

group diets are adequate and conform to recognized nutritional standards. Sometimes, group-mean intake is even compared with some percentage of the RDA. However, these comparisons are inappropriate and may result in very misleading conclusions.”

“Even if mean usual nutrient intake equals or exceeds the RDA, a significant proportion of the population may have inadequate nutrient intake.”

Since variability in nutrient intakes usually exceeds variability in nutrient requirements, and the RDA is defined as the EAR plus two standard deviations of nutrient requirement, the group means nutrient intake must exceed the RDA to ensure low prevalence of inadequate intake. Thus, if group mean nutrient intake *equals* the RDA then a substantial proportion of the group will have nutrient intakes less than their own nutrient requirements.

Hence, the DRI panel does not recommend use of the AI or the RDA to assess inadequate intakes of groups. The DRI panel recommends the use of the EAR to assess prevalence of inadequate intake within a group. Because of the way the AI was developed, the AI cannot be used to quantify the prevalence of inadequate intake in groups:

“Since the Adequate Intake (AI) is set in different ways for different nutrients and its relationship to the requirement for the nutrient is unknown, it cannot be used to estimate the proportion of the population with inadequate intake.”

However, while the AI cannot be used to determine the prevalence of inadequate intake in a group, the DRI panel stated:

“Groups with mean intakes at or above the AI can generally be assumed to have a low prevalence of inadequate intakes (low group risk) for the defined criterion of nutritional status.”

“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 (although it cannot be estimated). This evaluation can be used with confidence when the AI is based directly on intakes of healthy populations ...” [47]

Using the DRI guidelines for assessing dietary intake briefly described above, in the next section we report the intake of calcium and magnesium for various age groups from two large dietary surveys -- CSFII 1994-96, 1998 [57] and NHANES 1999-2000 [53]. We also report calcium and magnesium intake within the specific age groups of interest by whether individuals met/exceeded the FGP recommendations for dairy consumption or not and based on the number of dairy servings consumed. Dairy servings were defined using the USDA FGP servings database. We used the two-day average intake data from

CSFII in an attempt to better estimate usual intake. We used intake data from the single 24-hour recall in NHANES 1999-2000 [53]; these data were not adjusted to estimate usual intakes, as no replicate intake data were available. All data were developed using appropriate sample weights for each study.

We also report the percentage of the population meeting the AI for calcium and meeting the EAR for magnesium. We used the EAR cut-point method [47] to evaluate the prevalence of inadequate intake of magnesium since the DRI panel has indicated that magnesium requirements and magnesium intake meet the assumptions required for the EAR cut-point method to be valid. However, since we cannot use the percentage of the population meeting the AI for calcium to quantify adequacy of calcium intake, we are using the mean intake of calcium to determine if the prevalence of inadequate intake of calcium is likely to be low; according to the DRI panel, when mean calcium intake is greater than the AI then the likelihood of inadequate intake is low (see discussion above). For example, if the mean intake of a group of individuals aged 9-18 years (AI of calcium for males and females of this age is 1300 mg/day) is greater than 1300 mg/day then the likelihood of this group having an inadequate intake of calcium is low. With this approach, we can examine the number of dairy servings per day necessary, for various age groups, to ensure the likelihood of inadequate calcium intake is low (mean intake of calcium in the group exceeds the AI of calcium for the group).

#### **ASSESSMENT OF CALCIUM AND MAGNESIUM INTAKE WHEN MEETING OR EXCEEDING FGP RECOMMENDATIONS**

We assessed the calcium and magnesium intake of various age groups using both the Continuing Survey of Food Intake by Individuals (CSFII, 1994-96, 1998) [57] and NHANES, 1999-2000 [53]. We separated groups by age based on major differences in the DRI for calcium namely 2-8 years, 9-18 years, 19-50 years and 51+ years. We did not separate the data by gender, as the DRI for calcium are the same for each gender. While the DRI for magnesium does change with age/gender the actual changes are relatively small.

**Table 7a and 7b** present data on mean calcium intake and the percentage of the groups that met the AI for calcium for various age categories based on whether individuals within a particular age category met/exceeded the current FGP recommendation for dairy servings consumption, from CSFII and NH4, respectively. In CSFII (**Table 7a**), 44.5 % of children 2-8 years met/exceeded the FGP recommendations to consume 2 or more dairy servings per day. The average number of dairy servings for the group meeting/exceeding the FGP dairy recommendation was 2.95 dairy servings per day. With this level of dairy consumption, the mean intake of calcium in the 2-8 year olds that met/exceeded the FGP dairy recommendations was 1145 mg/day. Since the mean calcium intake of this group exceeds the AI for calcium for this age group (estimated as 714 mg/day, i.e.: individuals 2-3 years of age have an AI of 500 mg calcium/day while individuals aged 4-8 have an AI of 800 mg calcium/day. Since seven years are represented in the 2-8 year group, we combined 2/7 of the 500 mg/day AI with 5/7 of the

**TABLE 7a. Impact of Meeting or Exceeding Food Guide Pyramid Dairy Recommendations on Calcium Intake – CSFII 1994-96, 1998**

	Total for Age Group	FGP Dairy Recommendations <sup>1</sup>		Percentage Meeting FGP Dairy Recommendation
		Met/exceeded	Not Met	
<b>CHILDREN 2-8 YEARS</b>				
Calcium, mg/day <sup>2</sup>	849.9 (6.4)	1144.8 (7.8)	607.3 (4.3)	
Calcium, % meeting AI	60.8	97.4	30.8	
Number of subjects	6574	2928	3646	44.5
Dairy consumption, servings/day <sup>2</sup>	2.00 (0.02)	2.95 (0.02)	1.22 (0.01)	
<b>CHILDREN 9-18 YEARS</b>				
Calcium, mg/day	934.7 (13.5)	1665.1 (28.0)	748.1 (8.5)	
Calcium, % meeting AI	18.4	79.1	2.9	
Number of subjects	2031	389	1642	19.2
Dairy consumption, servings/day	2.01 (0.04)	4.19 (0.08)	1.45 (0.02)	
<b>ADULTS 19-50 YEARS</b>				
Calcium, mg/day	787.3 (12.9)	1420.2 (38.4)	596.4 (5.0)	
Calcium, % meeting AI	23.8	83.1	6.0	
Number of subjects	4913	1124	3789	22.9
Dairy consumption, servings/day	1.41 (0.03)	3.20 (0.06)	0.87 (0.01)	
<b>ADULTS 51+ YEARS</b>				
Calcium, mg/day	674.0 (6.0)	1566.9 (26.1)	627.9 (5.1)	
Calcium, % meeting AI	8.0	90.9	3.7	
Number of subjects	4442	235	4207	5.3
Dairy consumption, servings/day	1.16 (0.01)	3.87 (0.07)	1.02 (0.01)	

<sup>1</sup> Food Guide Pyramid recommends 2 servings of dairy products per day for those 8 years and younger, 3 servings/day for those 9-18 years, 2 servings/day for those 19-50 years and 3 servings/day for those greater than 50 years

<sup>2</sup>Mean (SEM)

**TABLE 7b. Impact of Meeting or Exceeding Food Guide Pyramid Dairy Recommendations on Calcium Intake – NHANES 1999-2000**

	Total for Age Group	FGP Dairy Recommendations <sup>1</sup>		Percentage Meeting FGP Dairy Recommendation
		Met/Exceeded	Not Met	
<b>CHILDREN 2-8 YEARS</b>				
Calcium, mg/day <sup>2</sup>	862.01 (19.3)	1233.8 (25.8)	563.8 (11.8)	
Calcium, % meeting AI	57.3	97.3	25.5	
Number of subjects	1143	501	642	43.8
Dairy consumption, servings/day <sup>2</sup>	2.04 (0.06)	3.28 (0.08)	1.04 (0.04)	
<b>CHILDREN 9-18 YEARS</b>				
Calcium, mg/day	924.8 (19.9)	1748.2 (42.8)	678.6 (12.5)	
Calcium, % meeting AI	21.9	80.1	4.4	
Number of subjects	2448	476	1972	19.4
Dairy consumption, servings/day	2.06 (0.06)	4.60 (0.12)	1.30 (0.03)	
<b>ADULTS 19-50 YEARS</b>				
Calcium, mg/day	899.9 (18.5)	1546.0 (36.9)	572.4 (9.2)	
Calcium, % meeting AI	34.1	86.5	7.5	
Number of subjects	2466	763	1703	30.9
Dairy consumption, servings/day	1.79 (0.05)	3.73 (0.08)	0.80 (0.02)	
<b>ADULTS 51+ YEARS</b>				
Calcium, mg/day	755.9 (14.6)	1625.1 (51.0)	633.8 (10.0)	
Calcium, % meeting AI	15.2	87.5	5.1	
Number of subjects	2016	207	1809	10.3
Dairy consumption, servings/day	1.47 (0.04)	4.43 (0.15)	1.05 (0.03)	

<sup>1</sup> Food Guide Pyramid recommends 2 servings of dairy products per day for those 8 years and younger, 3 servings/day for those 9-18 years, 2 servings/day for those 19-50 years and 3 servings/day for those greater than 50 years

<sup>2</sup>Mean (SEM)

800mg/day to obtain 714 mg/day as an average AI for the entire group. Hence,  $0.285 \times 500 \text{ mg/day} + 0.714 \times 800 \text{ mg/day} = 714 \text{ mg/day}$ ). We conclude that when children this age consume approximately three servings of dairy products per day there is a low likelihood that this group has inadequate calcium intake. In contrast, the 2-8 year olds not meeting the FGP dairy recommendations only consumed an average of 1.22 dairy servings per day and mean calcium intake of this group was only 607 mg/day.

In children 9-18 years of age, the group with the highest AI for calcium (1300 mg/day), the mean calcium intake of this age group was 935 mg/day, a value that is less than the AI for this group, so we cannot conclude the likelihood of inadequate calcium intake in this group is low. Individuals in this age group that met/exceeded the FGP dairy recommendation (19.2% of this age group) consumed, on average, 4.19 dairy servings per day and 1665 mg calcium per day. Hence, since this amount exceeds the AI for calcium for this age group we can conclude that when children 9-18 years of age consume approximately four servings of dairy per day there is a low likelihood of inadequate calcium intake. The 9-18 year olds not meeting the FGP dairy recommendations only consumed an average of 1.45 dairy servings per day and mean calcium intake of this group was 748 mg/day, less than half of calcium intake of peers that met the recommended number of dairy servings per day.

In adults aged 19-50 years, mean calcium intake was 787 mg/day. Adults in this group that met/exceeded the FGP dairy recommendation (22.9%) consumed an average of 3.20 dairy servings per day and had a mean calcium intake of 1420 mg/day. Adults that did not meet the FGP dairy recommendation consumed an average of 0.87 dairy servings per day and less than 600 mg calcium/day. Since the mean calcium intake of those adults that met/exceeded the recommended number of dairy servings exceeded the AI for calcium for this age group (1000 mg calcium per day), we conclude that when adults aged 19-50 years of age consume an average of 3.20 servings of dairy products per day the resulting calcium intake exceeds the AI for this group and thus the prevalence of inadequate intake in these adults is likely to be low. This conclusion cannot be made for adults who did not consume the recommended number of dairy servings (over 75% of this age group).

In older adults (51+ years), the mean calcium intake was 674 mg/day, significantly lower than the recommended 1200 mg for this age group. Thus, we cannot conclude that the likelihood of inadequate calcium intake in this group is low. When the FGP recommended number dairy servings were met/exceeded by individuals in this group (only 5.3%), the mean calcium intake was 1567 mg/day and the average dairy consumption was 3.87 servings per day (almost a serving higher than current FGP dairy recommendation). Hence, only in the group meeting/exceeding the FGP dairy recommendation, whose average consumption was almost four servings of dairy servings per day, can we conclude that the prevalence of inadequate intake of calcium is likely to be low.

The data from NHANES 1999-2000 (**Table 7b**) leads to similar conclusions as that from data in CSFII (even though these data are not adjusted for usual intake as suggested by the DRI panel). For example, the mean calcium intake in all groups greater than 9 years

of age was lower than the AI. In all groups greater than 9 years of age, only in those groups that met/exceeded the FGP dairy recommendation can we conclude that the likelihood of inadequate calcium intake is low (mean calcium intake exceeded the respective AI for calcium). For instance, children 9-18 years of age that met/exceeded the FGP dairy recommendation consumed an average of 4.60 dairy servings per day and had a mean calcium intake of 1748 mg/day. Additionally, in adults greater than 50 years of age, those that met/exceeded the FGP dairy recommendations consumed on average 4.43 servings of dairy per day and 1625 mg calcium per day. We can say, with some confidence, that in individuals greater than 9 years of age who met/exceeded the FGP dairy recommendations consumed, on average, more than 3 servings of dairy products per day and that mean calcium intake exceeded the respective AI. Hence, the likelihood of the prevalence of inadequate calcium intake in these groups is low. Again, we can only make this conclusion for the groups that consumed the recommended level of dairy servings per day.

Data regarding mean intake of magnesium and the percentage of the population that meet the EAR for magnesium are provided in **Tables 8a and 8b** from CSFII and NH4, respectively. From CSFII, the percentage of the population meeting the EAR for magnesium was very high (>97%) for young children (2-8 years of age) but very low (29-44%) for all other age groups (**Table 8a**). Given that the EAR estimates the median nutrient requirement of the population, there is a significant percentage of the population that may have inadequate magnesium intake. In individuals who meet/exceed the FGP recommendations for consumption of dairy servings, the percentage of the population meeting the EAR for magnesium was dramatically higher. Virtually all young children that consumed the recommended 2 servings of dairy products per day met the EAR for magnesium (average dairy consumption was about three servings per day and mean magnesium intake was 245 mg/day). For the other age categories, 63-87% of the respective group that consumed the recommended number of dairy servings per day met the EAR for magnesium. Specifically, for adults aged 19-50 years of age the mean magnesium intake was only 277 mg/day and only 34% of this population met the EAR for magnesium. Individuals in this age group that met/exceeded the FGP dairy recommendation consumed an average of 3.2 servings of dairy products per day and 372 mg magnesium per day. Even with an average consumption of over three servings per day (recall that the FGP dairy recommendation for this group is 2 servings of dairy per day) over 35% of this group still did not meet the EAR for magnesium. Additionally, almost 30% of older adults (51+ years) that met/exceeded the FGP dairy recommendations did not meet the ERA for magnesium even though the average dairy consumption was about four servings per day (almost a full serving higher than the current recommendation). Very similar conclusions are drawn from evaluating magnesium intake in NHANES 1999-2000 (**Table 8b**). Namely, in individuals greater than 9 years of age even those that met/exceeded the recommended number of dairy products (average dairy intakes of these groups are typically considerably higher than the

**TABLE 8a. Impact of Meeting or Exceeding Food Guide Pyramid Dairy Recommendations on Magnesium Intake – CSFII 1994-96, 1998**

	Total for Age Group	FGP Dairy Recommendations <sup>1</sup>		Percentage Meeting FGP Dairy Recommendation
		Met/Exceeded	Not Met	
<b>CHILDREN 2-8 YEARS</b>				
Magnesium, mg/day <sup>2</sup>	208.2 (1.2)	245.4 (1.7)	177.6 (1.3)	
Magnesium, % meeting EAR <sup>3</sup>	97.4	100.0	95.4	
Number of subjects	6574	2928	3646	44.5
Dairy consumption, servings/day <sup>2</sup>	2.00 (0.02)	2.95 (0.02)	1.22 (0.01)	
<b>CHILDREN 9-18 YEARS</b>				
Magnesium, mg/day	250.3 (2.9)	363.5 (7.1)	221.4 (2.4)	
Magnesium, % meeting EAR	43.7	86.6	32.8	
Number of subjects	2031	389	1642	19.2
Dairy consumption, servings/day	2.01 (0.04)	4.19 (0.08)	1.45 (0.02)	
<b>ADULTS 19-50 YEARS</b>				
Magnesium, mg/day	277 (2.6)	372.3 (6.7)	248.3 (2.1)	
Magnesium, % meeting EAR	34.0	63.1	25.2	
Number of subjects	4913	1124	3789	22.9
Dairy consumption, servings/day	1.41 (0.03)	3.20 (0.06)	0.87 (0.01)	
<b>ADULTS 51+ YEARS</b>				
Magnesium, mg/day	260.8 (1.8)	394.4 (8.9)	253.9 (1.8)	
Magnesium, % meeting EAR	29.2	72.0	27.0	
Number of subjects	4442	235	4207	5.3
Dairy consumption, servings/day	1.16 (0.01)	3.87 (0.07)	1.02 (0.01)	

<sup>1</sup>Food Guide Pyramid recommends 2 servings of dairy products per day for those 8 years and younger, 3 servings/day for those 9-18 years, 2 servings/day for those 19-50 years and 3 servings/day for those greater than 50 years

Mean (SEM)

Specific age/gender Estimated Average Requirements were used within each age category

**TABLE 8b. Impact of Meeting or Exceeding Food Guide Pyramid Dairy Recommendations on Magnesium Intake – NHANES 1999-2000**

	Total for Age Group	FGP Dairy Recommendations <sup>1</sup>		Percentage Meeting FGP Dairy Recommendation
		Met/Exceeded	Not Met	
		CHILDREN 2-8 YEARS		
Magnesium, mg/day <sup>2</sup>	208.6 (3.9)	261.6 (6.3)	166 (3.5)	
Magnesium, % meeting EAR <sup>3</sup>	92.7	99.4	87.4	
Number of subjects	1143	501	642	43.8
Dairy consumption, servings/day <sup>2</sup>	2.04 (0.06)	3.28 (0.08)	1.04 (0.04)	
<b>CHILDREN 9-18 YEARS</b>				
Magnesium, mg/day	241.8 (4.1)	358.6 (9.1)	206.9 (3.6)	
Magnesium, % meeting EAR	39.8	70.4	30.6	
Number of subjects	2448	476	1972	19.4
Dairy consumption, servings/day	2.06 (0.06)	4.60 (0.12)	1.30 (0.03)	
<b>ADULTS 19-50 YEARS</b>				
Magnesium, mg/day	293.9 (4.5)	376 (9.4)	252.2 (4.3)	
Magnesium, % meeting EAR	39.7	63.6	27.6	
Number of subjects	2466	763	1703	30.9
Dairy consumption, servings/day	1.79 (0.05)	3.73 (0.08)	0.80 (0.02)	
<b>ADULTS 51+ YEARS</b>				
Magnesium, mg/day	280.3 (4.1)	387.5 (11.5)	265.3 (4.1)	
Magnesium, % meeting EAR	35.3	65.8	31.0	
Number of subjects	2016	207	1809	10.3
Dairy consumption, servings/day	1.47 (0.04)	4.43 (0.15)	1.05 (0.03)	

<sup>1</sup> Food Guide Pyramid recommends 2 servings of dairy products per day for those 8 years and younger, 3 servings/day for those 9-18 years, 2 servings/day for those 19-50 years and 3 servings/day for those greater than 50 years

<sup>2</sup>Mean (SEM)

<sup>3</sup>Specific age/gender Estimated Average Requirements were used within each age category

recommended level of dairy consumption), over 30% of individuals in these groups are not meeting the EAR for magnesium.

### **Summary**

**Groups that met/exceeded the FGP dairy recommendations were more likely to have a mean calcium intake above the AI for calcium, which means the likelihood of inadequate calcium intake in these groups is low. However, the groups that met or exceeded the FGP dairy recommendations had an average dairy serving intake about one serving higher than current recommendations. This indicates that the number of dairy servings recommended by the FGP should be increased by one serving for all age groups over 9 years of age to ensure the likelihood of inadequate intake of calcium is low. Groups that met/exceeded the FGP dairy recommendations also had a higher percentage of the group meeting the EAR of magnesium. However, in some age groups less than two-thirds of the group meeting/exceeding the FGP dairy servings recommendation met the EAR for magnesium. Again, these data suggest the FGP recommendations for dairy servings should be increased by at least one serving/day.**

## **ASSESSING THE IDEAL LEVEL OF DAIRY SERVINGS TO MEET CALCIUM AND MAGNESIUM RECOMMENDATIONS**

To help determine the ideal level of dairy consumption to meet the calcium and magnesium DRI we examined calcium and magnesium intake by various levels of dairy consumption from CSFII and NHANES 1999-2000. We separated individuals in the four age classifications used previously into six levels of dairy consumption per day: 1) less than one serving; 2) 1.0 to 1.5 servings; 3) 1.5 to 2.5 servings; 4) 2.5 to 3.5 servings; 5) 3.5 to 4.5 servings; and 6) > 4.5 servings. We then calculated the mean calcium and magnesium intake and the percentage of the population not meeting the respective DRI for these nutrients. **Table 9a** presents calcium information from CSFII. Given the limitation discussed above regarding using the AI for calcium to determine inadequate intake and to be consistent with the DRI panel approach for dietary assessment [47], we used the first group mean intake that exceeded the AI (which means the likelihood of inadequate calcium intake in the group is low) to determine the ideal level of dairy consumption. In children 2-8 years of age, 1.5 to 2.5 servings (average about two servings per day) appeared to be the first intake level to exceed the AI for this age group (an average of 700 mg calcium per day --  $0.33*500+0.67*800$ ). In children 9-18 years of age, with an AI of 1300 mg calcium/day, the first group means intake above the AI was at 3.5 to 4.5 dairy servings per day (average of 3.92 servings per day). For adults 19-50 years of age the first group mean intake greater than the AI for this group (1000 mg calcium/day) occurred at 2.5 to 3.5 dairy servings per day (average of 2.94 servings per day). In adults older than 50 years of age, the first group mean intake to exceed the AI of 1200 mg calcium per day occurred at 2.5 to 3.5 dairy servings per day (average of 2.89 servings per day). **Table 9b** presents calcium data from NHANES 1999-2000. Results were very similar to data from CSFII, namely:

**TABLE 9a. Impact of Various Levels of Dairy Consumption on Calcium Intake -- CSFII 1994-96, 1998**

	NUMBER OF DAIRY SERVINGS CONSUMED PER DAY					
	> 1	1 to 1.5	1.5 to 2.5	2.5 to 3.5	3.5 to 4.5	> 4.5
<b>CHILDREN 2-8 YEARS</b>						
Calcium, mg/day <sup>1</sup>	415.3 (5.8)	617.8 (4.5)	835.4 (3.9)	1138.1 (6.2)	1466.3 (10.0)	1932.4 (43.5)
Calcium, % meeting AI	6.2	29.2	72.1	100.0	100.0	100.0
Number of subjects	1118	1244	2386	1228	429	169
Dairy consumption, servings/day <sup>1</sup>	0.59 (0.01)	1.26 (0.01)	1.96 (0.01)	2.93 (0.01)	3.92 (0.02)	5.47 (0.12)
<b>CHILDREN 9-18 YEARS</b>						
Calcium, mg/day (SEM)	436.6 (7.9)	680.4 (7.8)	915.1 (7.9)	1261.1 (11.9)	1539.7 (17.5)	2227.4 (50.1)
Calcium, % meeting AI	0.0	0.0	1.9	33.5	93.0	100.0
Number of subjects	495	363	591	349	133	100
Dairy consumption, servings/day	0.52 (0.01)	1.25 (0.01)	1.96 (0.01)	2.96 (0.02)	3.92 (0.03)	5.80 (0.14)
<b>ADULTS 19-50 YEARS</b>						
Calcium, mg/day (SEM)	458.2 (4.7)	727 (6.5)	964.8 (6.8)	1323.3 (12.8)	1679.5 (25.6)	2569.2 (164.6)
Calcium, % meeting AI	0.4	5.7	39.1	95.4	100.0	100.0
Number of subjects	2287	905	1025	417	165	114
Dairy consumption, servings/day	0.48 (0.01)	1.23 (0.01)	1.93 (0.01)	2.94 (0.02)	3.97 (0.03)	6.17 (0.15)
<b>ADULTS 51+ YEARS</b>						
Calcium, mg/day (SEM)	439.8 (4.1)	698.9 (6.1)	929.3 (6.8)	1241.3 (13.4)	1593.4 (24.9)	2100.7 (70.8)
Calcium, % meeting AI	0.3	1.3	7.0	53.0	100.0	100.0
Number of subjects	2310	837	884	271	97	43
Dairy consumption, servings/day	0.46 (0.01)	1.23 (0.01)	1.92 (0.02)	2.89 (0.02)	3.89 (0.03)	5.60 (0.21)

<sup>1</sup>Mean (SEM)

**TABLE 9b. Impact of Various Levels of Dairy Consumption on Calcium Intake -- NHANES 1999-2000**

	NUMBER OF DAIRY SERVINGS CONSUMED PER DAY					
	< 1	1 to 1.5	1.5 to 2.5	2.5 to 3.5	3.5 to 4.5	> 4.5
<b>CHILDREN 2-8 YEARS</b>						
Calcium, mg/day <sup>1</sup>	409.8 (14.9)	610.2 (11.1)	821.7 (10.8)	1121.7 (24.3)	1401.2 (22.0)	2002.1 (68.8)
Calcium, % meeting AI	8.7	24.8	68.3	99.1	100.0	100.0
Number of subjects	285	181	327	180	96	74
Dairy consumption, servings/day <sup>1</sup>	0.48 (0.03)	1.23 (0.01)	1.94 (0.02)	2.86 (0.03)	3.90 (0.03)	5.88 (0.31)
<b>CHILDREN 9-18 YEARS</b>						
Calcium, mg/day	382.3 (10.0)	652 (13.0)	900.7 (13.8)	1225.5 (16.3)	1517.7 (21.7)	2257.1 (80.8)
calcium, % meeting AI	0.0	0.6	5.0	35.6	85.9	100.0
Number of subjects	839	399	514	349	163	157
Dairy consumption, servings/day	0.40 (0.02)	1.22 (0.01)	1.97 (0.02)	2.95 (0.03)	3.97 (0.04)	6.14 (0.20)
<b>ADULTS 19-50 YEARS</b>						
Calcium, mg/day	423.4 (8.0)	728.1 (15.6)	955.8 (13.5)	1308.4 (20.3)	1604.2 (40.0)	2438.2 (123.3)
Calcium, % meeting AI	2.0	11.2	35.6	93.2	95.3	100.0
Number of subjects	1086	361	454	269	141	639
Dairy consumption, servings/day	0.38 (0.01)	1.23 (0.01)	1.94 (0.02)	2.98 (0.02)	3.99 (0.03)	6.39 (0.21)
<b>ADULTS 51+ YEARS</b>						
Calcium, mg/day	422.4 (9.3)	694.2 (13.4)	910.6 (13.9)	1217.1 (21.5)	1421.8 (37.3)	2103.2 (107.6)
Calcium, % meeting AI	0.6	1.8	8.5	53.2	85.3	100.0
Number of subjects	986	335	368	179	82	66
Dairy consumption, servings/day	0.38 (0.01)	1.24 (0.01)	1.92 (0.02)	2.93 (0.03)	3.87 (0.04)	6.01 (0.32)

<sup>1</sup>Mean (SEM)

1. 1.5 to 2.5 servings of dairy (average of about two servings per day) were necessary for children 2-8 years of age for the group mean calcium intake to exceed the AI of this group (average AI of 700 mg calcium/day);
2. 3.5 to 4.5 servings of dairy (average of about four servings per day) were necessary for children 9-18 years of age for the group mean calcium intake to exceed the AI of this group (AI of 1300 mg calcium /day);
3. 2.5 to 3.5 servings (average of about three servings per day) of dairy were necessary for adults 19-50 years of age for the group mean calcium intake to exceed the AI of this group (AI of 1000 mg calcium/day);
4. 2.5 to 3.5 servings (average of about three servings per day) of dairy were necessary for adults 50+ years of age for the group mean calcium intake to exceed the AI of this group (AI of 1200 mg calcium/day).

**Table 10a** presents magnesium intake data from CSFII for the various age groups based on the number of dairy servings consumed. This table also provides the percentage of each group that met the EAR for magnesium. We assume that it would be desirable for most of the population (75% or more) to meet the EAR for magnesium (recall the EAR is set at the median magnesium requirement – 50% of the population has a higher requirement and 50% of the population has a lower requirement). In children 2-8 years of age, over 99% of the group consuming 1.5 to 2.5 dairy servings per day met the EAR for magnesium (average EAR for this combined age group was calculated as 97 mg magnesium/day -- individuals 2-3 years of age have an EAR of 65 mg magnesium/day while individuals aged 4-8 have an EAR of 110 mg magnesium/day; since seven years are represented in the 2-8 year group, we combined 2/7 of the 65 mg/day EAR with 5/7 of the 110 mg/day EAR to obtain 97 mg/day as an average EAR for the entire group; i.e.,  $0.285*65 + 0.714*110$ ). For children 9-18 years of age, almost 90% of the group consuming 3.5 to 4.5 dairy servings per day (average of 3.92 servings/day) met the EAR for magnesium. Less than 70% of the group consuming 2.5 to 3.5 dairy servings per day (average dairy intake of almost 3 servings) met the EAR.

Almost 80% of the group of adults 19-50 years of age that consumed 3.5 to 4.5 servings of dairy per day (average dairy intake of about 4 servings) met the EAR for magnesium. In the group that consumed, on average, the recommended number of dairy servings for this age group (1.5 to 2.5 servings – average dairy serving intake of 1.9 servings per day) over 55% of the group did not meet the EAR for magnesium. In older adults (50 + years of age), 75% of the group consuming 3.5 to 4.5 servings per day (average dairy intake of 3.89 servings per day) met the EAR for magnesium. Less than 60% of the group consuming the recommended number of dairy servings for this age group (2.5 to 3.5 servings with an average dairy intake of 2.89 servings per day) met the EAR for magnesium.

**TABLE 10a. Impact of Various Levels of Dairy Consumption on Magnesium Intake -- CSFII 1994-96, 1998**

	NUMBER OF DAIRY SERVINGS CONSUMED PER DAY					
	< 1	1 to 1.5	1.5 to 2.5	2.5 to 3.5	3.5 to 4.5	> 4.5
<b>CHILDREN 2-8 YEARS</b>						
Magnesium, mg/day <sup>1</sup>	153.2 (2.2)	178.4 (2.0)	206.6 (1.6)	244.6 (2.3)	284.6 (4.1)	350.6 (7.5)
Magnesium, % meeting EAR <sup>2</sup>	88.8	97.0	99.7	100.0	100.0	100.0
Number of subjects	1118	1244	2386	1228	429	169
Dairy consumption, servings/day <sup>1</sup>	0.59 (0.01)	1.26 (0.01)	1.96 (0.01)	2.93 (0.01)	3.92 (0.02)	5.47 (0.12)
<b>CHILDREN 9-18 YEARS</b>						
Magnesium, mg/day	182.3 (4.1)	211.6 (4.5)	240.7 (3.7)	298.9 (5.9)	337.9 (7.1)	451.9 (15.3)
Magnesium, % meeting EAR	13.3	30.1	42.1	68.8	89.1	93.7
Number of subjects	495	363	591	349	133	100
Dairy consumption, servings/day	0.52 (0.01)	1.25 (0.01)	1.96 (0.01)	2.96 (0.02)	3.92 (0.03)	5.80 (0.14)
<b>ADULTS 19-50 YEARS</b>						
Magnesium, mg/day	227.2 (2.5)	263.7 (3.8)	306.8 (4.4)	363 (7.3)	401.4 (10.1)	552.1 (26.3)
Magnesium, % meeting EAR	18.1	30.5	44.2	63.9	79.9	94.4
Number of subjects	2287	905	1025	417	165	114
Dairy consumption, servings/day	0.48 (0.01)	1.23 (0.01)	1.93 (0.01)	2.94 (0.02)	3.97 (0.03)	6.17 (0.15)
<b>ADULTS 51+ YEARS</b>						
Magnesium, mg/day	221.3 (2.2)	268.4 (3.8)	307.4 (6.8)	341.6 (7.2)	400.9 (14.1)	484.4 (21.0)
Magnesium, % meeting EAR	16.7	29.4	45.4	56.6	75.0	92.0
Number of subjects	2310	837	884	271	97	43
Dairy consumption, servings/day	0.46 (0.01)	1.23 (0.01)	1.92 (0.02)	2.89 (0.02)	3.89 (0.03)	5.60 (0.21)

<sup>1</sup>Mean (SEM);

<sup>2</sup>Specific age/gender Estimated Average Requirements were used within each age category.

Magnesium intake data from NHANES 1999-2000 for the various age groups are presented in **Table 10b**. Again these data are very similar to those presented from CSFII. For example, in adults 19-50 years of age, 75% of the group consuming 3.5 to 4.5 servings of dairy (average dairy intake of 4 servings) met the EAR for magnesium and about two-thirds of children 9-18 years of age that consumed 3.5 to 4.5 servings of dairy (average dairy intake of 4 servings) met the EAR for calcium. The high percentage of the population not obtaining the estimated average requirement for magnesium ages 9 years and older, even though they are consuming the recommended level of dairy servings appears to be a significant nutritional issue.

### **Summary**

**Using current nutrient intake data from CSFII and NHANES 1999-2000 we have shown that groups that met or exceeded the FGP dairy recommendations (2-3 servings/day) are more likely to have a mean calcium intake above the AI for calcium, which means the likelihood of inadequate calcium intake in these groups, is low. However, the groups that met or exceeded the FGP dairy recommendations had an average dairy serving intake about one serving higher (3-4 servings/day) than the current recommendation. When we estimated the ideal number of dairy servings required to meet the DRI for both calcium and magnesium we conclude the following:**

- 1. Children 2-8 years of age need at least 2 servings of dairy per day;**
- 2. Children 9-18 years of age need on average 4 servings of dairy per day;**
- 3. Adults aged 19-50 years of age need at least 3 servings of dairy per day;**
- 4. Adults older than 51 years of age need 3-4 servings of dairy per day (3 servings to meet calcium recommendations and at least 4 servings to meet the EAR for magnesium).**

**Taken together, these data indicate that recommending 3-4 servings from the milk group for all individuals greater than 9 years of age is necessary in order to meet the DRI's and to ensure adequate intakes of calcium and magnesium.**

**TABLE 10b. Impact of Various Levels of Dairy Consumption on Magnesium Intake -- NHANES 1999-2000**

	NUMBER OF DAIRY SERVINGS CONSUMED PER DAY					
	< 1	1 to 1.5	1.5 to 2.5	2.5 to 3.5	3.5 to 4.5	> 4.5
<b>CHILDREN 2-8 YEARS</b>						
Magnesium, mg/day <sup>1</sup>	145.5 (6.0)	176.6 (6.0)	198.3 (4.0)	257.9 (10.6)	266.7 (12.3)	362 (16.6)
Magnesium, % meeting EAR <sup>2</sup>	78.9	88.4	98.6	100.0	100.0	100.0
Number of subjects	285	181	327	180	96	74
Dairy consumption, servings/day <sup>1</sup>	0.48 (0.03)	1.23 (0.01)	1.94 (0.02)	2.86 (0.03)	3.90 (0.03)	5.88 (0.31)
<b>CHILDREN 9-18 YEARS</b>						
Magnesium, mg/day	170.6 (4.8)	197.8 (6.8)	238 (7.1)	282.4 (8.5)	320.3 (14.9)	429.1 (16.1)
Magnesium, % meeting EAR	17.3	26.4	41.5	54.5	66.6	85.6
Number of subjects	839	399	514	349	163	157
Dairy consumption, servings/day	0.40 (0.02)	1.22 (0.01)	1.97 (0.02)	2.95 (0.03)	3.97 (0.04)	6.14 (0.20)
<b>ADULTS 19-50 YEARS</b>						
Magnesium, mg/day	233.0 (5.5)	273.8 (8.6)	298.7 (7.6)	337.5 (10.2)	397.6 (15.2)	494.7 (31.8)
Magnesium, % meeting EAR	22.4	31.6	42.5	57.3	75.0	83.9
Number of subjects	1086	361	454	269	141	639
Dairy consumption, servings/day	0.38 (0.01)	1.23 (0.01)	1.94 (0.02)	2.98 (0.02)	3.99 (0.03)	6.39 (0.21)
<b>ADULTS 51+ YEARS</b>						
Magnesium, mg/day	226.2 (5.0)	283.6 (9.4)	317.3 (9.8)	338.6 (11.5)	367.8 (16.4)	446.1 (19.9)
Magnesium, % meeting EAR	20.1	36.5	43.3	56.8	56.6	83.6
Number of subjects	986	335	368	179	82	66
Dairy consumption, servings/day	0.38 (0.01)	1.24 (0.01)	1.92 (0.02)	2.93 (0.03)	3.87 (0.04)	6.01 (0.32)

an (SEM);

specific age/gender Estimated Average Requirements were used within each age category

## A PATHWAY FOR ADDING ONE ADDITIONAL SERVING OF DAIRY TO FOOD GUIDE RECOMMENDED DIETARY PATTERNS

Our results raise some important considerations for dietary recommendations. It is clear that the FGP recommends an idealized dietary pattern and thus if certain components of the dietary pattern are not consumed as suggested, then the intake of certain nutrients may be compromised. For example, depending on the caloric pattern, FGP expects 250-475 mg of calcium to come from grains, fruits, and vegetables, particularly dark green leafy vegetables and legumes [52]. However, consumption of dark green leafy vegetables and legumes are each only 0.2 of a serving per day [40], considerably less than amounts suggested. The Dietary Guidelines suggest that certain non-dairy sources (e.g., canned fish with bones, fortified orange juice, fortified soy beverage, tofu, and some dark green leafy vegetables [greens]) could be consumed to increase calcium in the diet. In CSFII, less than 0.2% of food occasions were for canned fish, fortified orange juice, fortified soy beverage, tofu, and greens combined as compared to 10% of food occasions for milk, cheese and yogurt (data not shown). Our data looks at actual food consumption and suggests that, at least to meet calcium requirements, an additional serving of dairy products might be more impactful to calcium nutriture than to try and increase dark green vegetable, legumes or other sources of calcium suggested by others. Furthermore, Healthy People 2010 have stated the critical need of dairy products to meet calcium needs: “With current food selection practices, use of dairy products may constitute the difference between getting enough calcium in one’s diet or not” [38].

Although food groups such as dark-green leafy and deep yellow vegetables, legumes, and whole-grains have been identified as alternative sources of calcium, the FGP already recommends more servings of these groups than are currently consumed by most Americans [40,44]. **Table 11** shows that considerable amounts of these foods (6-15 servings) would be required to meet the calcium content of one dairy serving. Hence, increasing servings of food groups others than dairy foods to meet calcium DRI’s is unlikely to be realistic or practical [52].

We evaluated the nutrient compositional effects of adding one additional servings of low-fat or fat-free dairy products to sample USDA FGP recommended menus [58]. In this exercise, foods in each FGP daily menu representing one serving of a refined grain from the Bread Group and its accompanying condiments (margarine, jelly, etc.) were replaced with one serving from the Milk Group. A total of 5 days of menus at three calorie levels (1600, 2200, and 2800) were evaluated. The refined grains that were replaced included a slice of white bread or white toast, a small white roll, a medium bagel, a large soft pretzel and crackers. The dairy foods replacing the refined grains and condiments included skim milk (plain and chocolate) and non-fat yogurt.

**Table 12** shows nutrient compositional changes resulting from replacing one serving of refined grains and its accompanying condiments with one serving of dairy on: total fat, saturated fat, energy and total calcium. At all menu calorie levels assessed, daily levels of total fat and saturated fat were reduced and caloric levels were lowered or not altered while daily calcium levels were increased by about 280 mg/day. These data demonstrate

**TABLE 11. Food Group Intakes and Servings Required to Achieve an Amount of Calcium Equivalent to Dairy<sup>a</sup>**

Food Group or Subgroup	Average Servings Consumed <sup>b</sup>	Daily Servings in Food Guide Pattern			Servings for 300 mg Ca
		Pattern A	Pattern B	Pattern C	
Milk Group	1.5	2	2	2	1
Vegetables					
Dark-green leafy	0.1	0.43	0.57	0.72	6
Legumes	0.2	0.43	0.57	0.72	7
Grain Group					
Whole grain foods	1	3	3	3	15
Refined grain foods	5.8	3	6	8	11.5

<sup>a</sup>Adapted from [52].

<sup>b</sup>Data from CSFII 1994, all individuals 2 years of age and older.

Pattern A = 6 grains, 3 vegetables, 2 fruit, 5-oz. meat, 2 milk.

Pattern B = 9 grains, 4 vegetables, 3 fruit, 6-oz. meat, 2 milk.

Pattern C = 11 grains, 5 vegetables, 4 fruit, 7-oz. meat, 2 milk.

**TABLE 12. Effects of Replacing One Serving of Refined Grain Foods with Low-fat and Fat-free Dairy Foods<sup>1</sup>**

FGP Menus (kcal/d)	Bread Group		Dairy Group		Total Fat (g)		Saturated Fat (g)		Calories (kcal)		Calcium (mg)	
	(no. servings)		(no. servings)									
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1600	6.6	5.6	2.1	3.1	37.6	34.1	10.5	9.8	1622	1627	1000	1275
2200	10.0	8.9	2.5	3.5	65.9	61.0	20.3	19.4	2207	2152	1215	1497
2800	11.8	10.6	3.2	4.2	85.2	80.7	25.2	23.6	2809	2785	1624	1908

<sup>1</sup> Adapted from [58]; Five days of menus for each calorie level were modified by replacing refined grain products and accompanying condiments (i.e., jelly, margarine) with dairy products. Average nutrients per day were then recalculated. Refined grains replaced included white bread/toast, white rolls, bagels, soft pretzels, and crackers. Dairy foods added included skim milk (plain and chocolate) and non-fat yogurt.

the practical feasibility of increasing dairy from 2-3 to 3-4 servings per day in a realistic dietary regimen that improves the overall nutrient composition of the diet through the use of naturally nutrient dense foods. It is reasonable to expect that the public health benefits of recommending an increase in dairy servings in conjunction with these FGP dietary patterns could have long-term favorable effects on achieving the calcium DRI's as well as other synergistic nutrients associated with milk, including potassium, magnesium, phosphorus, and vitamins D, A, B<sub>12</sub>, riboflavin and niacin.

Taken together, these data indicate that recommending 3-4 servings from the milk group for all individuals greater than 9 years of age is necessary and appears practical in order to ensure adequate intakes of calcium.

### **IMPACT OF ADOPTING FOOD LABELING SERVING SIZES ON FGP DAIRY RECOMMENDATIONS**

Serving sizes used in the FGP are, in many cases, different than those used on the Nutrition Facts panel for the same food. For example, the FGP serving size for natural cheese is 1.5 ounces; the serving size used for the Nutrition Facts panel is 1 ounce and the FGP serving size for cooked pasta is ½ cup while the serving size used for the Nutrition Facts panel is 1 cup [59]. The FGP serving size for processed cheese is 2 ounces while the serving size used for the Nutrition Facts panel is ¾ ounce. Also, the FGP serving size for yogurt is 8 ounces; the serving size used for the Nutrition Facts panel varies from 4-8 ounces, with 6 ounces being very common. On the other hand, for numerous food products the FGP serving size is the same as that used on the Nutrition Facts panel (e.g., 1 cup milk, ½ cup cut-up fruit, etc.). While the objectives of the FGP and Nutrition Facts panel may be different, they are related. Both programs are aiming to help educate American consumers about food and nutrition -- the amount and types of food they should eat and nutritional content of the food they purchase.

Mandatory nutrition labeling of food products, including labeling of serving size, have been in place since 1993. American consumers have become accustomed to reading the Nutrition Facts panel [60]. Thus, it may be time for USDA and FDA to consider harmonizing their respective programs to better serve the American consumer. In an effort to help understand the impact of aligning serving sizes, we have assessed the impact of using serving sizes encountered on the Nutrition Facts panel of dairy products, which we term “marketplace” serving sizes, on achieving dietary recommendations for calcium and magnesium.

We repeated the analysis of Shaw and colleagues [52] using serving sizes encountered on the Nutrition Facts panel of dairy products. To do this we created a nutritional composite for dairy products based on current consumption patterns and current marketplace serving sizes. To calculate a calcium/magnesium composite for a dairy serving we used the percentage of milk, cheese and yogurt consumed and adjusted the composite based on the actual consumption of various types milk (full fat, low fat, and skim), cheese (processed versus natural) and yogurt (8 oz versus 6 oz). The calculated dairy composite for calcium

and magnesium are presented in **Tables 13a and 13b**, respectively. The average composite dairy product contained 247 mg calcium and 26 mg magnesium per marketplace serving. The calcium content of the average composite marketplace serving of dairy is considerably lower than the 302 mg calcium per FGP dairy serving. This is partly due to the lower calcium content of marketplace servings of natural and processed cheese and to the increased presence of 6 oz containers of yogurt (which are labeled as one serving under FDA labeling rules).

**TABLE 13a. Composite Calcium Content of Marketplace Dairy Products**

Marketplace Servings	Calcium mg/serving
Milk, 1 cup	300
Yogurt, 8 oz	300
Yogurt, 6 oz	200
Cheese, natural - 1 oz	200
Cheese, proc. - 3/4 oz	129
Composite <sup>1,2</sup>	247

Note: From USDA ERS, US consumption of dairy products is 44.4% from milk, 34.7% from cheese and 20.8% from other dairy products including yogurt

<sup>1</sup>Assumes 55% yogurt consumption is 8 ozs and 45% of yogurt consumption is 6 oz; assumes cheese consumption split 62.3 % natural cheese

<sup>2</sup>For children 2-6 the composite is 170 mg/serving, which represents 1/3 servings except milk

**TABLE 13b. Composite Magnesium Content of Marketplace Dairy Products**

Marketplace Servings	Magnesium mg/serving
Milk, 1 cup	31.5
Yogurt, 8 oz	34.5
Yogurt, 6 oz	25.5
Cheese, natural - 1 oz	8.1
Cheese, proc. - 3/4 oz	4.6
Composite <sup>1,2</sup>	26.0

Note: From USDA ERS, US consumption of dairy products is 44.4% from milk, 34.7% from cheese and 20.8% from other dairy products including yogurt

<sup>1</sup>Assumes 55% yogurt consumption is 8 ozs and 45% of yogurt consumption is 6 oz; assumes cheese consumption equally split 62.3 % natural cheese

<sup>2</sup>For children 2-6 the composite is 18 mg magnesium per serving, which represents 1/3 servings except milk

We then modeled the approach taken by Shaw et al [52] to estimate calcium and magnesium intake using the calculated marketplace serving size dairy composite. When we used the FGP dietary patterns to calculate non-dairy calcium and magnesium intake and added 2-4 marketplace servings of dairy we found that at least 3, and for most age/gender groups, 4 marketplace servings of dairy products would be needed to meet the calcium AI (**Table 14a**). For example, in females (50% or more of whom consume a diet similar to dietary Pattern A, ~1600 kcal/day), adding 2 marketplace servings of dairy products to the non-dairy calcium provided by other foods recommended by the FGP only provided 60-78% of the AI for calcium. Three servings of marketplace dairy products raised the calcium intake to 79-103% of the AI for calcium but 9-18 year olds and those older than 50 years of age needed 4 marketplace servings to meet or exceed 100% of the AI for calcium. In those consuming pattern B, all those aged 9 years and older needed at least three marketplace dairy servings to meet the AI for calcium. With four marketplace servings almost all groups regardless of age or dietary pattern met or exceeded the AI for calcium. Using the same approach for magnesium (**Table 14b**) at least 4 marketplace servings of dairy were needed to reach or approach the RDA for magnesium for most age/gender groups. However, those groups that consumed Pattern C met or exceeded that RDA for magnesium with 3 servings of marketplace dairy servings.

When we used *actual* food consumption data from NH4 to estimate the non-dairy calcium intake and added 2-4 marketplace servings of dairy products (**Table 15a**), we conclude that 3-4 marketplace servings of dairy products are necessary to meet or exceed

**TABLE 14a. Calcium Provided by Food Guide Pyramid Patterns with Marketplace Based Dairy Servings<sup>1</sup>**  
 Percentage of DRI

Ages	Calcium DRI, mg/d	Mean Calories/d <sup>2</sup>	Percent Pattern A <sup>3</sup>	Child 2-6 years (2 dairy)	Pattern A			Pattern B			Pattern C		
					(2 dairy)	(3 dairy)	(4 dairy)	(2 dairy)	(3 dairy)	(4 dairy)	(2 dairy)	(3 dairy)	(4 dairy)
1-3 years	500	1548	77.0	<b>97</b>									
4-8 years	800	1845	59.7	<b>79</b>	<b>98</b>	129	159	116	147	178	129	160	191
9-13 years	1300	2107	47.8		<b>60</b>	<b>79</b>	98	<b>72</b>	<b>91</b>	110	<b>80</b>	<b>99</b>	118
Females													
14-18 years	1300	1958	50.8		<b>60</b>	<b>79</b>	98	<b>72</b>	<b>91</b>	110	<b>80</b>	<b>99</b>	118
19-30 years	1000	2040	51.2		<b>78</b>	103	128	<b>93</b>	118	143	104	128	153
31-50 years	1000	1939	54.5		<b>78</b>	103	128	<b>93</b>	118	143	104	128	153
51-70 years	1200	1697	68.5		<b>65</b>	<b>86</b>	106	<b>78</b>	<b>98</b>	119	<b>86</b>	107	127
>70 years	1200	1440	80.6		<b>65</b>	<b>86</b>	106	<b>78</b>	<b>98</b>	119	<b>86</b>	107	127
Males													
14-18 years	1300	2806	24.6					<b>72</b>	<b>91</b>	110	<b>80</b>	<b>99</b>	118
19-30 years	1000	2867	22.8					<b>93</b>	118	143	104	128	153
31-50 years	1000	2713	22.9					<b>93</b>	118	143	104	128	153
51-70 years	1200	2354	33.0		<b>65</b>	<b>86</b>	106	<b>78</b>	<b>98</b>	119	<b>86</b>	107	127
>70 years	1200	1930	50.3		<b>65</b>	<b>86</b>	106	<b>78</b>	<b>98</b>	119	<b>86</b>	107	127

<sup>1</sup> 72% of calcium comes from dairy sources; 32% from milk, 25% from cheese and 15% from other dairy products including yogurt (ERS, 1999). Non-dairy calcium intake calculated from food patterns and calcium composites from Shaw, et al., 2000 -- Pattern A: 287 mg/d; Pattern B : 437 mg/day and Pattern C: 541mg/d. Marketplace dairy serving composite was 256 mg/d.

<sup>2</sup>Calories from NHANES IV.

<sup>3</sup>Pattern A defined as less than 1900 kcal/day in NHANES IV; the midpoint between Pattern A and B.

**TABLE 14b. Magnesium Provided by Food Guide Pyramid Patterns with Marketplace Based Dairy Servings<sup>1</sup>**

Ages	Magnesium DRI, mg/d	Mean Calories/d <sup>2</sup>	Percent Pattern A <sup>3</sup>	Percentage of DRI										
				Child 2-6 years (2 dairy)	Pattern A (2 dairy) (3 dairy) (4 dairy)			Pattern B (2 dairy) (3 dairy) (4 dairy)			Pattern C (2 dairy) (3 dairy) (4 dairy)			
1-3 years	80	1548	77.0	157										
4-8 years	130	1845	59.7	177	196	216	236	255	275	295	302	322	342	
9-13 years	240	2107	47.8		106	117	128	138	149	160	164	174	185	
Females														
14-18 years	360	1958	50.8		<b>71</b>	<b>78</b>	<b>85</b>	<b>92</b>	<b>99</b>	107	109	116	124	
19-30 years	310	2040	51.2		<b>82</b>	<b>91</b>	<b>99</b>	107	115	124	127	135	143	
31-50 years	320	1939	54.5		<b>80</b>	<b>88</b>	<b>96</b>	104	112	120	123	131	139	
51-70 years	320	1697	68.5		<b>80</b>	<b>88</b>	<b>96</b>	104	112	120	123	131	139	
>70 years	320	1440	80.6		<b>80</b>	<b>88</b>	<b>96</b>	104	112	120	123	131	139	
Males														
			Percent Pattern A & B <sup>3</sup>											
14-18 years	410	2806	45.3					<b>81</b>	<b>87</b>	<b>94</b>	<b>96</b>	102	108	
19-30 years	400	2867	43.7					<b>83</b>	<b>89</b>	<b>96</b>	<b>98</b>	105	111	
31-50 years	420	2713	46.3					<b>79</b>	<b>85</b>	<b>91</b>	<b>93</b>	100	106	
51-70 years	420	2354	59.9		<b>61</b>	<b>67</b>	<b>73</b>	<b>79</b>	<b>85</b>	<b>91</b>	<b>93</b>	100	106	
>70 years	420	1930	80.9		<b>61</b>	<b>67</b>	<b>73</b>	<b>79</b>	<b>85</b>	<b>91</b>	<b>93</b>	100	106	

<sup>1</sup> 44.4% of dairy product consumption is milk, 35% of dairy product consumption is cheese and 20.1% of dairy product consumption is from other dairy products including yogurt (ERS, 1999). Non-dairy magnesium intake calculated from food patterns and calcium composites from Shaw, et al., 2000 -- Pattern A: 203 mg magnesium per day; Pattern B: 280 mg magnesium per day and Pattern C: 341mg magnesium per day. Marketplace dairy serving composite was 26 mg of magnesium per serving.

<sup>2</sup>Calories from NHANES IV.

<sup>3</sup>Pattern A defined as less than 1900 kcal/day in NHANES IV; the midpoint between Pattern A and B. Pattern B defined as greater than 1900 kcal/day and less than or equal to 2500 kcal/day.

**TABLE 15a. Calcium Provided by Non-dairy plus Marketplace Based Dairy Servings<sup>1</sup>**

Ages	Calcium	Non-Dairy	Percentage of DRI		
	DRI	Calcium,	(2 dairy)	(3 dairy)	(4 dairy)
	mg/day	mg/day <sup>2</sup>			
<b>Females</b>					
1-3 years	500	191.6	106	140	174
4-8 years	800	226.3	90	121	152
9-13 years	1300	273.5	<b>59</b>	<b>78</b>	<b>97</b>
14-18 years	1300	273.9	<b>59</b>	<b>78</b>	<b>97</b>
19-30 years	1000	296.2	<b>79</b>	104	128
31-50 years	1000	312.5	<b>81</b>	105	130
51-70 years	1200	283.5	<b>65</b>	<b>85</b>	106
>70 years	1200	238.7	<b>61</b>	<b>82</b>	102
<b>Males</b>					
1-3 years	500	216.7	111	145	179
4-8 years	800	286.1	<b>98</b>	128	159
9-13 years	1300	283.6	<b>60</b>	<b>79</b>	<b>98</b>
14-18 years	1300	381.9	<b>67</b>	<b>86</b>	105
19-30 years	1000	404.7	<b>90</b>	115	139
31-50 years	1000	423.5	<b>92</b>	116	141
51-70 years	1200	377.2	<b>73</b>	<b>93</b>	114
>70 years	1200	312.3	<b>67</b>	<b>88</b>	108

<sup>1</sup>Marketplace dairy serving defined as 256 mg/serving.

<sup>2</sup>Non-dairy calcium intake calculated from NHANES IV.

the AI for calcium in 9-18 year olds (e.g. three marketplace servings of dairy products provided 78% of the AI for calcium in females and 79-86% of the AI for calcium in males). Additionally, in those older than 50 years of age, three marketplace servings of dairy products provided 82-93% of the AI for calcium. Four marketplace servings of dairy products helped these age groups approach or exceed that AI for calcium. For magnesium, 4 marketplace servings of dairy products are necessary for most groups to approach the DRI for magnesium (**Table 15b**). However, even with 4 marketplace servings of dairy, children 14-18 years of age obtained only 75-81% of RDA for magnesium.

**TABLE 15b. Magnesium Provided by Non-dairy plus Marketplace Base Dairy Servings<sup>1</sup>**

Ages	Magnesium DRI mg/day	Non-Dairy Magnesium, mg/day <sup>2</sup>	NEW Percentage of DRI		
			(2 dairy)	(3 dairy)	(4 dairy)
<b>Females</b>					
1-3 years	80	126.4	203	226	248
4-8 years	130	143.7	151	171	191
9-13 years	240	162.1	<b>89</b>	100	111
14-18 years	360	165	<b>60</b>	<b>68</b>	<b>75</b>
19-30 years	310	189.2	<b>78</b>	<b>86</b>	<b>95</b>
31-50 years	320	214.2	<b>83</b>	<b>91</b>	<b>99</b>
51-70 years	320	208.4	<b>81</b>	<b>90</b>	<b>98</b>
>70 years	320	184.1	<b>74</b>	<b>82</b>	<b>90</b>
<b>Males</b>					
1-3 years	80	151	234	256	279
4-8 years	130	161.2	164	184	204
9-13 years	240	182	<b>98</b>	108	119
14-18 years	410	228.2	<b>68</b>	<b>75</b>	<b>81</b>
19-30 years	400	261.6	<b>78</b>	<b>85</b>	<b>91</b>
31-50 years	420	298	<b>83</b>	<b>90</b>	<b>96</b>
51-70 years	420	291	<b>82</b>	<b>88</b>	<b>94</b>
>70 years	420	257.6	<b>74</b>	<b>80</b>	<b>86</b>

<sup>1</sup>Marketplace dairy serving defined as 26 mg magnesium per serving.

<sup>2</sup>Non-dairy magnesium intake calculated from NHANES IV.

### **Summary**

**We have that shown changing serving sizes for dairy products to those used on the Nutrition Facts panel would require the dairy serving recommendation to increase from 2-3 servings per day to at least 3-4 servings per day for individuals to meet 100% of the AI for calcium. Four servings of dairy products are particularly necessary for those 9-18 years of age and those 51+ years of age when we factor in actual non-dairy calcium intake. Consumers who may mistakenly equate FDA Nutrition Facts panel servings of dairy products with FGP servings could very easily run the risk of under-consuming critical nutrients such as calcium as well as other essential nutrients.**

**It seems an appropriate time for the USDA to seriously consider ways to harmonize the FGP serving sizes to those required by the FDA on the Nutrition Facts panel to be consistent with serving sizes that consumers encounter in the marketplace. While this may cause a realignment of the number of recommended servings of various foods, we believe the effort is worthwhile, since consumers will then be able to link the FGP recommendations with product labels.**

## DAIRY VERSUS NON-DAIRY SOURCES OF CALCIUM

Conclusions from the previous sections of this document provide ample evidence for the need for additional calcium and magnesium in the diets of Americans and suggest that one additional serving of dairy products per day would help most individuals meet their calcium and magnesium needs. There are other foods that could be suggested to increase calcium and magnesium in the diet. The Dietary Guidelines (DG), while recommending dairy products to meet calcium needs, also indicate that there are other calcium containing foods as alternative sources of calcium, including canned fish with soft bones (e.g., salmon and sardines), tofu made with calcium sulfate, calcium fortified fruit juices and soy beverages, and dark green vegetables (e.g., collards and turnip greens).

While dairy products are the primary source of calcium in the US diet, they also provide meaningful amounts of other nutrients to the diet including protein, phosphorous, potassium, magnesium, riboflavin and vitamins A, D and B<sub>12</sub> (see Table 1).

We were interested in determining if the consumption of non-dairy calcium sources would impact the consumption of other essential nutrients. To determine the impact of consuming non-dairy calcium sources on overall nutrient intake we recruited registered dietitians to create 30 diets that met the FGP recommended dietary pattern and were consistent with recently established Daily Reference Intakes (DRI's). The dietitians did not know the purpose of the study and were asked to create 10 diets for each dietary caloric pattern defined by the FGP.<sup>1</sup> Nutritionist IV was used to determine the nutritional content of each daily diet.

The nutrient content of five non-dairy calcium sources (canned fish, fortified orange juice, fortified soy beverage, tofu and greens) was obtained from a combination of Nutritionist IV, USDA food composition database (release 15), and from product packages. For example, to obtain the nutrient composition of soy beverages we combined data from USDA, Nutritionist IV and then modified the values based on the fortification profile identified from two major manufacturers of soy beverages (Eden Foods and Silk). For dark green vegetables we took the average of collards and turnip greens cooked from fresh and cooked from frozen with and without salt. We also calculated the average nutrient content of the dairy products in the 30 diets.

With the nutrient content of the various sources of calcium identified, we then modeled the impact of removing one or two servings of the average dairy product and replacing them with one or two servings of the non-dairy calcium sources. Total daily nutrient content of the 30 diets were recalculated and compared to the original dairy containing diets to assess any alterations in nutrient content. All statistical comparisons were conducted with SAS (release 8.2) and differences with a p-value of less than 0.05 were considered significant.

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<sup>1</sup> The FGP are set for three different calorie levels (1600, 2200, and 2800 kcal/day). The lower calorie level is appropriate for young children and many sedentary women and older adults. The middle calorie level is appropriate for other children, teenage girls, active women and many sedentary men. The highest calorie range is appropriate for teenage boys, many active men and some very active women.

The mean calorie and nutritional content of the ten model diets for each of the FGP calorie levels are presented in **Table 16**. The overall summary of the thirty diets is presented in **Table 17**. The diets were well balanced and met the recommended calorie levels for each dietary pattern. In general, calories from total fat and saturated fat met DG recommendations (less than 30% of calories for total fat and less than 10% of calories for saturated fat) for all three dietary patterns. The sodium level of the diets typically exceeded the DG recommendations. The number of dairy servings ranged from 1.5 to 2.7 per day in the 1600 calorie/day diets, 1.5 to 3.9 in the 2200 calorie/day diets, and 2.0 to 3.5 in the 2800 calorie/day diets.

The percentage of nutrients from dairy products for each of the dietary patterns is presented in **Table 18**. The nutritional density of dairy products was quite evident. In model diets that provided <30% of calories from total fat and <10% of calories from saturated fat, dairy products provided 14-17% of calories, 17-25 % of total fat, and 26-35% of saturated fat but also providing 25-28% of protein, 58-69% of calcium, 22-27% of potassium, 38-42% of phosphorous, 57-83% of vitamin D, 31-46% of the riboflavin, 33-57% of the vitamin B<sub>12</sub>, and 20-24 % of magnesium. Dairy products only provided 13-16% of sodium in these diets.

The nutritional composition of a serving of various non-dairy calcium sources is presented in **Table 19**. All of the foods were good sources of calcium; soy beverage had the lowest calcium content (137 mg/serving) while tofu had the highest content (480 mg/serving). **Table 20** presents the results of replacing one or two servings of dairy products with one or two servings of the non-dairy calcium sources. The replacement of one serving of dairy products with one serving of non-dairy calcium sources caused a few significant changes in nutrient intake. Calcium was significantly lower with the soy beverage replacement, which was a function of the fortification level of soy products in the market place. Vitamin D was reduced by approximately 26% with fortified orange juice, greens, and tofu replacement. Phosphorus was lower for the fortified orange juice replacement while vitamin D and vitamin B<sub>12</sub> were higher for the canned fish replacement, and vitamin A was higher for the greens replacement.

When two servings of dairy products were replaced with non-dairy calcium sources many more significant changes in nutrient content of the diets were identified. Protein intake was higher for the fish replacement and lower for the fortified orange juice replacement. Calcium intake was lower when dairy was replaced by fish, greens, and soy beverage but was higher when replaced with tofu. Vitamin D levels were dramatically lower when replaced with fortified orange juice, greens and tofu while they are higher with fish replacement. Vitamin B<sub>12</sub> was lower for the replacements with fortified orange juice, greens and tofu. Replacement of two servings of all the non-dairy calcium sources resulted in significantly lower levels of riboflavin. It is also worth noting is that vitamin A was dramatically higher with the replacement with greens.

**TABLE 16. Summary of 30 Diets Formulated to Meet FGP Recommendations By Calorie Level (ten each)**

Daily Intake	Calorie Level								
	1600 kcal/day			2200 kcal/day			2800 kcal/day		
	Standard Mean ± Deviation	Minimum	Maximum	Standard Mean ± Deviation	Minimum	Maximum	Standard Mean ± Deviation	Minimum	Maximum
Number of Dairy									
Servings	2.0 ± 0.5	1.5	2.7	2.8 ± 0.7	1.5	3.9	3.0 ± 0.5	2.0	3.5
Calories, kcal	1599.8 ± 17.6	1578.2	1625.5	2198.6 ± 16.3	2177.0	2227.9	2807.1 ± 20.5	2782.9	2837.6
Protein, g	74.6 ± 13.1	45.1	96.7	103.5 ± 13.0	77.9	120.7	116.9 ± 12.0	98.8	135.3
Total fat, g	47.0 ± 12.9	27.6	65.8	71.9 ± 11.2	50.1	86.5	96.1 ± 4.8	85.7	101.2
Saturated fat, g	13.8 ± 5.0	6.8	22.9	23.6 ± 5.0	13.5	29.5	33.2 ± 6.4	25.3	41.1
Monounsaturated fat, g	14.2 ± 6.0	5.7	26.0	25.8 ± 5.3	19.4	36.3	31.6 ± 5.1	19.5	35.9
Vitamin A, RE	1369.0 ± 670.8	519.4	2653.3	1986.9 ± 1239.9	771.3	4311.4	1658.7 ± 683.8	720.2	2606.8
Vitamin B2, mg	2.2 ± 0.9	1.2	3.8	2.7 ± 0.3	2.2	3.2	2.7 ± 0.4	2.0	3.5
Vitamin B12, mcg	5.1 ± 3.7	2.2	11.9	5.3 ± 1.6	3.1	8.0	5.2 ± 1.7	3.4	8.3
Vitamin D, IU	213.5 ± 66.2	120.5	301.3	347.6 ± 188.5	212.7	765.8	235.3 ± 52.2	153.6	304.2
Calcium, mg	1076.0 ± 183.0	851.9	1404.1	1479.9 ± 158.0	1288.1	1758.7	1434.5 ± 255.0	1006.4	1873.3
Magnesium, mg	291.5 ± 97.1	221.9	524.2	361.1 ± 86.8	264.9	566.2	415.4 ± 70.5	289.5	517.9
Phosphorus, mg	1326.9 ± 279.1	902.3	1836.9	1802.7 ± 293.0	1363.3	2234.9	1902.6 ± 250.9	1637.4	2444.6
Potassium, mg	3119.9 ± 655.5	2261.1	4712.8	3768.4 ± 421.6	3125.3	4629.2	4298.0 ± 646.0	3136.2	5116.8
Sodium, mg	2905.0 ± 659.1	2050.7	4186.3	4180.3 ± 755.5	2804.6	5116.7	4956.7 ± 1402.9	2925.9	7564.8

**TABLE 17. Summary of Thirty Diets Formulated to Meet FGP Requirements (ten each at 3 different calorie levels)<sup>1</sup>**

Daily Intake	Mean $\pm$ SD	Min.	Max.
Number of Dairy Servings	2.6 $\pm$ 0.7	1.5	3.9
Calories, kcal	2201.8 $\pm$ 501.6	1578.2	2837.6
Protein, g	98.3 $\pm$ 21.7	45.1	135.3
Total fat, g	71.6 $\pm$ 22.6	27.6	101.2
Saturated fat, g	23.5 $\pm$ 9.7	6.8	41.1
Vitamin A, RE	1671.5 $\pm$ 909.8	519.4	4311.4
Vitamin B2, mg	2.5 $\pm$ 0.6	1.2	3.8
Vitamin B12, mcg	5.2 $\pm$ 2.4	2.2	11.9
Vitamin D, IU	265.5 $\pm$ 129.6	120.5	765.8
Calcium, mg	1330.2 $\pm$ 268.5	851.9	1873.3
Magnesium, mg	356.0 $\pm$ 97.3	221.9	566.2
Phosphorus, mg	1677.4 $\pm$ 368.3	902.3	2444.6
Potassium, mg	3728.8 $\pm$ 747.1	2261.1	5116.8
Sodium, mg	4014.0 $\pm$ 1289.5	2050.7	7564.8

<sup>1</sup>Ten diets each with 1600 kcal/day, 2200 kcal/day and 2800 kcal/day

**TABLE 18. Nutrient Contribution from Dairy as a Percentage of Daily Intakes of 30 Diets**

Daily Intake	1600 kcal/day			2200 kcal/day			2800 kcal/day		
	Dairy Contribution	Total Diet	Dairy as Percent of Total	Dairy Contribution	Total Diet	Dairy as Percent of Total	Dairy Contribution	Total Diet	Dairy as Percent of Total
Calories, kcal	225.8	1599.8	14.1	370.0	2198.6	16.8	484.4	2807.1	17.3
Protein, g	18.8	74.6	<b>25.3</b>	27.8	103.5	<b>26.9</b>	32.8	116.9	<b>28.1</b>
Total fat, g	7.8	47.0	16.6	16.3	71.9	<b>22.7</b>	24.2	96.1	<b>25.2</b>
Saturated fat, g	3.6	13.8	<b>26.1</b>	7.7	23.6	<b>32.7</b>	11.9	33.2	<b>35.8</b>
Vitamin A, RE	254.3	1369.0	18.6	378.3	1986.9	19.0	364.5	1658.7	<b>22.0</b>
Vitamin B2, mg	0.7	2.2	<b>30.7</b>	1.1	2.7	<b>40.9</b>	1.2	2.7	<b>45.5</b>
Vitamin B12, mcg	1.7	5.1	<b>32.7</b>	2.5	5.3	<b>48.0</b>	2.9	5.2	<b>56.7</b>
Vitamin D, IU	144.1	213.5	<b>67.5</b>	198.2	347.6	<b>57.0</b>	196.0	235.3	<b>83.3</b>
Calcium, mg	632.4	1076.0	<b>58.8</b>	877.0	1479.9	<b>59.3</b>	986.5	1434.5	<b>68.8</b>
Magnesium, mg	58.3	291.5	<b>20.0</b>	87.8	361.1	<b>24.3</b>	98.2	415.4	<b>23.6</b>
Phosphorus, mg	512.8	1326.9	<b>38.6</b>	769.2	1802.7	<b>42.7</b>	794.7	1902.6	<b>41.8</b>
Potassium, mg	711.9	3119.9	<b>22.8</b>	991.5	3768.4	<b>26.3</b>	1145.7	4298.0	<b>26.7</b>
Sodium, mg	388.0	2905.0	13.4	647.0	4180.3	15.5	687.6	4956.7	13.9

**TABLE 19. Nutritional Composition Used To Replace One/Two Dairy Servings<sup>1</sup>**

	<u>Dairy</u>	<u>Fish</u>	<u>Greens</u>	<u>Fortified OJ</u>	<u>Soy Beverage</u>	<u>Tofu</u>
Serving Size	Varies	3 ozs	~1 cup	1 cup	1 cup	1/4 brick
Calories, kcal	136.1	139.3	41.0	109.6	123.2	102.9
Protein, g	10.2	17.4	3.4	2.0	9.3	11.1
Total fat, g	6.1	7.2	0.5	0.7	4.3	6.3
Saturated fat, g	2.8	1.6	0.1	0.1	0.5	0.9
Vitamin A, RE	129.1	149.7	7642.1	194.2	415.7	116.7
Vitamin B2, mg	0.4	0.2	0.1	0.1	0.2	0.1
Vitamin B12, mcg	0.9	4.5	0.0	0.0	1.2	0.0
Vitamin D, IU	70.7	389.9	0.0	0.0	40.0	0.0
Calcium, mg	322.3	224.9	226.2	350.0	137.4	479.6
Magnesium, mg	31.7	28.2	34.1	27.4	58.5	40.9
Phosphorus, mg	269.8	317.1	41.2	27.4	140.8	133.2
Potassium, mg	368.8	296.0	349.2	473.0	383.1	166.2
Sodium, mg	222.4	352.1	187.7	2.5	91.3	9.7

<sup>1</sup>Dairy composition was calculated from the average dairy product used to create diets. Composition of other foods was created by combining relevant values from USDA, Nutritionist IV, and from nutrition labels (especially for fortification)

**TABLE 20. Effects Of Replacing Dairy Servings With Other Foods Recommended By Food Guide Pyramid<sup>1,2</sup>**

Nutrient	Diet as Formulated	Replace One Dairy Serving With <sup>3</sup>					Replace Two Dairy Servings With <sup>4</sup>				
		Fish	Fortified	Greens	Soy	Tofu	Fish	Fortified	Greens	Soy	Tofu
			OJ	Beverage				OJ	Beverage		
Calories, Kcal	2202	2205	2175	2107	2189	2169	2208	2149	2012	2176	2135
Protein	98.3	105.6	90.1	91.5	97.4	99.2	<b>112.8</b>	<b>81.9</b>	84.7	96.4	100.1
Total Fat	71.6	72.7	66.2	66.0	69.9	71.8	73.7	60.7	60.4	68.1	72.0
Saturated Fat	23.5	22.3	20.8	20.8	21.2	21.6	21.1	18.0	18.1	18.9	19.7
Calcium	1330.2	1232.8	1357.9	1234.1	<b>1145.2</b>	1487.5	<b>1135.4</b>	1385.6	<b>1138.1</b>	<b>960.3</b>	<b>1644.8</b>
Magnesium	356.0	352.5	351.7	358.4	382.8	365.2	349.0	347.4	360.8	409.5	374.4
Phosphorus	1677	1725	<b>1435</b>	1449	1548	1541	1772	<b>1193</b>	<b>1220</b>	<b>1419</b>	<b>1404</b>
Sodium	4014	4144	3794	3979	3883	3801	4273	3574	3945	3752	3589
Potassium	3729	3656	3833	3709	3743	3526	3583	3937	3690	3757	3324
Vitamin A	1672	1692	1737	<b>9184</b>	1958	1659	1713	1802	<b>16697</b>	2245	1647
Vitamin D	265.5	<b>584.7</b>	194.8	194.8	234.8	194.8	<b>903.9</b>	<b>124.1</b>	<b>124.1</b>	204.1	<b>124.1</b>
Riboflavin	2.5	2.3	2.2	2.3	2.3	2.2	<b>2.1</b>	<b>1.9</b>	<b>2.0</b>	<b>2.1</b>	<b>1.9</b>
Vitamin B12	5.2	<b>8.7</b>	4.3	4.3	5.5	4.3	<b>12.3</b>	<b>3.3</b>	<b>3.3</b>	5.7	<b>3.3</b>

<sup>1</sup>Based on 30 diets formulated by dieticians to meet Food Guide Pyramid recommendations (10 diets each for Patterns A, B & C).

<sup>2</sup>Bolded numbers are significantly higher (p < 0.05) than diet as formulated (with recommended dairy servings); Bolded and underlined numbers are significantly lower (p < 0.05) than formulated diets.

<sup>3</sup>One average dairy serving was replaced with one serving of these foods (recommended by Food Guide Pyramid as alternative calcium sources).

<sup>4</sup>Two average dairy servings were replaced with two servings of these foods (recommended by Food Guide Pyramid as alternative calcium sources).

These data indicate that when one serving of dairy products is replaced by one of the recommended non-dairy sources of calcium, few nutrient changes occur. However, calcium levels were 14% lower when soy beverage replaced dairy products. Recommendations to include soy beverage in the diet as a calcium alternative to dairy products should be made with caution as calcium levels can vary greatly since no standard level of calcium fortification exists for soy based beverages. The lower bioavailability of calcium from soy and other non-dairy calcium sources beverages should also be considered [61-63]. When two servings of dairy products are removed and replaced with non-dairy calcium sources, significant dietary changes occur. Vitamin D, riboflavin, vitamin B12 were significantly lower when two servings of dairy products were replaced by two servings of certain non-dairy calcium sources.

We also determined the frequency of consumption of these non-dairy calcium sources using one-day of intake from the Continuing Survey of Individuals (CSFII 1994-96, 1998). We determined the total number of eating occasions and then isolated consumption of dairy and non-dairy calcium sources via individual food codes for these products. **Table 21** shows the frequency of consumption of dairy and non-dairy calcium sources based on CSFII consumption data. Dairy products (milk, cheese and yogurt) comprised about 10% of all eating occasions while all the non-dairy calcium sources we examined comprised less than 0.2% of eating occasions. Amongst all of the non-dairy calcium sources, leafy green vegetables had the highest percentage of eating occasions of 0.06%. These data indicate that since dairy products are more widely consumed (50 times more frequently consumed) as compared to 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.

### **Summary**

**Thus, while calcium intake was, in general, maintained (except for soy beverage, primarily due to level of fortification in the marketplace) when replacing one serving of dairy products with non-dairy calcium sources whereas replacing two servings with non-dairy calcium sources resulted in significant reductions occurred. Careful consideration of the impact on the intake of other nutrients is warranted when recommending non-dairy sources, especially if these sources replace dairy products in the diet. Considering the high nutrient density of dairy products, particularly low-fat dairy products, more emphasis should be placed on consumption of more dairy products rather than attempting to add other less nutrient dense non-dairy calcium sources to the diet.**

**TABLE 21. Eating Occasions Of Dairy And Non-Dairy Sources Of Calcium In CSFII<sup>1</sup>**

Foods	Eating Occasions	% Eating Occasions
TOTAL	311153	
Whole milk	10256	3.296
2% fat milk	8155	2.621
1% fat milk	2150	0.691
Skim milk	2797	0.899
<b><u>TOTAL MILK</u></b>	<b>23358</b>	<b>7.507</b>
Natural Cheese	4149	1.333
Processed Cheese	2592	0.833
<b><u>TOTAL CHEESE</u></b>	<b>6741</b>	<b>2.166</b>
Yogurt	1028	0.330
<b><u>TOTAL DAIRY</u></b>	<b>31127</b>	<b>10.004</b>
Sardines	14	0.004
Salmon	19	0.006
<b><u>TOTAL CANNED FISH</u></b>	<b>33</b>	<b>0.011</b>
Fortified Orange Juice	70	0.022
Soy Beverage	61	0.020
Turnip	86	0.028
Collard	109	0.035
<b><u>TOTAL GREENS</u></b>	<b>195</b>	<b>0.063</b>
Tofu	NA	
<b><u>TOTAL NON-DAIRY</u></b>	<b>587</b>	<b>0.189</b>

<sup>1</sup>Food occasions from one-day of CSFII

## **PART II**

### **IMPACT OF DAIRY FOODS ON CHRONIC DISEASE RISK**

#### **Osteoporosis**

Osteoporosis is characterized by low bone mass and bone tissue deterioration, leading to skeletal fragility. Bone mass later in life is determined primarily by peak bone mass, of which more than 90% is attained by 20 years of age [64]. Osteoporosis is recognized today to be a “pediatric disease with geriatric consequences” [65]. Dietary calcium intake early in life is positively associated with bone mass [66-69]. In a cross-sectional study of 139 women, Nieves et al. [66] found that higher lifetime calcium intake was associated with higher hipbone density compared with low lifetime calcium intake. These authors estimated that an increase in teenage calcium intake from 800 to 1,200 mg per day would increase hipbone density by 6%. In an analysis of papers published since 1975 describing studies of the relationship of calcium intake and bone health, Heaney [70] found that of 52 investigator-controlled calcium intervention studies, 50 demonstrated better bone balance at high intakes, greater bone gain during growth, reduced bone loss in the elderly, or reduced fracture risk. Of the 86 observational studies, 64 were positive; confirming that the causal relationship observed in the intervention studies also exists in free-living persons. Fully three-fourths of the observational studies support the hypothesis that increased calcium and calcium-rich dairy foods protect the skeleton.

Six of the intervention studies used dairy foods as the calcium sources and all reported the positive link between calcium intake and bone health. All showed significant positive effects that were at least as strong as the effects of calcium supplements. This is not surprising as it has been long established and well understood that milk supports growth; thus, it is evident that milk and milk products are good sources of the nutrients needed for bone development and maintenance.

At least four randomized clinical trials (RCT) have reported significant fracture reduction with increased calcium intake [65-67,70]. For example, Chapuy et al. [71] employed a combination of calcium, phosphorus, and vitamin D, and observed an approximately 40% reduction in hip and other extremity fractures within 18 months. Dawson-Hughes et al. [72] reported that supplementation with calcium and vitamin D reduced non-vertebral fractures by 55% within 3 years. These studies also highlight the importance of the multiple nutrients existing in combination in dairy foods. In an osteoporosis-prevention study in which women received 1000 mg/day calcium via either a supplement or milk, the latter concurrently and significantly improved the intake of 11 other key dietary nutrients. Analysis by Barger-Lux and Heaney [11] of the diets of premenopausal women revealed that women consuming <60% of recommended levels of calcium were also consuming inadequate levels of at least four other key nutrients, which are delivered by dairy foods.

#### **Summary**

**While the importance of calcium to bone health early in life is well established, its importance to skeletal integrity across the life span is now well accepted.**

**Inadequate calcium and dairy food intake in youth sets the stage for skeletal fragility in later life, resulting in osteoporosis and increased risk of osteoporotic fractures which can be debilitating and life-threatening. Dietary calcium has been unequivocally demonstrated to enhance bone health at every stage of life, with high usual intakes being associated with formation of greater bone mass in childhood and adolescence, and with reduced bone loss and fracture risk in the elderly. The data regarding bone health and calcium and dairy products validate the critical need for regular, lifelong consumption of at least 3-4 dairy servings a day to maintain the structural integrity of the human skeleton.**

### ***Hypertension***

Substantial scientific evidence indicates that calcium or calcium-rich dairy foods have a beneficial effect on blood pressure regulation [24-28, 73-76]. A 1984 analysis of the first National Health and Nutrition Examination Survey (NHANES I), comprising dietary data from more than 10,000 American adults identified an inverse association between dietary calcium and blood pressure levels; dietary calcium intake >1000 mg was associated with a 40-50% reduction in hypertension prevalence [77]. Of the 17 nutrients assessed in that study, including sodium and potassium, calcium was the only nutrient that differed significantly in intake between persons with and without hypertension. The relationship between higher calcium intake and lower blood pressure has now been reported in numerous population surveys [reviewed in 74-76].

Randomized clinical trials that have assessed the effects on blood pressure of calcium or dairy products have confirmed a blood pressure-lowering effect of adequate calcium consumption from foods and from supplements [24-26,72]. Although blood pressure responses to modifications in nutrient intake typically vary among individuals, the beneficial blood pressure effect tends to be more consistent when foods rather than calcium supplements are used as the mineral source (24,25,78). This finding indicates that calcium may serve as a marker for dairy foods, and that observed blood pressure benefits are not derived solely from calcium, but from the full nutritional profile of dairy foods, which include multiple minerals, vitamins, protein and essential fatty acids.

In the landmark controlled-feeding intervention trial *Dietary Approaches to Stop Hypertension* (DASH) [24], persons with high-normal blood pressures consumed one of three diets for 8 weeks. A control, or “typical American,” diet was compared to a diet rich in fruits and vegetables (8-10 servings/day), and a diet rich in fruits and vegetables that also included 3 servings of dairy products/day and was lower in total fat, saturated fat and high in fiber. The latter, the “DASH diet,” resulted in impressive reductions in both systolic blood pressure (SBP) (5.5 mm Hg) and diastolic blood pressure (DBP) (3 mm Hg) compared to the control, or typical American, diet. The fruits-and-vegetables diet (without the dairy component) produced blood pressure reductions of roughly half that magnitude (SBP 2.7 mm Hg; DBP 1.9 mm Hg).

Subgroup analysis of the trial revealed even more profound effects of the DASH diet within certain populations. Among African-Americans, the DASH diet resulted in blood pressure reductions of 6.9 mm Hg systolic and 3.7 mm Hg diastolic compared to the

control diet [79]. These reductions were approximately double those achieved with the fruits-and-vegetables diet that did not include dairy foods. Particularly noteworthy in this cohort, in which lactose maldigestion is presumed to occur more commonly than in other racial groups, was the lack of adverse gastrointestinal effects that might be expected with the addition of 3 dairy servings to the daily diet [24].

Blood pressure changes with the DASH diet were most dramatic in persons with established hypertension (SBP  $\geq 140$  mm Hg or DBP  $\geq 90$  mm Hg). While the fruits-and-vegetables diet compared to the control produced decreases of 7.2 SBP and 2.8 mm Hg DBP, the DASH diet, with its inclusion of dairy foods, resulted in decreases of 11.4 mm Hg SBP and 5.5 mm Hg DBP. As noted by the investigators, these blood pressure improvements rival those attainable with antihypertensive medications [24]. At study completion, 70% of the DASH diet group had normal blood pressure (SBP  $< 140$ , DBP  $< 90$  mm Hg), compared with 23% of the control group and 45% of the fruits-and-vegetables diet group [80].

The effects on blood pressure of the DASH diet were further examined in the DASH-Sodium Trial in which the diet was tested with various levels of sodium [25]. As seen in the first DASH Trial, blood pressure was significantly reduced in persons consuming the DASH diet compared to the control diet, and this occurred across all levels of sodium intake. This study confirmed that for most adults, with the exception of older persons with established hypertension, regular consumption of a high quality diet, rich in fruits, vegetables, and dairy products, is the optimal dietary means of controlling blood pressure.

The recently published results of the PREMIER Trial, an RCT assessing effects of simultaneous lifestyle modifications to improve blood pressure including the DASH diet, demonstrated the feasibility of increasing dairy intake in the population [81]. Nearly 60% of the study participants on the DASH diet met their dairy intake goal, whereas only one-third achieved the fruits and vegetable intake.

In the Coronary Artery Risk Development in Young Adults (CARDIA) Trial, a multicenter population-based prospective observational study, a consistent reduction was observed in the incidence of hypertension with higher consumption of dairy foods – including low and full-fat varieties, butter, and ice cream – (p for trend  $< 0.001$ ) in overweight individuals ( $\geq 25$  kg/m<sup>2</sup>) [34]. Other factors related to the insulin resistance syndrome (IRS) were also lower with higher dairy intake, including obesity, abnormal glucose tolerance, and dyslipidemia. The 10-year cumulative incidence of hypertension with the lowest dairy consumption ( $< 10$  times/week or  $< 1.5$  servings/day) was 22.9% compared to 8.7% in those with the highest ( $\geq 35$  times/week or  $\geq 5$  servings/day). The odds of elevated blood pressure were considerably lower with both low-fat (OR 0.79, 95% CI 0.64-0.98) and full-fat dairy (OR 0.84, 95% CI 0.71-0.99). The odds of elevated blood pressure were lower by nearly 20% for each daily eating occasion of dairy products.

## **Summary**

**A considerable database of observational and clinical trials exists regarding the beneficial effects of dairy food consumption on blood pressure and the risk of hypertension. Prospective and cross-sectional observational studies indicate that dairy food consumption is associated with lower prevalence as well as lower risk of developing hypertension. The results of randomized controlled clinical trials suggest that the consumption of recommended levels of dairy products can contribute to lower systolic and diastolic blood pressure in individuals with normal and elevated blood pressure. The blood pressure-lowering effect of dairy products is best exemplified by the Dietary Approaches to Stop Hypertension (DASH) clinical trial. This study demonstrated that a low-fat dietary pattern high in fruits and vegetables (8-9 servings/d) and dairy products (~3 servings/d) produced greater reductions in SBP and DBP than either a diet high in only fruits and vegetables or the control diet.**

**Taken together, these data support the notion of a blood pressure-lowering effect of dairy, and provide strong support for recommending at least 3 servings per day of dairy foods in conjunction with the FGP-recommended numbers of servings of fruits and vegetables for an overall healthy diet.**

## **Weight Management and Body Composition**

Emerging research indicates that dairy products may contribute to body weight regulation through its influence on the ability of adipose tissue to store, mobilize and oxidize depot fat.

### ***Animal Model Studies***

Recent studies have used transgenic mice that over-express the agouti gene specifically in adipocytes (aP2-agouti) [82] to assess the impact of increased dairy intake on weight gain, weight loss and body fat alterations [33,83]. Zemel and colleagues [33] evaluated the effects of diets high in sucrose and fat containing graded levels of calcium from CaCO<sub>3</sub> or dairy (nonfat dry milk) on body weight and body fat gain for 6 weeks.

Compared to a low calcium control diet (0.4%), weight gain was reduced by 26 and 29% in animals consuming 'medium' calcium diets (1.2% wt/wt) from either CaCO<sub>3</sub> or from dairy (25% of total dietary protein), respectively (p<0.04) without changes in food intake. On a 'high' calcium diet containing 2.4% calcium derived from dairy (50% of total dietary protein), body weight was reduced further by 39% (p<0.04).

Total fat pad mass was reduced 36% by all three elevated calcium diets, whereas the reduction in abdominal fat pad mass was greater on the 'medium' and 'high' dairy diets than on the higher CaCO<sub>3</sub> diets. Also, core temperature increased about 0.5°C in response to all three higher calcium diets (p<0.03). The control low calcium diet caused a 67% reduction in lipolysis while the higher calcium diets stimulated lipolysis by 3.4 to 5.2 fold (p<0.015). These data indicate from this transgenic model that increasing dietary calcium attenuates diet-induced adiposity by modulating adipocyte intracellular calcium and thereby coordinately regulating lipogenesis and lipolysis.

In a second study, this same group evaluated the effect of graded levels of calcium from CaCO<sub>3</sub> or dairy (nonfat dry milk) on body weight and lipid metabolism in aP2-agouti transgenic mice fed an energy-restricted diet [83]. A low calcium (0.4% wt/wt) diet ad lib resulted in ~100% increase in adipocyte calcium levels, a 29% increase in body weight and a doubling of total fat pad mass, whereas the higher calcium diets resulted in a 50% reduction in adipocyte calcium levels (p<0.001). Energy restriction of the low calcium control diet had no effect on adipocyte calcium levels but did result in an 11% decrease in body weight (p<0.001). However, greater body weight reductions of 19%, 25%, and 29% were observed in the high CaCO<sub>3</sub>, medium (1.2% Ca<sup>++</sup>) and high (2.4% Ca<sup>++</sup>) dairy diets, respectively. Thus, in this animal model, dietary calcium facilitates reduction of adipose tissue mass and body weight by modulating energy metabolism, serving to reduce energy storage and increase thermogenesis.

### **Human Studies**

Epidemiologic studies have identified strong inverse relationships between body weight and dietary calcium and dairy product intake [33,34,83,35]. In their 1984 analysis of the NHANES I database, McCarron et al. [77] reported a statistically significant inverse association between calcium intake and body weight. Investigating the antihypertensive effect of calcium by increasing its intake from approximately 400 mg to 1000 mg/day with the addition of yogurt to the diets of obese blacks, Zemel et al. [33] observed a 4.9 kg reduction in body fat. In a later analysis of the NHANES III database, these investigators found “a profound reduction in the odds of being in the highest quartile of adiposity associated with increases in calcium and dairy product intake” [33].

Although RCT data directly assessing the calcium-weight association are somewhat limited, a review of studies in which calcium intake was the independent variable and bone mass or blood pressure as the outcome variable, has confirmed other observational reports [84,85]. In a study of 82 young girls, Cadogan et al. [19] reported the impact on bone mineral acquisition of providing one pint of milk/d for 18 months. Mean calcium intake of the milk group was 1125 mg/d compared to 703 mg/d for the control group. Protein, calcium, phosphorus, magnesium, zinc, riboflavin and thiamine were higher in the milk group at the end of the trial. There was also greater acquisition of bone mineral in the milk-supplemented group; total bone density increased 9.6% compared to 8.5% in the control group (p=0.017). Both groups showed similar increments in height, weight, lean body mass, and fat mass, although the milk group showed non-significant trends toward greater gain in weight and lean body mass and reduction in percentage of body fat. This suggests that the weight gain in the milk group was predominately lean tissue.

Lin et al. [30] examined the effects of calcium intake on changes in body composition during a 2-year exercise intervention in 54 normal weight young women consisting of three resistance-exercise sessions and one hour of jumping rope per week. Mean calcium intake was 781 mg/d and dairy calcium was 537 mg/d. At the end of 2 years, except for a 0.68 kg increase in lean mass, there were no changes in body composition among exercisers and non-exercisers. Total calcium and dairy calcium per kcal were negatively related to change in body weight and body fat. Thus, as calcium intake per energy intake (mg/kcal) increased, there was a decrease in body weight and body fat. These researchers

concluded that the effect of calcium was specific to dairy calcium because total calcium and dairy, when adjusted for energy, predicted changes in body weight and body fat whereas non-dairy calcium did not.

Davies et al. [31] reevaluated five clinical trials originally designed to determine skeletal end points to determine the association of calcium intake and body weight. In this study, BMI and change in body weight were regressed against calcium intake per protein intake. Significant negative slopes of BMI regressed against calcium to protein ratio were found for individual studies and in combined analysis. The pooled slope was  $-0.186 \text{ kg/m}^2/\text{mg/g}$  ( $p < 0.01$ ). The odds ratio for being overweight for calcium below the median intake was 2.25 ( $p < 0.02$ ). These results indicate that a 100 mg/d increase in calcium intake may result in a 0.82 kg/y decrease in body weight in young women, 0.038 kg/y in middle-aged women, and 0.052 kg/y in older women. In another retrospective analysis, Melanson et al. [86] have shown, using whole body, indirect calorimetry, that high calcium intake promotes fat oxidation, supporting similar conclusions of Zemel et al. in their animal model [33].

Recent findings in animals and in humans demonstrate that there are greater effects on body weight from dairy-containing foods than might be predicted from their calcium content alone. In the CARDIA trial described above, a consistent reduction in the incidence of obesity was observed in overweight individuals ( $\geq 25 \text{ kg/m}^2$ ) with increasing consumption of dairy foods ( $p$  for trend  $< 0.001$ ) [34]. Other components of IRS were also improved by higher dairy intakes including hypertension, abnormal glucose tolerance, and dyslipidemia. The 10-year cumulative incidence of obesity in overweight individuals with the lowest dairy consumption ( $< 1.5$  servings/d) was 64.8% compared to 45.1% in those with the highest dairy consumption ( $\geq 5$  servings/d). The odds of obesity were considerably reduced with both reduced fat dairy (OR 0.84, 95% C, 0.70-1.02) and full-fat dairy (OR 0.84, 95% CI 0.73-0.97). The odds of obesity were lower by nearly 20% for each daily eating occasion of total dairy products.

A recent clinical study compared the relative effects of supplemental calcium and dairy products for 24 wk on weight loss during energy restriction in 32 obese adults [87]. Body weight loss was 26% greater in the supplemental calcium group (1200-1300 mg Ca/d), but was 70% greater in subjects consuming identical levels of calcium supplied from 3-4 servings of dairy/d (milk, cheese, yogurt) compared to the low-calcium control group (total calcium intake: 400-500 mg/d) ( $p < 0.01$ ). When compared with the low-calcium diet, fat loss (measured by DEXA) in the high supplemental calcium and high dairy groups was augmented by 38% and 64%, respectively ( $p < 0.01$ ). Participants who consumed the high supplemental calcium diet or the high-dairy diet also showed significantly greater ( $p < 0.001$ ) fat loss in the trunk area than did those who consumed the low-calcium diet. These findings are consistent with two other abstract reports by these same authors, one looking at obese African Americans [88] with essentially the same beneficial outcomes in terms of decrease in body fat, trunk fat, and increase in lean mass and the second in obese adults [89]. This latter abstract documented a greatly augmented improvement in waist circumference as well as other indicators of reduced body fat mass. In all these studies the dietary (dairy) calcium intake in the group of adults experiencing

the marked improvement in measures of adiposity was equivalent to 3-4 servings of a dairy product per day.

### **Summary**

**Taken together, the available data provide strong support for a beneficial effect of increased dairy foods on body weight and fat loss. Animal studies have demonstrated an important role of increased dairy on decreasing body weight and body fat during over consumption and during energy restriction. Most observational data and clinical trial results indicate a statistically significant inverse relationship between dairy intake/calcium intake and body weight and body fat loss. Recent clinical studies have also demonstrated that body weight and body fat loss occurs when adequate calcium is provided by supplements and that this effect is augmented by an equivalent amount of calcium supplied from dairy foods, indicating that additional nutrients from dairy foods are playing a role. As recently stated in the proceedings of a symposium on dairy products and weight regulation: “If emerging data can be confirmed, increasing the low dairy product and calcium intakes in the United States may greatly contribute to reducing the growing epidemic of obesity and IRS” [90].**

### **Blood Lipid Effects of Dairy**

Daily calcium intake in which dairy products provided 60% of the total calcium was negatively correlated with plasma LDL cholesterol (LDL-C), total cholesterol and the ratio of total/HDL cholesterol [35]. In a cross-sectional analysis of NHANES III dairy product consumption ranging from <1 to >5 servings per day was associated with a modest increase in total and saturated fat intake. However, dairy consumption was not related to plasma LDL-C, TC or triglycerides [91]. In a prospective population based study that examined the association between dairy intake and the incidence of the Insulin Resistance Syndrome, no association between dairy intake and the incidence of high LDL-C was observed [34].

### **ESTIMATED HEALTHCARE SAVINGS ASSOCIATED WITH ADEQUATE DAIRY FOOD INTAKE**

The economic impact of increasing consumption of dairy products across the population has been assessed [92]. Based on several decades of data from prospective longitudinal studies and randomized controlled trials, adequate intake of dairy foods, with their broad complement of essential nutrients, was shown to be a common factor in the reduction of the disease burden of several medical conditions.

The authors of that study searched the medical literature for both RCTs and observational and prospective longitudinal studies that assessed 1) the relationship between dairy calcium or dairy product consumption and the prevalence of these disorders, or 2) the impact on the disorder of an intervention utilizing calcium or dairy intake as a major

component of the intervention. They distinguished between observational cross-sectional and prospective longitudinal studies because the latter in many cases were established to study specific conditions, while the former often include multivariate probing analyses. Annual cost figures for the respective conditions were obtained from recent literature and published data from public and private health organizations. To derive first-year cost savings for each condition, the authors used projections of benefit from clinical outcomes data that were mid-range. It was not possible to estimate year-1 cost reductions for all disorders; for stroke, coronary artery disease, and colorectal cancer, the published data do not indicate response times of less than several years.

In addition to those described above, low calcium/dairy intake was also linked to type 2 diabetes, kidney stones, certain outcomes of pregnancy, and some cancers. Summarizing the available evidence of the net benefits of increased dairy food intake on these conditions, their outcomes, and their costs, first- and fifth-year direct healthcare cost savings were conservatively estimated.

The authors estimate that increasing dairy food intake to 3-4 servings per day would be associated with an annual reduction of 5% in the incidence of obesity in Americans, increasing by an additional 5% per year, yielding a 25% reduction at 5 years. Using that estimate of impact, one-year healthcare savings would approach \$2.5 billion and at 5 years would exceed \$37.5 billion.

On the basis of the collective observations for hypertension, the authors project a virtually immediate 40% reduction in the prevalence of mild to moderate hypertension with an increase in dairy product intake to 3-4 servings/d. First-year healthcare cost savings would approach \$14 billion, and be sustained for a cumulative savings at 5 years of \$70 billion.

For purposes of this analysis, the authors used a conservative estimate, i.e., a 20% reduction in fracture risk related to dairy intakes that provide, with other food calcium sources, 1000-1500 mg Ca/d. Direct costs for all osteoporotic fractures combined were estimated to be \$17 billion for 2002. A 20% reduction translates to \$3.5 billion savings each year, achievable by year 2 of the higher intake, reaching cumulative savings of \$14 billion over five years.

For the other conditions assessed in this study, stroke (\$20 B), coronary artery disease (\$16.5 B), type 2 diabetes (\$37.5 B) nephrolithiasis (\$2.5 B), pregnancy (\$15 B) and colorectal cancer (\$0.75 B) the five year savings were equally impressive. This analysis demonstrated that if adult Americans increased their intake of dairy foods to 3-4 servings/d, healthcare savings within the first year would be approximately \$26 billion and 5-year cumulative savings would exceed \$200 billion.

## FINAL SUMMARY STATEMENT

This review provides what we believe are relevant data and a public health rationale for recommending the consumption of 3 - 4 servings of dairy foods per day. These data demonstrate the practical feasibility of increasing dairy from 2 – 3 to 3 – 4 servings per day in a realistic dietary regimen that improves the overall nutrient composition of the diet through the use of naturally nutrient dense foods. A recommendation to increase dairy food intake to 3 – 4 servings per day is also consistent with recommendations from Health Canada [93], The American Academy of Pediatrics [94] and the American Heart Association [95]. In addition, the National Medical Association, the nation's oldest and largest organization representing African American physicians and health professionals in the United States, has recently adopted a recommendation that African Americans should consume at least three servings of low-fat milk, cheese, or yogurt daily to reduce the risk of certain chronic diseases and conditions such as osteoporosis, hypertension, some cancers and obesity [National Medical Association Consensus Statement: "The Case for Calcium in the African American Diet", pending publication in the J. Natl Med Assoc., 2004].

Finally, it is reasonable to expect long term public health benefits and potential healthcare cost savings from recommendations to increase the consumption of dairy foods by helping Americans meet their calcium needs as well as increasing the intake of other synergistic nutrients associated with dairy foods, including potassium, magnesium, phosphorus, and vitamins D, A, B<sub>12</sub>, riboflavin and niacin.

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