Vitamin E intakes and sources in the United States[1,2]

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ABSTRACT Twenty-four-hour-recall data from 11 658 adults interviewed in the Second National Health and Nutrition Examination Survey (NHANES II) were used to estimate intakes of vitamin E and polyunsaturated fatty acids (PUFAs) in the United States. Although mean intakes of vitamin E were close to the recommended dietary allowance for both men and women (9.6 and 7.0 mg/d, respectively), median intakes were considerably lower (7.3 and 5.4 mg/d). If a ratio of vitamin E to PUFAs of ≥ 0.4 is considered desirable, 23% of men and 15% of women had diets with low ratios. Ratios tended to decrease as PUFAs in the diet increased. The fruits-and-vegetables group and the fats-and-oils group each provided 20% of the vitamin E in the US diet. Increasing food choices from the fruits-and-vegetables group would provide low-fat sources of vitamin E for individuals whose intakes are likely to be inadequate. *Am J Clin Nutr* 1990;52:361–7.

KEY WORDS Vitamin E, nutrient intakes

Introduction

Walton and Packer (1) postulated that vitamin E plays a protective role in preventing the formation of potentially carcinogenic oxidative products of unsaturated fatty acids. Thus, requirements for this vitamin may increase as intakes of polyunsaturated fatty acids (PUFAs) increase. There is an increasing body of prospective epidemiologic evidence showing low serum concentrations of vitamin E are associated with increased incidence of certain types of cancer (2–5).

The recommended dietary allowance (RDA) for vitamin E is 10 mg α-tocopherol equivalents (TE) per day for men and 8 mg TE/d for women and assumes a customary intake of PUFAs (6). Previous reports of vitamin E intakes indicated that mean intakes approach the RDA (7–11). With recent dietary guidance emphasizing substitution of PUFAs for saturated fatty acids, it is likely that the diets of many individuals now contain higher amounts than has been customary in the past. Although foods that are high in PUFAs are often also high in vitamin E, this is not always the case (9), and it is possible to select diets that have relatively low ratios of vitamin E to PUFAs. This paper reports intakes of vitamin E and PUFAs and ratios of vitamin E to PUFAs for adults in the United States as reflected in the Second National Health and Nutrition Examination Survey (NHANES II). Major food sources of vitamin E in US diets are also presented.

Methods

NHANES II was a large representative sample of the noninstitutionalized population of the United States. The survey was conducted between 1976 and 1980 by the National Center for Health Statistics (12). Dietary data were collected by means of 24-h recalls, with the aid of three-dimensional abstract models to aid in portion-size estimation. Although 24-h recalls are not valid for inferences about an individual's diet, they can provide valid information about group intakes. Data were used from 11 658 black or white adults (ages 19–74 y) after imputed, surrogate, or unreliable responses were excluded. These methods were described in detail elsewhere (13, 14).

The NHANES II nutrient database does not contain values for vitamin E. Linoleic acid is included but total PUFAs is not. Thus, it was necessary to assign values for vitamin E and PUFAs to all the 2244 food items reported by adults in the survey. Nutrient values from the University of California, Berkeley, (UCB) Minilist were used as the basis for this assignment. Sources of vitamin E values for the UCB Minilist included US Department of Agriculture (USDA) *Handbook No. 8-4* for fats and oils (15) and several published papers giving analytic values for vitamin E (9, 16–18). When values were given for different forms of the vitamin, the recommended conversion factors were applied (6) to obtain TE: β-tocopherol was multiplied by 0.5, γ-tocopherol by 0.1, and α-tocotrienol by 0.3. PUFA values were obtained primarily from the revised USDA *Handbook No. 8* (19) plus *Handbook No. 456* (20). There are no missing values on the UCB Minilist; when analytic values are not available for a food item, an imputed value is assigned by a nutritionist experienced in the development of food composition data on the basis of values for similar foods.

As previously described (21), the UCB Minilist food codes were cross-referenced to the NHANES II food codes by using a combination of direct substitution, adjustment factors for calorie differences, and recipes. This process involved an initial detailed review of comparability between the food codes, refinement and extension of the substitution index, and comparison of the resulting NHANES II vitamin E and PUFA values with those on the nutrient database developed by the USDA for

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TABLE 1
Mean and median vitamin E intake and density per 1000 kcal, by sex, age, race, poverty-index ratio (PIR), and education: data from NHANES II 1976–1980

		Vitamin E intake		Vitamin E density	
	n	$\bar{x} \pm$ SEM	Median	$\bar{x} \pm$ SEM	Median
		mg TE		*mg TE/1000 kcal*	
Men					
All ages	5509	9.62 ± 0.17	7.33	3.97 ± 0.06	3.39
19–34 y	1818	10.54 ± 0.33	8.57	3.75 ± 0.10	3.29
35–50 y	1118	9.31 ± 0.25	7.65	3.88 ± 0.09	3.36
51–65 y	1587	8.80 ± 0.31	6.99	4.23 ± 0.16	3.51
>65 y	986	8.33 ± 0.37*	6.06	4.67 ± 0.22*	3.52
White	4905	9.82 ± 0.17	7.52	4.03 ± 0.06	3.42
Black	604	7.82 ± 0.29†	6.07	3.49 ± 0.09†	3.17
PIR (percentile)					
0–25th	1196	8.72 ± 0.34	6.55	3.59 ± 0.13	3.18
25–50th	1380	9.08 ± 0.20	7.21	3.73 ± 0.09	3.40
50–75th	1444	10.17 ± 0.45	7.55	4.22 ± 0.16	3.43
75–100th	1489	10.11 ± 0.35‡	7.91	4.18 ± 0.10‡	3.50
Education (grade)					
≤8th	1141	7.70 ± 0.28	6.02	3.75 ± 0.17	3.25
9–12th	2527	9.24 ± 0.21	7.34	3.73 ± 0.08	3.33
>12th	1841	10.71 ± 0.30§	8.37	4.33 ± 0.11§	3.62
Women					
All ages	6149	7.01 ± 0.12‖	5.42	4.63 ± 0.08‖	3.89
19–34 y	1973	7.17 ± 0.18	5.73	4.37 ± 0.13	3.68
35–50 y	1253	7.12 ± 0.24	5.67	4.59 ± 0.11	3.91
51–65 y	1740	6.78 ± 0.23	5.37	4.93 ± 0.14	4.05
>65 y	1183	6.60 ± 0.26*	4.90	5.05 ± 0.18*	4.15
White	5417	7.14 ± 0.13	5.46	4.68 ± 0.08	3.91
Black	732	6.01 ± 0.16†	5.03	4.17 ± 0.09†	3.83
PIR (percentile)					
0–25th	1798	6.61 ± 0.23	4.91	4.35 ± 0.13	3.66
25–50th	1544	7.00 ± 0.26	5.35	4.60 ± 0.14	3.86
50–75th	1417	7.22 ± 0.25	5.94	4.70 ± 0.15	4.05
75–100th	1390	7.23 ± 0.15‡	5.82	4.87 ± 0.10‡	4.17
Education (grade)					
≤8th	1142	5.85 ± 0.20	4.50	4.33 ± 0.10	3.72
9–12th	3254	6.79 ± 0.18	5.33	4.48 ± 0.10	3.81
>12th	1753	7.86 ± 0.22§	6.21	4.99 ± 0.13§	4.19

* Significantly different from 19–34-y age group, $p < 0.0001$.
† Significantly different from white race, $p < 0.0001$.
‡ Significantly different from lowest quartile of PIR, $p < 0.0001$.
§ Significantly different from education < 9th grade, $p < 0.0001$.
‖ Significantly different from men, $p < 0.0001$.

use in the Continuing Survey of Food Intakes by Individuals (CSFII) conducted in 1985–1986. Most discrepancies involved processed-food items and, in particular, those with vitamin E fortification. In these cases manufacturers' data were used to update the NHANES II nutrient data.

The resulting nutrient values were then applied to the NHANES II 24-h-recall data, and daily totals of vitamin E and PUFA intake were calculated for each individual. These totals did not include vitamin E intake from vitamin supplements because quantified data on supplement amounts were not available. As a result, total vitamin E intake will be underestimated for some individuals. Mean intakes were determined for all adults, and for population groups on the basis of age, sex, race, years of education, and poverty-index ratio (PIR), a measure of income adjusted for family size and composition. Means were calculated using sample weights provided by the National Center for Health Statistics, and SEMs were adjusted for the clustered design effect (22) so that the results may be generalized to the US population as a whole.

To determine food sources of vitamin E, the 2244 different food codes in the original NHANES II data were grouped into 147 food categories by conceptual and nutrient similarities as previously described (23); these categories were then slightly modified to ensure similarity of vitamin E content, giving a final set of 144 categories. For a presentation of an overview of vitamin E sources, foods were further aggregated into 15 broad categories, roughly corresponding to those used for food guidance (24). For each food category the amount of vitamin E obtained from that category and the proportion of total vitamin E intake supplied by each category was calculated. Thus, these

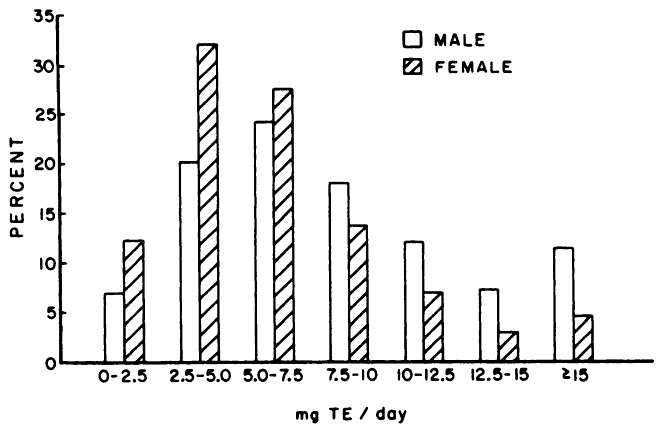

FIG 1. Frequency distribution of adult US vitamin E intakes. Data from NHANES II 1976–1980.

data combine information on frequency of consumption, average serving size, and vitamin E concentration for each food so that the contribution of each category to the vitamin E in the US diet can be calculated. The percentage of persons in the United States consuming foods in each category on a single day was also estimated by use of sample-weighted data.

The ratio of vitamin E intake (in mg TE) to PUFA intake (in g) was calculated for each individual. A ratio cannot be calculated if PUFA intake is zero, and very large ratios result from diets with very small PUFA content. Therefore, for diets with a PUFA value of 0 (n = 38), the ratio was set to a high value of 99. Thus, means of the ratios are not meaningful and only medians and percentiles are reported.

Results

As shown in **Table 1**, mean vitamin E intakes were slightly below the RDA for both men (96% of the RDA) and women (88% of the RDA). Median intakes were considerably lower, 73% percent of the RDA for men and 68% of the RDA for women. The distributions are skewed by a few individuals with very high intakes as shown in **Figure 1**. Thus, even though the means were close to the RDA, the diets of 69% of men and 80% of women were below the respective RDAs.

Mean and median intakes declined with increasing age for both sexes (Table 1). Intake by whites exceeded that by blacks. Intake increased with increasing PIR and with completion of more years of education. When intake was calculated as density (mg TE/1000 kcal), the same trends were seen for race, PIR, and education. However, although women had lower vitamin E intakes than men had, women had a higher density of vitamin E in their diets. Likewise, although older adults had lower intakes, their diets had higher densities of vitamin E.

Mean intakes of PUFAs were 16.3 g/d for men and 10.8 g/d for women (**Table 2**) whereas median intakes were lower, 13.2 g/d for men and 8.7 g/d for women. As with vitamin E intakes, PUFA intakes declined with age and were lower for blacks than for whites.

The distribution of ratios of vitamin E to PUFA intake is shown in **Figure 2.** Twenty-three percent of men and 15% of women had ratios < 0.4. As shown in **Table 3,** ratios were high (median 0.94) for individuals with diets low in PUFAs (< 5 g/d) and declined with increasing PUFA intakes to a median of 0.44 for individuals with PUFA intakes > 25 g/d. Almost 25% of individuals with PUFA intakes > 10 g/d had ratios of ≤ 0.4.

The richest food sources of vitamin E per average portion (those providing ≥ 1.0 mg) are shown in **Table 4** (these 21 foods were selected from the 144 items representing all foods reported in NHANES II after those reported fewer than 100 times were excluded). Superfortified cereals, which often are fortified to 100% of the USRDA (20 mg TE per serving) (25), are by far the most concentrated source of vitamin E. Instant breakfasts and diet bars, also products that are usually fortified, provide the second richest source. Although salad and cooking oils are rich sources of vitamin E (ranging from 12 mg TE/100 g for olive oil to 51 mg/100 g for sunflower oil), they are consumed in relatively small servings and thus rank only 20th on this list. Foods that are high in fats and oils (such as pies and fried foods) or that are usually consumed in relatively large portions (such as vegetables and mixed dishes) are rich sources of vitamin E per average serving.

TABLE 2
Mean and median PUFA intake, by sex, age, and race: data from NHANES II 1976–1980

	n	$\bar{x}$ ± SEM	Median
		g/d	*g/d*
Men			
All ages	5509	16.3 ± 0.28	13.2
19–34 y	1818	18.4 ± 0.38	15.8
35–50 y	1118	16.4 ± 0.48	14.4
51–65 y	1587	13.8 ± 0.30	11.9
>65 y	986	12.0 ± 0.31	10.4
White	4905	16.5 ± 0.28	13.4
Black	604	14.4 ± 0.50	11.2
Women			
All ages	6149	10.8 ± 0.15	8.7
19–34 y	1973	11.5 ± 0.18	9.9
35–50 y	1253	11.4 ± 0.26	9.4
51–65 y	1740	9.7 ± 0.19	8.2
>65 y	1183	8.9 ± 0.27	7.4
White	5417	10.9 ± 0.15	8.8
Black	732	10.0 ± 0.21	8.2

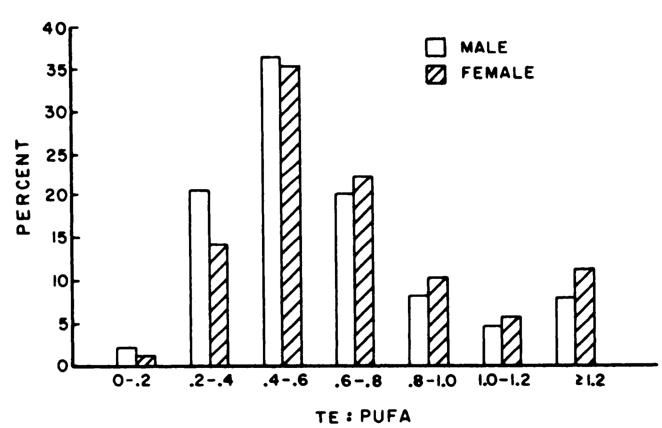

FIG 2. Frequency distribution of dietary ratios of vitamin E to PUFA, expressed in mg TE and g PUFA. Data from NHANES II 1976–1980.

TABLE 3
Percentiles of vitamin E-PUFA ratios, by PUFA intake: data from NHANES II 1976-1980

PUFA intake	*n*	Vitamin E:PUFA 25th percentile	Median	75th percentile
g/d				
0-5	1911	0.59	0.94	1.47
>5-10	3519	0.48	0.65	0.86
>10-15	2803	0.44	0.54	0.69
>15-20	1530	0.41	0.51	0.64
>20-25	809	0.38	0.48	0.58
>25	1086	0.35	0.44	0.54

Also shown in Table 4 are the ratios of vitamin E to PUFAs for these foods. As expected most ratios were high because the foods are all high in vitamin E. Foods containing very small amounts of PUFAs often have ratios that are very high (such as 254 for superfortified cereals) or cannot be calculated because the amount of PUFAs is essentially zero (most fruits and vegetables). However, foods with higher PUFA contents tend to have relatively low ratios and 6 of the 144 food groups had ratios < 0.2: sausage, bacon, cooking fat and lard, liverwurst, roast chicken and turkey, and fried chicken.

TABLE 4
Vitamin E content per usual portion size: data from NHANES II 1976-1980

Food group	Vitamin E per portion*	Vitamin E per 100 g*	Ratio of vitamin E to PUFA†
	mg TE	*mg TE*	
1 Superfortified cereals	33.5	137.5	254.4
2 Instant breakfast and diet bars	4.3	12.8	28.5
3 Shellfish	2.8	4.5	58.2
4 Mustard or turnip greens, kale, and collards	2.5	2.6	‡
5 Pies	2.5	2.5	1.9
6 Fried fish	2.1	2.3	0.8
7 French fries and fried potatoes	1.9	1.5	0.5
8 Spaghetti with tomato sauce	1.7	0.7	94.9
9 Chili	1.7	0.8	1.8
10 Peanuts and peanut butter	1.6	8.1	0.5
11 Mixed dishes with chicken	1.5	1.2	6.4
12 Pizza	1.4	0.9	1.0
13 Beef stew and pot pie	1.4	0.4	93.0
14 Coleslaw and cabbage	1.3	2.4	52.2
15 Fish, broiled, baked, or canned	1.3	1.4	21.7
16 Mayonnaise and salad dressings	1.3	11.3	0.4
17 Tuna, tuna salad, and tuna casserole	1.3	2.1	0.4
18 Spinach	1.2	1.9	95.1
19 Melons	1.2	0.4	‡
20 Salad and cooking oils	1.2	14.7	0.8
21 Salty snacks	1.0	4.8	0.5

* Vitamin E values are weighted, aggregate values of the individual foods within each category.
† Expressed in mg TE and g PUFA.
‡ These foods contain no PUFA, so a ratio cannot be calculated.

TABLE 5
Contribution of food categories to vitamin E in the adult US diet: data from NHANES II 1976-1980

Food category	Percent of total vitamin E	Cumulative percent of vitamin E	Percent of persons consuming*
		%	
Fats and oils	20.2	20.2	82.2
Vegetables	15.1	35.2	81.2
Meat, poultry, and fish	12.6	47.9	92.2
Desserts	9.9	57.8	79.1
Breakfast cereals	9.3	67.1	23.4
Fruit	5.3	72.4	58.3
Bread and grain products	5.3	77.7	92.1
Dairy products	4.5	82.2	78.4
Mixed main dishes	4.0	86.2	20.3
Nuts and seeds	3.8	90.0	12.8
Eggs	3.2	93.2	31.3
Salty snacks	3.0	96.2	15.9
Legumes	2.1	98.2	14.5
Soups, sauces, and gravies	1.7	100.0	30.8
Beverages	0.0	100.0	95.6

* Percent of persons reporting one or more items from each food group on the day of the 24-h recall.

Table 5 presents data on the contribution of 15 aggregated food categories to vitamin E in the US diet. Fats and oils were the number-one contributor, providing > 20% of vitamin E in the US diet. These foods are both rich in vitamin E and frequently consumed (82.2% of US adults consumed fats and oils on any given day). Vegetables were the second major contributor, providing ~15%, whereas fruits, the sixth-highest contributor, provided ~5%. If fruits and vegetables are combined, they provided more vitamin E in the US diet than do fats and oils. Although nuts and seeds are rich sources of vitamin E, they contributed only 3.8% to the diet because they were infrequently consumed (12.8% of persons on any given day).

More detailed information on food sources of vitamin E for blacks and whites is given in **Table 6.** The contribution to total intake of the top 25 food items (of 144) for each race is given. There were several differences by race. The top contributor for whites was superfortified cereals whereas this item did not appear in the top 25 contributors for blacks (actual rank 40). Greens were the second highest contributor for blacks and did not appear in the top 25 contributors for whites (actual rank 54). Foods in the top 10 that were in common for both races included mayonnaise and salad dressing; margarine; doughnuts, cookies, and cake; French fries and fried potatoes; salad and cooking oils; pies; and eggs.

Discussion

Frank deficiency of vitamin E is rare and is generally limited to premature infants or adults with fat malabsorption (26, 27).

TABLE 6
Vitamin E sources, by race: data from NHANES II 1976–1980

Food group	Percent of total vitamin E	Cumulative percent of vitamin E	Percent of persons consuming*
		%	
For blacks			
1 Margarine	6.93	6.93	34.66
2 Mustard or turnip greens, kale, and collards	6.47	13.40	12.16
3 Fried fish	6.25	19.65	12.83
4 Doughnuts, cookies, and cake	5.88	25.53	31.41
5 Mayonnaise and salad dressings	5.58	31.11	21.94
6 Eggs	5.31	36.42	36.66
7 Salad and cooking oils	3.97	40.39	14.96
8 French fries and fried potatoes	3.60	43.99	12.92
9 Pies	3.14	47.13	7.98
10 Cornbread, grits, and tortillas	3.11	50.24	23.31
11 White bread, rolls, and crackers	2.96	53.21	74.03
12 Salty snacks	2.92	56.12	12.38
13 Spaghetti with tomato sauce	2.09	58.22	7.52
14 Peanuts and peanut butter	2.02	60.24	4.90
15 Coleslaw and cabbage	1.85	62.09	7.44
16 Pinto, navy, and other dried beans	1.85	63.94	12.53
17 Green salad	1.83	65.77	24.55
18 Whole milk and whole milk beverages	1.56	67.33	33.21
19 Beef steaks, roasts	1.42	68.75	18.90
20 Pork, including chops, roast	1.38	70.12	20.53
21 Potatos, excluding fried	1.29	71.42	17.10
22 Tuna, tuna salad, tuna casserole	1.23	72.65	4.77
23 Shellfish	1.21	73.86	1.47
24 Instant breakfast, diet bars	1.03	74.90	1.08
25 Fish broiled, baked, canned	0.95	75.85	4.38
For whites			
1 Superfortified cereals	8.17	8.17	1.40
2 Mayonnaise and salad dressings	7.88	16.05	32.47
3 Margarine	7.14	23.19	42.69
4 Doughnuts, cookies, and cake	5.44	28.63	42.08
5 French fries and fried potatoes	4.33	32.97	17.88
6 Salad and cooking oils	3.71	36.67	16.24
7 White bread, rolls, and crackers	3.32	39.99	76.98
8 Pies	3.06	43.05	8.46
9 Eggs	3.01	46.06	30.66
10 Green salad	2.98	49.04	42.23
11 Salty snacks	2.97	52.01	16.32
12 Peanuts and peanut butter	2.94	54.94	10.53
13 Spaghetti with tomato sauce	2.34	57.29	9.87
14 Coleslaw and cabbage	1.87	59.15	9.68
15 Shellfish	1.82	60.97	3.33
16 Whole milk and whole-milk beverages	1.71	62.68	42.34
17 Cheeses, excluding cottage cheese	1.69	64.37	34.57
18 Fried fish	1.67	66.04	5.03
19 Tomatoes and tomato juice	1.64	67.68	26.75
20 Beef steaks and roasts	1.43	69.11	23.27
21 Bran and granola cereals	1.26	70.37	7.42
22 Tuna, tuna salad, and tuna casserole	1.24	71.61	6.31
23 Potatoes, excluding fried	1.13	72.74	26.80
24 Pinto, navy, and other dried beans	1.06	73.79	10.48
25 Instant breakfast and diet bars	0.97	74.76	1.47

* Percent of persons reporting one or more items from each food group on the day of the 24-h recall.

However, erythrocyte fragility can occur with long-term intakes of 2 mg/d (28). As a fat-soluble antioxidant, vitamin E may protect unsaturated fatty acids from degradation by free radical reactions, and thus optimal intakes may offer some protection against long-term effects such as cellular aging and cancer (1). It was shown that breath pentane, an indicator of lipid peroxidation, may be related to vitamin E status (29). In the Elgin experiments Horwitt (28) showed that the amount of vitamin E required to prevent erythrocyte fragility increases as PUFAs in the tissues increase. Because the lipid composition of tissue cannot be measured directly, dietary intake of PUFAs is used as an indicator of requirement. Horwitt (30) postulates a base requirement of 4 mg TE/d plus a factor for percent of calories from PUFAs and grams PUFAs in the diet as follows:

$$\text{Requirement (mg TE)} = 4 + 0.25\,(\%\ \text{PUFA kcal} + \text{g PUFAs})$$

From the data on mean PUFA intakes in Table 2, the requirement for men would be 9.6 mg TE/d and for women would be 8.3 mg TE/d. These numbers are close to the RDA of 10 and 8 mg TE/d for men and women, respectively, as specified by the

National Research Council (6). As reported in Table 1, the mean intake for men (9.6 mg/d) was close to the RDA whereas the mean intake for women (7.0 mg/d) was somewhat below the recommended intake. However, it is important to note the skewed distribution of intakes as shown in Figure 1—the median intake for both men (7.3 mg/d) and women (5.4 mg/d) is well below the corresponding recommendation, and 25% of men reported intakes < 4.7 mg/d whereas 25% of women reported intakes < 3.6 mg/d. The recommendation is based on the assumption that average intakes in the United States are adequate, but average intakes are well above median intakes. If recommendations are to be based on intake, it might be more appropriate to consider median rather than mean values.

These intake data are based on a single 24-h recall, and thus the distribution would be greater than that for mean intakes based on multiple days of dietary data (31). Data from the CSFII (7) for women 19–50 y of age showed mean intakes of 7.1 mg TE/d based on data collected for 4 d in 1985—very close to intakes reported in Table 1 for women in this age group (7.2 mg/d for women 19–34 y and 7.1 mg/d for women 35–50 y). In the CSFII, 25% of the women reported 4-d average intakes < 4.4 mg/d whereas 25% of the NHANES II women reported 1-d intakes < 3.6 mg/d. Thus, averaging data collected for 4 d appears to have increased the 25th percentile by only 0.8 mg/d.

Fortification of selected food items contributed substantially to the skewed distribution of vitamin E intakes. The USRDA for this vitamin is 20 mg TE [assuming 1 IU is equivalent to 1.49 mg TE (11)]. This value is based on the 1968 RDA for men, which was twice the current RDA. As a result, several ready-to-eat cereals, instant breakfasts, and meal-replacement products are fortified to an amount twice the men's RDA per serving or 2.5 times the women's RDA. Very high intakes of vitamin E were invariably due to consumption of these highly fortified products. Although there is no evidence that these amounts are toxic (32), they are a major cause of the difference between the mean and median intake values.

Because the requirement for vitamin E is partially based on PUFA intakes, it is important to examine the ratio of vitamin E to PUFAs in diets. A desirable ratio is thought to be ~0.4 (6) but allowance must be made for diets very low in PUFAs. As would be expected, ratios (shown in Table 3) were highest for diets low in PUFAs and decreased with increasing PUFA intakes. Thus, it appears that vitamin E consumption was not linearly predicted by PUFA consumption—the ratio for diets with PUFAs > 25 g/d was less than half that for diets with PUFAs < 5 g/d. If there is a base requirement for vitamin E of ~4 mg/d, even with no PUFAs in the diet (and thus before any antioxidant needs are considered), then it would be necessary for ratios to be > 0.4 for diets low in PUFAs. It is obvious that evaluating intakes based on a fixed ratio is not appropriate for all diets.

Ratios of vitamin E to PUFAs in foods vary widely. Fortified foods often have very high amounts of vitamin E and little or no PUFAs, giving ratios that can approach infinity. Few foods are high in PUFAs without containing at least moderate amounts of vitamin E, but the ratios can be as low as 0.07 (walnuts) or as high as 1.42 (olive oil). The ratio for soy oil is 0.43 whereas that for sunflower oil is 0.77. The data in Table 3 show a decrease in ratios of vitamin E to PUFAs as PUFAs in the diet increases; therefore, the types of foods chosen differ as PUFAs increase. The additional dietary PUFAs must come from foods with relatively low ratios. Low ratios are found in meat and chicken (~0.2). As shown by Block et al (14), pork, chicken, and hamburgers are among the top 20 food sources of linoleic acid in the US diet. Mayonnaise and salad dressing, the top contributors of linoleic acid in the US diet, have a ratio of 0.35. Diets that are high in PUFAs but have low ratios are likely to contain substantial amounts of these foods.

Although dietary guidelines have emphasized the desirability of substituting PUFAs for saturated fatty acids (33, 34), intakes appear to have increased only slightly between collection of these data (1976–1980) and the CSFII (1985–1986): mean intakes of women 19–50 y were 11.4–11.5 mg/d in 1976–1980 (Table 2) and 11.8–12.6 mg/d in 1985–1986 (7, 8). If PUFA intakes are increasing, an increase in vitamin E need will occur. Fortunately, most foods that are high in PUFAs also are high in vitamin E. Oils used in processing often have been low in both PUFAs and vitamin E (eg, coconut oil), but consumer pressure is changing the types of oils used by the food industry. However, the destruction of vitamin E during the processing of foods such as salty snacks, crackers, and commercially fried foods may lead to low dietary ratios of vitamin E to PUFAs.

Vitamin E values on nutrient databases are of necessity means representing a variety of processing and storage conditions. For nutrients such as vitamin E, which are subject to destruction by exposure to light, heat, and various chemical agents (17, 35), it is difficult to estimate the amount in a specific food item or diet without chemical analyses. Furthermore, analytic data are not available on a wide variety of frequently consumed foods, and these data must be imputed from similar food items. Publication of data on vitamin E composition for more foods and for a wider variety of processing and preparation methods would allow more accurate estimation of the vitamin E content of individual diets.

The data in Table 6 indicate that foods that are frequently consumed can be good sources of vitamin E even though they are not concentrated sources of this vitamin. For example, doughnuts, cookies, and cake provide > 5% of the vitamin E in the diets of both blacks and whites, but this food category does not appear in Table 4 as one with high vitamin E density. Thus, to adequately estimate intakes of vitamin E, it is necessary to include these foods on food frequency questionnaires. Furthermore, the foods that should be included may vary depending on the race of the population being studied. The data in Table 6 will be useful to investigators developing quantified food frequency questionnaires. (A complete list of the vitamin E content of the 144 categories may be obtained by contacting the authors.)

If the RDAs for vitamin E are correct, it is of concern that so many individuals have intakes well below these amounts. Some groups of individuals have particularly low vitamin E intakes relative to recommendations: median intakes of blacks, elderly persons (> 65 y of age), persons with < 9 y education, and persons with low income (of both sexes) fell below two-thirds of the RDA. Although women chose diets of higher vitamin E density than did men, their lower calorie intake made attainment of the recommendation difficult. For these groups, food choices from the list in Table 4 could increase vitamin E intakes. However, care must be taken to consider the fat content of the resulting diet, because many foods that are rich in vitamin E also are high in fat and dietary guidelines emphasize reducing total fat intakes (36–38). However, there are many low-fat options in Table 4, eg, fruits and vegetables. Increasing intakes of these food items is likely also to have other benefits, such as increasing intakes of dietary fiber and other vitamins, such as A, C, and folacin.

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