Dietary Magnesium Intake in a National Sample of U.S. Adults

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ABSTRACT Despite the role of magnesium in maintaining health, much of the U.S. population has historically not consumed adequate amounts of magnesium. Furthermore, significant racial or ethnic disparities in magnesium intake exist. Our objective was to provide more recent data about magnesium intake in the U.S. population. We analyzed the 24-h dietary recall data from 4257 participants aged ≥20 y from the National Health and Nutrition Examination Survey 1999–2000. The median intake of magnesium was 326 mg/d (mean 352 mg/d) among Caucasian men, 237 mg/d (mean 278 mg/d) among African American men, 297 mg/d (330 mg/d) among Mexican American men, 237 mg/d (mean 256 mg/d) among Caucasian women, 177 mg/d (mean 202 mg/d) among African American women, and 221 mg/d (mean 242 mg/d) among Mexican American women. Among men and women, Caucasians had significantly higher mean intakes of dietary magnesium than African Americans but not Mexican Americans. Magnesium intake decreased with increasing age (*P* for linear trend = 0.035 for Caucasians; *P* for linear trend <0.001 for African Americans and Mexican Americans). Men had higher intakes of magnesium than women for each of the three race or ethnic groups (P < 0.001 in each group). Caucasian men, African American men and Caucasian women who used vitamin, mineral or dietary supplements consumed significantly more magnesium in their diets than did those who did not. Substantial numbers of U.S. adults fail to consume adequate magnesium in their diets. Furthermore, racial or ethnic differences in magnesium persist and may contribute to some health disparities. J. Nutr. 133: 2879–2882, 2003.

KEY WORDS: • diet • magnesium • nutrition surveys • sex

Magnesium is an essential element that is crucial to hundreds of physiologic processes in humans (1). Not surprisingly, inadequate intake of magnesium has been linked to various adverse health outcomes, including the development of cardiovascular disease (2), hypertension (3), diabetes mellitus (4) and headaches (5). Furthermore, magnesium is important in bone growth (6) and may play a role in athletic performance (7). Studies of magnesium supplementation have been conducted in patients with cardiovascular disease (8,9), hypertension (10), diabetes mellitus (11), asthma (12), migraines (13) and pregnant women (14). Furthermore, magnesium is used to treat cardiac arrhythmias, myocardial infarction, asthma, preeclampsia and eclampsia (15,16).

Despite the physiologic role of magnesium and its proven or potential benefits, surveys show that the dietary intake of magnesium is inadequate in the U.S. population as well as in other populations (17–20). Several population groups, such as African Americans, people with less education, and the elderly, have particularly low intakes of magnesium (20,21). The findings of magnesium intake below recommendations by many raises the issue of the adequacy of magnesium status in the U.S. population (22). Yet, little is known about the magnesium status in this population. The only population-based survey in the United States of serum magnesium concentrations was conducted from 1971 through 1974. A striking result of an analysis of that survey was the lower mean serum magnesium concentration among African American participants compared with Caucasian participants (23). About 23% of U.S. adults aged 25–74 y had a serum magnesium concentration of <0.8 mmol/L, a concentration that is consistent with hypomagnesemia (24). Some population groups have lower magnesium concentrations than reference groups. For example, people with diabetes have a lower magnesium concentration than people without this condition (25). To examine more recent intakes of magnesium in the U.S. population, we examined data from the National Health and Nutrition Examination Survey (NHANES)[2] 1999–2000.

SUBJECTS AND METHODS

This analysis is based on NHANES data obtained during 1999–2000 (26). A representative sample of the noninstitutionalized civilian U.S. population was selected by using a stratified, multistage sampling design. Trained interviewers, using a computer-assisted personal interview system, interviewed participants at home. Participants were requested to attend the mobile examination center, where they were asked to complete additional questionnaires, undergo various examinations and provide a blood sample. Persons with low incomes, persons aged ≥60 y, African Americans and Mexican Americans were oversampled. The study received human subjects approval, and participants were asked to sign an informed consent form.

Unlike previous NHANES in which all participants were interviewed in person, a 24-h dietary recall was administered either in person to participants attending the mobile examination center or by telephone 4–10 d after the health examination. In a subsample of primary sampling units, participants who were randomly assigned to a morning session in the mobile examination center were interviewed in person. Those randomly assigned to an afternoon or evening session were scheduled for a telephone interview. However, some of these participants completed a dietary interview in person because

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[2] Abbreviations used: EAR: estimated average requirement; NHANES: National Health and Nutrition Examination Survey; RDA: recommended dietary allowance.

they did not have a telephone or because of scheduling problems. Of the 4273 adults aged ≥20 y who participated in the recall, 3521 were interviewed in person in the mobile examination center and 752 were interviewed by telephone. Trained, bilingual interviewers conducted the interviews using a computer-assisted dietary interview system in English and Spanish. Translators assisted with participants who spoke other languages. Various probes, such as lists of frequently forgotten food or drinks and specific food probes, were used to enhance reporting by the participants. The dietary information was processed using the University of Texas Food Intake Analysis System and the USDA 1994–1998 Survey Nutrient Database (27,28).

We stratified the analyses by age, sex, and race or ethnicity (Caucasian, African American and Mexican American). The analyses included only participants aged ≥20 y who attended the mobile examination center. We present means or percentages ± 1 SEM in the text. Differences in means or geometric means were examined with *t* tests. Linear trends were examined using orthogonal polynomial contrasts. We used SUDAAN (Software for the Statistical Analysis of Correlated Data, Research Triangle Park, NC) for analyses to account for the complex sampling design.

RESULTS

Of the 4880 participants aged ≥20 y who were interviewed, 4444 attended the mobile examination center where the dietary recall was administered. Information about magnesium intake was available from 4257 participants (3510 in person and 747 by telephone). For 171 participants, the recall was not done, and for 16 the recall was unreliable.

The mean magnesium intakes were 290 ± 4 mg/d for those who were interviewed in person and 286 ± 10 mg/d for those who were interviewed by telephone ($P = 0.741$). No differences were observed in age ($P = 0.844$) or in the percentages that were men ($P = 0.970$), Caucasian ($P = 0.340$) or had graduated from high school ($P = 0.101$). Because of these similarities, the two groups were analyzed together.

Magnesium intake decreased with increasing age (P for linear trend = 0.035 for Caucasians; P for linear trend <0.001 for African Americans and Mexican Americans). Men had higher intakes of magnesium than women for each of the three race or ethnic groups ($P < 0.001$ in each group). Caucasian men had the largest mean and median magnesium intake followed in order of decreasing mean intake by Mexican American men, African American men, Caucasian women, Mexican American women and African American women (**Table 1**).

Overall, 53.0 ± 1.7% of participants (men: 48.0 ± 1.9%; women: 57.6 ± 2.0%) reported using vitamin, mineral or dietary supplements. A higher percentage of Caucasian men (52.7 ± 2.3%) used such supplements than African American men (29.9 ± 2.8%) and Mexican American men (26.3 ± 3.4%), and a higher percentage of Caucasian women (62.3 ± 2.4%) used supplements than African American women (38.0 ± 2.9%) and Mexican American women (39.8 ± 2.2%). Significantly increased use with age occurred among Caucasian and Mexican American participants but not African American participants.

Among Caucasian and African American men and Caucasian women, those who used supplements had significantly higher mean dietary magnesium intakes than those who did not (**Table 2**).

We also examined the food sources for magnesium intake. Participants reported 3719 different foods that contributed dietary magnesium. According to the food codes, the top 10 contributors to dietary magnesium intake were ground coffee (3.7% of intake), 2% milk (2.6%), whole milk (2.1%), raw bananas (1.8%), beer (1.8%), skim or nonfat milk (1.5%), orange juice (1.5%), lite beer (1.4%), French fries (1.1%) and 1% milk (0.9%). When we grouped the food codes into broad categories, the top 10 contributors were vegetables (12.9%), milk (7.5%), meat (7.3%), bread (6.6%), mixed dishes (6.5%), pizza, pasta, and other miscellaneous dishes (5.6%), coffee (5.3%), sweets (4.6%), cold cereals (4.1%) and alcoholic

TABLE 1

Unadjusted dietary magnesium intakes, National Health and Nutrition Examination Survey, 1999–2000

	Men				Women			
		Magnesium intake				Magnesium intake		
	n	Mean[1]	Mean[2]	Median[3]	*n*	Mean[1]	Mean[2]	Median[3]
		mg/d				*mg/d*		
Caucasians	930	352 ± 6	314 ± 7	326	983	256 ± 7	228 ± 7	237
20–30 y	137	329 ± 14	290 ± 15	299	203	241 ± 13	211 ± 13	213
31–50 y	267	377 ± 13	337 ± 10	353	295	268 ± 11	239 ± 10	249
51–70 y	305	344 ± 11	315 ± 10	325	266	261 ± 6	238 ± 6	241
≥71 y	221	314 ± 15	267 ± 17	280	219	230 ± 10	205 ± 8	205
African Americans	371	278 ± 10*	222 ± 15*	237	439	202 ± 6*	173 ± 6*	177
20–30 y	59	305 ± 27	261 ± 22	270	73	208 ± 14	179 ± 14	176
31–50 y	153	284 ± 15*	218 ± 27*	245	182	208 ± 10*	181 ± 8*	183
51–70 y	107	245 ± 10*	200 ± 13*	213	123	192 ± 9*	169 ± 7*	179
≥71 y	52	227 ± 23*	187 ± 19*	202	61	161 ± 8*	116 ± 23*	144
Mexican Americans	518	330 ± 9	288 ± 7*	297	631	242 ± 7	213 ± 8	221
20–30 y	99	336 ± 24	291 ± 16	275	161	262 ± 15	235 ± 14	239
31–50 y	175	345 ± 11	302 ± 10*	324	201	241 ± 13	213 ± 12	214
51–70 y	178	291 ± 12*	258 ± 12*	262	201	216 ± 14*	185 ± 15*	201
≥71 y	66	251 ± 18*	222 ± 16*	223	68	205 ± 15	177 ± 16	188

1 Values are means ± SEM.
2 Values are geometric means ± SEM.
3 Values are medians.
* Different from Caucasians, $P < 0.05$.

TABLE 2

Unadjusted dietary magnesium intakes, stratified by vitamin, mineral or dietary supplement user status, National Health and Nutrition Examination Survey, 1999–2000

	Users			Nonusers				
		Magnesium intake			Magnesium intake			
	n	Mean[1]	Mean[2]	*n*	Mean[1]	Mean[2]	*P* means	*P* geometric means
		mg/d			*mg/d*			
Men								
Caucasians	517	368 ± 9	331 ± 7	412	333 ± 9	294 ± 9	0.015	0.001
20–30 y	52	320 ± 24	287 ± 22	85	335 ± 19	291 ± 21	0.625	0.905
31–50 y	132	391 ± 20	350 ± 12	135	362 ± 15	324 ± 14	0.229	0.160
51–70 y	193	368 ± 11	339 ± 11	111	297 ± 12	272 ± 12	<0.001	<0.001
≥71 y	140	342 ± 19	302 ± 14	81	263 ± 19	213 ± 30	0.003	0.015
African Americans	116	333 ± 19	284 ± 14	255	255 ± 13	199 ± 20	0.002	0.004
20–30 y	16	345 ± 70	279 ± 55	43	291 ± 27	254 ± 22	0.462	0.659
31–50 y	47	366 ± 30	317 ± 24	106	248 ± 19	185 ± 35	0.005	0.016
51–70 y	37	279 ± 21	255 ± 17	70	226 ± 9	175 ± 16	0.025	0.001
≥71 y	16	204 ± 24	172 ± 30	36	236 ± 30	193 ± 24	0.379	0.600
Mexican Americans	151	355 ± 16	320 ± 16	366	321 ± 13	277 ± 8	0.153	0.033
20–30 y	17	334 ± 42	297 ± 41	82	336 ± 27	290 ± 17	0.960	0.869
31–50 y	55	384 ± 22	350 ± 21	120	324 ± 16	280 ± 13	0.054	0.010
51–70 y	55	307 ± 23	281 ± 22	122	283 ± 12	248 ± 11	0.316	0.104
≥71 y	24	264 ± 38	236 ± 30	42	243 ± 21	214 ± 21	0.631	0.541
Women								
Caucasians	657	273 ± 7	246 ± 6	325	226 ± 10	201 ± 10	<0.001	<0.001
20–30 y	117	276 ± 16	246 ± 14	86	211 ± 16	184 ± 17	0.004	0.007
31–50 y	182	289 ± 15	260 ± 13	112	233 ± 10	209 ± 11	0.002	0.001
51–70 y	193	268 ± 7	245 ± 6	73	243 ± 16	222 ± 15	0.169	0.186
≥71 y	165	239 ± 10	215 ± 8	54	203 ± 20	181 ± 15	0.082	0.046
African Americans	167	213 ± 11	184 ± 9	272	194 ± 7	166 ± 7	0.141	0.096
20–30 y	24	219 ± 29	176 ± 41	49	204 ± 22	180 ± 18	0.716	0.939
31–50 y	71	214 ± 19	186 ± 14	111	204 ± 10	179 ± 9	0.648	0.661
51–70 y	55	217 ± 16	192 ± 13	68	169 ± 8	150 ± 8	0.009	0.009
≥71 y	17	169 ± 16	160 ± 14	44	158 ± 11	102 ± 28	0.615	0.084
Mexican Americans	278	249 ± 11	216 ± 12	351	237 ± 8	211 ± 7	0.256	0.621
20–30 y	59	289 ± 22	255 ± 22	101	250 ± 15	227 ± 14	0.073	0.164
31–50 y	77	244 ± 17	216 ± 17	123	239 ± 16	210 ± 13	0.785	0.724
51–70 y	108	227 ± 23	192 ± 28	93	200 ± 11	176 ± 12	0.303	0.578
≥71 y	34	193 ± 16	171 ± 13	34	218 ± 24	184 ± 25	0.364	0.539

1 Values are means ± SEM.
2 Values are geometric means ± SEM.

beverages (3.8%). Mixed dishes included dishes made with meat or fish and vegetables. Furthermore, a combined category of fruits and fruit juices accounted for 6.3% of magnesium intake.

DISCUSSION

During 1999–2000, the diet of a large proportion of the U.S. population did not contain adequate magnesium. Among men, the estimated average requirement (EAR) and recommended dietary allowance (RDA) are 330 mg and 400 mg for men aged 19–30 y and 350 mg and 420 mg for men aged ≥31 y (29). Among women, the EAR and RDA are 255 mg and 310 mg for women aged 19–30 y and 265 mg and 320 mg for women aged ≥31 y, respectively. The fact that the median dietary intake of magnesium was lower than either the EAR (except Caucasian men aged 31–50 y) or the RDA in all groups suggests that magnesium intake from dietary sources in the U.S. population remains suboptimal.

Supplement use can be an important source of magnesium intake. Many of the most commonly used multivitamin preparations contain 100 mg of magnesium. Unfortunately, data to evaluate the contribution of these supplements to total magnesium intake were unavailable. However, if one assumes that everyone who indicated that they used a supplement consumed 100 mg of magnesium every day, the resulting upper-bound median total magnesium concentrations would increase by as little as 15 mg/d among African American men aged 20–30 y and as much as 76 mg/d among Caucasian women aged 51–70 y. Even then, none of the upper-bound median magnesium intakes of any sex, race and age group reached the RDA. However, the upper-bound median values among Caucasian men aged 20–70 y and Mexican American men aged 31–50 y, all Caucasian women, and Mexican American women aged 20–50 y would equal or exceed the EAR. But large proportions of participants did not consume supplements, and the dietary intake of magnesium was particularly low among these participants. In this analysis, we did not include magnesium from water intake. However, water is not thought to be a major source of magnesium intake for most people (30).

The mean intake for participants from the first phase of NHANES III, which was conducted from 1988 to 1991, was 361 mg for Caucasian men and 291 mg for African American men, 256 mg for Caucasian women and 215 mg for African American women. The NHANES III means were higher than the NHANES 1999–2000 means; however, the differences between the means from the two surveys were not significant. About a decade after NHANES III was conducted, dietary magnesium intake in the U.S. population remains essentially unchanged. Furthermore, race or ethnic differences in magnesium intake also persist (19,31–37).

The dietary data used in these analyses were obtained from a single 24-h dietary recall. However, the 24-h dietary recall method is thought to provide valid estimates of mean and median intakes of nutrients in populations (38).

In conclusion, dietary magnesium intake continues to be inadequate among large numbers of people in the United States. The health implications of suboptimal magnesium intake by many U.S. adults remain poorly understood. Thus, research that addresses the health consequences of inadequate magnesium intake is warranted, particularly in population groups such as African Americans among whom intake is especially low. Increasing numbers of people are using vitamin, mineral or dietary supplements, which provide an important source of magnesium for many. Because magnesium has many potential health benefits, increasing the dietary intake of magnesium in the U.S. population should be an important public health goal. Green vegetables, nuts, seeds, dried beans, whole grains and meats are good food sources of magnesium. Yet, policy approaches that promote the consumption of magnesium remain to be developed. Although diets that followed the food pyramid were thought to provide enough magnesium to meet the RDA before 1997 (39), the upward revision of the RDA for magnesium in 1997 makes it unclear whether diets that follow the food pyramid include sufficient magnesium to meet the current RDA. Current nutritional recommendations that encourage the adequate intake of fruits and vegetables and an increased emphasis on the benefits of nut consumption may, in time, lead to more adequate dietary intake of magnesium. Because magnesium intake is low among many people in the United States and inadequate magnesium status is associated with increased risk of acute and chronic conditions, an urgent need exists to perform a current survey to assess the physiologic status of magnesium in the U.S. population.

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