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# **NUTRITION REPORTS**

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# NUTRITION REPORTS INTERNATIONAL

## DIETARY INTAKE AND NUTRITIONAL STATUS IN REGARD TO MAGNESIUM OF ADOLESCENT FEMALES

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### ABSTRACT

In 1976 and 1977 the dietary intake and nutritional status in regard to magnesium of 80 and 72 adolescent females, respectively, were assessed. The 44 girls who participated in both surveys on the average grew 3cm in height and gained 4kg in the year between the two surveys. The average magnesium intake of subjects in 1976 was  $238 \pm 86$  (SD)mg daily ( $5.56 \pm 4.28$ mg/kg body weight) and in 1977 was  $231 \pm 85$ mg daily ( $4.31 \pm 2.06$ mg/kg body weight). Over one-third of the subjects consumed less than two-thirds of the Recommended Dietary Allowance for magnesium. However, all subjects had a normal concentration of magnesium in their serum. Serum magnesium levels were correlated to dietary magnesium levels in 1976 ( $r = 0.369$ ,  $p < 0.005$ ) but not in 1977. Serum magnesium levels were similar in 1976 and 1977 and were not affected by the age or maturational stage of the subjects.

### INTRODUCTION

Numerous investigators have reported that adolescent females often consume less than optimal levels of iron, calcium, vitamins A and C, and B<sub>6</sub>, and zinc (1-7). However, the dietary intake and nutritional status of adolescent females in regard to magnesium has generally been ignored. White (8) reported that the average magnesium intake of 15 adolescent girls who she studied was 176mg daily.

On the basis of data collected in metabolic studies, investigators have estimated that adults require about 223mg magnesium (4.2mg magnesium per kilogram body weight) daily to compensate for urinary and fecal losses (9,10). Schwartz, et al. (11) estimated that adolescent males required slightly more magnesium than adult subjects to achieve magnesium balance. However, Seelig (12) has noted few investigators considered dermal magnesium losses. Hence she believes human magnesium requirements are about 6mg per kilogram body weight. According to her estimate, a 50kg adolescent female would require 300mg magnesium daily.

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The purposes of this study were to: 1. Estimate the dietary intake of magnesium of adolescent females, 2. Determine the relationship between serum magnesium levels and dietary magnesium intake of subjects, and 3. Assess if serum magnesium levels varied with the growth and development of adolescent subjects.

### METHODS

Adolescent girls who had been surveyed in regard to zinc, copper, and iron nutrition status in 1975 (5) were invited to participate in surveys in the fall of 1976 and the fall of 1977. Eighty girls participated in the survey in the fall of 1976; 72 girls participated in the survey in the fall of 1977. A total of 44 girls participated in both surveys.

Girls were surveyed for dietary intake and serum magnesium levels. They were also measured in stocking feet for height and weight with a beam balance and were questioned regarding their menstrual history. The tricep skinfold was measured on the left arm of each subject as it hung in a relaxed position with a Lange skinfold caliper (Cambridge Scientific Industries, Inc., Maryland) as described by Johnston, et al. (13). Skinfolts were measured three times consecutively on each subject. The average of these measurements were recorded. When 6 skinfold measurements were made on one individual, the coefficient of variation was 5%.

All procedures involving human subjects had been approved by a Purdue University committee on the use of human subjects. All subjects and their parents gave informed consent.

### Nutrition Intake

Dietary intake on week days of subjects was determined through 24-hour diet recalls conducted by trained survey aides using food models. Diet histories were conducted to determine typical meal and snack patterns of the subjects during the previous month. The meal patterns on the day of the diet recalls were typical of the meal pattern described in diet histories by 86% (1976) and 90% (1977) of the subjects. Nutrient composition of diets as determined by the diet recalls was calculated by computer using United States Department of Agriculture food composition tables (14). Additional values were obtained from the literature (14,15). More than 100 foods consumed by these subjects were analyzed for their magnesium content in our laboratory (16).

In 1976, 24% of the subjects took a nutrient supplement at least once a week. In 1977, 18% of the subjects took a nutrient supplement at least once a week. None of the supplements contained magnesium. None of the subjects reported consuming medications regularly in 1976. One subject reported using oral contraceptive agents in 1977.

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### Serum Analysis

Blood samples were drawn with Vacutainer tubes whose stoppers were specially prepared to reduce mineral contamination (Donated by Becton Dickinson, Inc., Fairfield, NJ). When 5 ml of deionized water was stored in inverted Vacutainer tubes for 4 hours and were shaken periodically, the water contained less than 0.2 ug/ml magnesium. Actual blood samples were centrifuged and serum removed within 2 hours after samples were collected. Serum samples were frozen in acid-washed plastic tubes, diluted with strontium to a final concentration of 0.1% (w/v) strontium, and analyzed by atomic absorption spectrophotometry for magnesium as described previously. When known amounts of magnesium were added to three serum samples, 95% of the added magnesium was recovered. When 5 replicates of a pooled blood sample were analyzed for magnesium in this manner, the coefficient of variation was 4%.

### Statistical Treatment

Means, standard deviations, and Pearson correlation factors were calculated by computer using the Statistical Package for the Social Sciences (17). Student's "t" tests were applied when all the subjects who participated in the surveys were compared. Paired "t" tests were applied when the 44 subjects who participated in both surveys were compared to themselves.

### RESULTS

The demographic characteristics of the subjects are summarized in Table 1. These subjects were still growing as evidenced by their significantly greater heights, weights, and skinfold measurements in 1977 than in 1976. The 44 who participated in both surveys, on the average, grew 3cm in height, gained 4kg and increased tricep skinfold measurements by 4mm in the year between the two surveys. Some of the subjects seem to have gained excessive weight. In 1976, 10% of the 80 subjects were taller and 11% of the subjects were heavier than 90% of the girls of similar age included in the National Center for Health Statistics (NCHS) survey (18); 4% of the subjects had greater tricep skinfold measurements than 90% of the girls of similar age in the Health Examination Survey (13). In 1977, only 8% of the 72 subjects were taller than 90% of the age-matched girls in the NCHS survey. However, in 1977 18% of the subjects were heavier and 15% of the subjects had tricep skinfold measurements greater than 90% of the reference females.

### Intake of Magnesium and Other Nutrients

The magnesium intake of subjects in 1976 and 1977 were similar (Table 2). On the days of the surveys in both 1976 and 1977, more than one-third of the subjects consumed less than two-thirds of the Recommended Dietary Allowance (RDA) (19) for magnesium.

TABLE I. DEMOGRAPHIC CHARACTERISTICS OF ADOLESCENT GIRLS SURVEYED IN 1976 and 1977

	All subjects		Subjects participating in both surveys	
	1976	1977	1976	1977
Number of subjects	80	72	44	44
Age (years)+**	13.3 ± 0.7*	14.5 ± 0.9	13.3 ± 0.7	14.3 ± 0.7
Height (cm)+**	158 ± 7	161 ± 5	158 ± 6	161 ± 6
Weight (kg)+**	51 ± 12	57 ± 14	52 ± 14	56 ± 14
Triceps skinfold (mm)+**	12 ± 5	16 ± 6	12 ± 5	16 ± 6
Menarche experienced (%)+**	50	81	55	82

\* Mean ± SD

+ Significant difference ( $\rho < 0.01$ ) between all subjects in 1976 and 1977.

\*\* Significant difference ( $\rho < 0.001$ ) between 44 subjects participating in both surveys.



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TABLE II. CALCULATED DIETARY INTAKE OF ADOLESCENT FEMALES SURVEYED IN 1976 and 1977.

	RDA+	dietary intake		% of subjects consuming less than 2/3 of RDA+	
		1976	1977	1976	1977
Magnesium (mg)	300	238+ 86*	231+ 85	35	38
Protein (g)	44	71+ 26	72+ 23	4	3
Vitamin A (IU)	4000	3500+ 3336	3143+ 2320	44	54
Thiamin (mg)	1.2	1.0+ 0.4	1.1+ 0.5	8	25
Riboflavin (mg)	1.3	1.9+ 0.9	1.8+ 0.7	9	13
Niacin (mg)	16	13+ 5	14+ 5	24	32
Ascorbic Acid (mg)	45	72+ 65	79+ 78	32	29
Calcium (mg)	1200	1018+ 541	945+ 447	38	42
Iron (mg)	18	10.4+ 3.4	10.1+ 3.6	65	72
Zinc (mg)	15	9.5+ 4.1	10.1+ 4.0	58	49

\*Mean + S.D.

+ RDA for 11 to 14 year old females

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The magnesium intake of the girls was also calculated on the basis of their body weight. On the days surveyed in 1976, the girls consumed  $5.56 \pm 4.28$  (SD)mg magnesium per kilogram body weight; on the days surveyed in 1977, the girls consumed  $4.31 \pm 2.06$ mg magnesium per kilogram body weight. The magnesium intake per kilogram body weight was significantly less ( $p < 0.01$ ) in 1977 than in 1976 among the 44 subjects who participated in both surveys. This difference reflects the increase in weight noted among all the subjects in 1977.

### Serum Magnesium Levels

The mean level of magnesium in the serum of 80 subjects in 1976 was  $1.96 \pm 0.19$ mg/100ml and of 72 subjects in 1977 was  $2.00 \pm 0.19$ /100ml. In both years all serum magnesium levels ranged from 1.5 to 2.5mg/100ml. These levels are within the range considered to be normal for healthy human subjects (20,21).

Dietary magnesium intake was positively correlated to serum magnesium levels in 1976 ( $r = 0.369$ ,  $p < 0.005$ ) but not in 1977. Serum magnesium levels were not correlated to the subjects' age or stage of growth and development. The serum magnesium levels of the 44 subjects who participated in both surveys were similar in 1976 ( $1.96 \pm 0.21$ mg/100ml) and in 1977 ( $2.00 \pm 0.19$ mg/100ml). Thirteen girls from this group experienced menarche during the year that elapsed between the two surveys. There was no significant difference in the serum magnesium levels of the girls before ( $2.04$ ug/100ml) and after ( $1.99$ ug/100ml) menarche.

### DISCUSSION

The dietary intake of the adolescent subjects in this study were similar to the dietary intake of adolescent females in regard to protein, vitamins, calcium, iron, and zinc in previous studies (1-7). The magnesium intake of these subjects was much greater than the magnesium consumption of 15 adolescents observed by White (8).

Seelig (12) has suggested that Americans should consume 6mg magnesium per kilogram body weight. According to this standard few of the subjects in 1976 (29%) or 1977 (15%) consumed adequate magnesium. However, the average magnesium intake of these subjects was slightly greater than the levels of dietary magnesium found to be adequate for adults in balance studies (9,10). In 1976 and 1977, 64% and 44% respectively, of the adolescent females surveyed consumed more than 4.6mg magnesium per kilogram body weight. This is the amount of magnesium Schwartz and her associates (11) estimated the average adolescent male required to achieve balance when fed a high protein (90g daily) diet.

Our observation that serum magnesium levels were correlated to the subjects' dietary magnesium levels in 1976 but not in 1977 may reflect one or a combination of four factors. 1.) Serum magnesium levels may



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not be good indicators of magnesium nutritional status. While serum magnesium levels are responsive to extreme changes in dietary magnesium levels, they do not always reflect small variations in dietary magnesium levels (12,21). However, Alfrey, et al (22) found among human subjects a highly significant correlation between serum and bone magnesium levels. Accordingly, they suggested serum magnesium levels were a valid indicator of total body magnesium. 2.) Calculations of dietary intake, based on dietary recalls may not reflect subjects' usual magnesium intake. The meal and snack patterns of subjects recorded on the diet recalls were typical of the meal patterns described by 86% (1976) and 90% (1977) of the subjects in the diet histories. Previously, the validity of the 24-hour dietary recall as a tool to estimate nutrient intake of adolescent females was evaluated by this laboratory (23). The data collected with dietary recalls were found to be valid estimates of a group of adolescents' mean intake of protein, calcium, and zinc. Although magnesium was not specifically considered in this previous evaluation, it seems likely that dietary recalls could be the basis of valid estimates of magnesium intake in this study because the magnesium intake of these subjects was significantly correlated to their protein ( $r=0.682$ ,  $p<0.001$ ) and calcium ( $r=0.652$ ,  $p<0.001$ ) intakes. 3.) Other characteristics of diets may affect serum magnesium levels. A variety of dietary factors, such as phytate, phosphorus, and lactate have been demonstrated to affect magnesium utilization (12). 4.) The physiological state of subjects might affect their utilization of magnesium. However, age, per se, did not appear to affect serum magnesium levels because the 44 subjects participating in both surveys had similar serum magnesium levels both years. The maturational stage of subjects also did not appear to affect serum magnesium levels. The 13 girls who experienced menarche in the year that elapsed between the two surveys had similar serum magnesium levels both years. Prior to menarche the girls would be expected to be growing more rapidly (24). On the basis of a cross-sectional survey, Arnaud, et al. (25) concluded serum magnesium levels were stable from 6 years of age to adulthood also.

The magnesium intake of many of these adolescent subjects was low as compared to the Recommended Dietary Allowance. However, the average intake of magnesium by these subjects was similar to the level of dietary magnesium that were found in metabolic balance studies to compensate for urinary and fecal losses of average adults and adolescent males. Moreover, the serum levels of magnesium were normal for all subjects.

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