Magnesium Requirement of Young Women Receiving Controlled Intakes[1]

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The present status of our knowledge of magnesium requirement and its relation to other dietary constituents has been summarized recently by O'Dell ('60). Magnesium is an important constituent of cardiac and skeletal muscle, of nerve tissue and bone. It is involved in protein, fat, nucleic acid and coenzyme synthesis; in glucose utilization and in neuromuscular activity. It is also an essential activator for several enzymes, some that transfer phosphate, some that are involved with the decarboxylation of pyruvic acid and others concerned with reactions of the Krebs cycle.

Tibbetts and Aub ('37) noted that with intakes of 300 mg of magnesium daily, medical students regularly showed positive balances. Duckworth and Warnock ('42) suggested 220 mg as the magnesium requirement for women, but this amount is low in view of results reported since that time. Leichsenring et al. ('51) found a mean daily retention of 11.6 mg in 9 college women receiving a magnesium intake of 260 mg but 4 of the women were in negative balance for a part of the 21-day period at this intake. More recently Scoular et al. ('57) have reported the magnesium intake and output for 86 young women during a 5-day period when they used analyzed self-chosen diets. Of the 26 subjects with daily intakes between 100 mg and 200 mg of magnesium, 22 were in negative balance; of the 12 subjects with intakes between 220 mg and 300 mg, 10 were in negative balance; and of the 48 subjects with intakes above 300 mg, only 7 were in negative balance.

The purpose of this paper is to add to our knowledge of the quantitative requirements of human subjects for magnesium by presenting the results of metabolic studies of healthy young women receiving a controlled diet with variations in magnesium intake. These results are one phase of a project that measured the range in metabolic response to controlled intakes of several nutrients studied simultaneously.

PROCEDURE

Information on the locations and times of the studies, the young women who served as subjects, and the levels of magnesium intake is given in table 1.[4] The subjects were judged to be in good health on the basis of a thorough medical examination.

The length of each study was divided into consecutive periods of 5 days each and designated A, B, C, D and so on. During the first 5 days of the study, period A, the subjects ate their customary self-chosen diets. They recorded their food consumption in estimated household measures and the magnesium content of

Received for publication January 7, 1961.

[1] Published as Paper 638 Journal Series, Oklahoma Agricultural Experiment Station; Paper 1097 Journal Series, Nebraska Agricultural Experiment Station. Most of the data herein were presented at the meeting of the Fifth International Congress on Nutrition, 1960, Washington, D.C.

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[4] At each of the 4 locations the research was supported in part by a U. S. Department of Agriculture contract sponsored by the Human Nutrition Research Division, Agricultural Research Service.

TABLE 1

General information

Location and initial date of study	Length of study	Subjects—women students				Controlled Mg intake[1]	
		Number	Range				
			Age	Height	Weight		
	days		*years*	*cm*	*kg*	*mg/day*	*days*
Oklahoma State University February, 1956	40	9	19–22	161–178	56–71	247	15
						183	10
						280	10
University of Minnesota January, 1957	35	7	18–21	158–173	47–62	320	15
						236	15
University of Nebraska February, 1956	40	8	18–24	159–176	47–73	278	35
University of Alabama November, 1955	20	6	20–23	159–175	52–65	252	15

[1] During the first 5 days the subjects consumed self-chosen diets.

the self-chosen diets was calculated from figures given by McCance and Widdowson ('36, '47), supplemented by those given by Sherman ('52).

Beginning with the 6th day, the first day of period B, and continuing until the end of the study, all of the subjects were fed the standardized diet which had been developed by the Human Nutrition Research Division of the Agricultural Research Service and is described in detail in USDA Technical Bulletin no. 1126 (Meyer et al., '55). The diet includes ordinary foods which provide palatable meals but only small amounts of most of the minerals and vitamins. Supplements of synthetic and purified products are added so that the total intake provides adequate amounts of essential nutrients.

The intake closely approximated 11 gm of nitrogen daily, 80 gm of fat, 750 mg of calcium, and 950 mg of phosphorus, 60 mg of ascorbic acid, 0.8 mg of thiamine, and 1.0 mg of riboflavin. The exact intakes of these nutrients by the subjects at each location were determined by analyses of food composites (Meyer et al., '55). The basal diet supplied 250 gm of carbohydrate but more sugar was added as needed for sufficient energy value to maintain each subject at a constant weight. By calculation the amounts of trace elements and vitamins provided daily were: (in milligrams) iron, 10; copper, 0.8; iodine, 0.105; manganese, 2; zinc, 4; niacin, 7; pantothenic acid,[2] 4; pyridoxine, 0.8; choline, 300; also folic acid, 100 μg; cobalamin, 5 μg, vitamin A, 4000 I.U. and vitamin D, 400 I.U.

The magnesium in the standardized diet was supplied about equally by the foods and by magnesium gluconate which was incorporated into yeast rolls. The amount of the gluconate was altered to accomplish changes in the total magnesium intake.

Complete collections of urine and feces were made beginning with the first day of period A and continuing throughout the study. Carmine was used to mark the feces at the beginning of each 5-day period.

Magnesium was determined by the method of Orange and Rhein ('51) on aliquots of 5-day composites of food, urine, and feces which had been dry-ashed. The intensity of the color developed was measured in a Beckman spectrophotometer exactly 10 minutes after the addition of the reagents.

RESULTS AND DISCUSSION

The mean daily intake and balance of magnesium for the subjects in each state and for all subjects during different periods are shown in table 2 together with

[2] In Nebraska, response to pantothenic acid intakes of 8 mg and 13 mg was studied also, but the magnesium balances were not affected by these variations in the level of pantothenic acid.

TABLE 2

Mean daily intake and balance of magnesium for subjects in each state and for all subjects during different periods[1]

State and period	Intake[2]	Balance	Range in balance	Subjects in negative balance
	mg	*mg*	*mg*	*no.*
Oklahoma, 9 subjects				
Period A	317 ± 76[3]	53 ± 72[3]	− 75 to 134	2
Period B	251	23 ± 34	− 21 to 16	3
Periods C, D	247 ± 2	− 5 ± 14	− 24 to 16	6
Periods E, F, 8 subjects	183 ± 6	−33 ± 25	− 3 to −80	8
Periods G, H, 8 subjects	280 ± 3	5 ± 10	− 2 to 22	3
Minnesota, 7 subjects				
Period A	263 ± 64	4 ± 70	− 71 to 147	4
Period B	292	−29 ± 34	− 98 to 2	6
Periods C, D	320	28 ± 23	2 to 68	0
Periods E, F	238	−22 ± 36	−101 to 4	6
Period G	233	−43 ± 22	− 77 to −15	7
Nebraska, 8 subjects				
Period A	275 ± 54	48 ± 85	− 69 to 129	2
Period B	260	14 ± 49	− 54 to 71	3
Periods C, D	274	9 ± 21	− 20 to 42	3
Periods E, F	275	16 ± 23	− 12 to 52	3
Periods G, H	286	0 ± 40	− 87 to 26	2
Alabama, 6 subjects				
Period A	244 ± 46	19 ± 39	− 11 to 96	2
Period B	252	16 ± 23	− 8 to 47	2
Periods C, D	252	−11 ± 14	− 28 to 10	4
All states				
Period A, 30 subjects	279 ± 65	34 ± 65	− 75 to 147	10

[1] Each letter represents a 5-day period; as periods C, D equal 10 days, and E, F equal 10 days.
[2] Intakes for period A were calculated rather than determined by analysis.
[3] Standard deviation of observations.

the ranges in balances and the number of subjects in negative balance. Period B, the first 5 days that the women received the standardized diet, was considered a transition or adjustment period and the intake and excretion values were not included in calculations of subsequent means or in the regression equation. Also the values for periods beyond the first two with the same intake, namely, period G in Minnesota and periods E through H in Nebraska, were omitted from the statistical treatment and from figure 1 in order to keep the length of time at each intake the same for all subjects.

The magnesium balance of each subject at each level of intake for which she was studied is charted in figure 1 for both the controlled and the self-chosen diets. No significant difference was found in the magnesium retention of the subjects in the 4 locations when analysis of covariance was employed to adjust for differences in intake. Variation in retention between subjects was not reduced when intake and retention were calculated on the basis of per kilogram of body weight.

Results of regression analyses are shown in table 3. The equation and the line for regression of intake on balance are given in figure 1 for the controlled intakes and for the calculated self-chosen intakes. Magnesium excretion and retention increased significantly as intake increased. Because only 20 to 22% of the variation in excretion is explained by differences in the controlled intake, intake cannot be considered a good predictor of excretion. It can be used to predict retention, however, inasmuch as 44% of the variation in retention values during periods of controlled intake is explained by differences in intake.

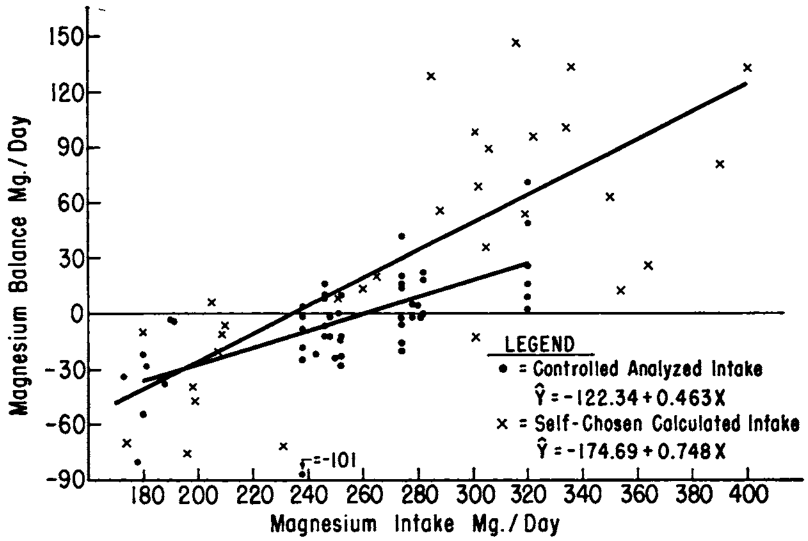

Fig. 1 Relation of intake to balance of magnesium with controlled and self-chosen diets.

TABLE 3

Regression of magnesium intake on excretion and balance

Regression	No.	b[1]	Proportion of variation explained by Mg intake[2]
Controlled magnesium intake (mg/day) on			
Urinary excretion, mg/day	53	0.22[3]	22
Fecal excretion, mg/day	53	0.32[3]	20
Retention, mg/day	53	0.46[3]	44
Self-chosen magnesium intake (mg/day) on			
Urinary excretion, mg/day	30	0.04	2
Fecal excretion, mg/day	30	0.21	11
Retention, mg/day	30	0.75[3]	57

[1] Change in excretion or retention for an increase of 1 mg/day intake of magnesium.
[2] Square of correlation coefficient.
[3] Significant at 1% level.

The regression values for period A must be interpreted cautiously because the magnesium intake was calculated from records of food intake estimated in terms of household measures rather than by quantitative analysis of actual intake. There was, however, a highly significant relationship between intake and retention, and 57% of the variation in retention in period A was explained by differences in intake. The calculated magnesium content of the self-chosen diets ranged from 174 mg to 400 mg daily. Ten subjects had intakes below 250 mg and 9 of these were in negative balance. Of the 20 subjects with calculated daily intakes above 250 mg, only one was in negative balance.

In table 4 the data have been grouped on the basis of the controlled levels of magnesium intake at which the women were studied. Both urinary and fecal excretion as well as retention increased directly with intake. Coefficients of variation for intake and excretion were stable for each of the groups of magnesium intakes. Coefficients of variation for retention were about 80% for both the low magnesium intake, 173 to 191 mg per day, and for the high intake, 320 mg per day, and were about 200% for the two intermediate intake groups. Thus there is little doubt about daily intakes from 173 to 191 mg being inadequate, or about an intake of 320 mg being adequate, for

TABLE 4

Means, standard deviations, and coefficients of variation for intake, excretion, and balance of magnesium for all subjects, grouped according to controlled magnesium intakes

Intake group	Statistic	Intake	Urine	Feces	Balance	Subjects in negative balance
mg/day		*mg/day*	*mg/day*	*mg/day*	*mg/day*	%
173–191(8)[1]	Mean	183	88	128	−33	100
	S.D.[2]	6	12	31	26	
	C.V., %[3]	3	14	24	77	
233–252(22)	Mean	245	99	158	−12	77
	S.D.	6	19	26	24	
	C.V., %	2	19	17	196	
274–282(16)	Mean	277	101	170	7	37
	S.D.	3	15	23	16	
	C.V., %	1	15	14	223	
320(7)	Mean	320	123	169	28	0
	S.D.	—	12	24	23	
	C.V., %	—	10	14	83	

[1] Figures in parentheses indicate number in group.
[2] Standard deviation of observations.
[3] Coefficient of variation.

maintaining magnesium equilibrium in these women. Six, or 37%, of the 16 women who had daily intakes between 274 and 282 mg of magnesium were excreting slightly more than they were taking in, but the extent of their negative balances was slight. Three of the 6 women had daily balances of −2 mg and the other three had balances of −6, −16, and −20 mg of magnesium daily.

In the 8 Nebraska subjects it was possible to observe the response to a constant magnesium intake for 30 days. The mean daily balances for the three consecutive 10-day periods CD, EF, and GH were 9 mg, 16 mg, and 0 mg, respectively, and were not significantly different. The mean intake for the 30 days was 278 mg and the mean balance was 8 mg with a standard deviation of 14 mg.

When Meyer et al. ('55) were developing and testing the standardized diet used in the present study, they determined magnesium balances for 6 young women for 35 consecutive days. At an intake of 181 mg of magnesium daily, the mean daily balance was −26 ± 18 mg and one of the 6 subjects was in equilibrium. Comparable results were obtained with the 8 Oklahoma subjects during only 10 days at an intake of 183 mg of magnesium daily. The mean balance was −33 ± 25 mg daily, all subjects were in negative balance, and the range in balances was from −3 to −80 mg daily.

The balances obtained in the present study during the 10-day periods of controlled intake suggest that a daily magnesium intake of more than 280 mg and perhaps as much as 320 mg would have been needed to insure equilibrium in all of these 30 subjects. On the basis of reports in the literature and the results of this study, a magnesium requirement of about 300 mg daily seems indicated for women.

A deficiency of magnesium has never been considered a dietary problem in the U.S.A. In its report of recommended dietary allowances, the Food and Nutrition Board ('58) states " . . . it is difficult to visualize a human diet deficient in this element (magnesium)." In general a diet that is adequate in other essential nutrients, especially protein of high quality, is considered to supply generous amounts of magnesium. When a magnesium deficiency occurs, it is usually associated with alcoholism or electrolyte imbalance, rather than an inadequate dietary intake. As the interrelationships among dietary essentials, including the role of magnesium in fat metabolism, are elucidated, the importance of magnesium intakes adequate for maintaining equilibrium or retention will be established.

SUMMARY

Metabolism studies were conducted on 30 young women to determine their magnesium balances when they received a controlled standardized diet. The daily magnesium intakes ranged from a low of 173 mg, through intermediate amounts of 230 and 250 mg, to higher intakes of 280 and 320 mg. Each subject was studied at one, two or three levels of magnesium intake for at least 10 days following an adjustment period when the standardized diet was supplied.

At daily magnesium intakes of 173 to 191 mg the mean balance was −33 mg, and at intakes of 233 to 252 mg, the balance was −12 mg. With intakes of 274 to 282 mg mean retention was 7 mg, but 6 of the 16 subjects were in slight negative balance. Subjects receiving a daily intake of 320 mg had a mean daily retention of 28 mg. The relationship between the intake and the retention of magnesium for these women was significant at the 1% level. This was also true for a 5-day period when subjects consumed their self-chosen diets and the magnesium content of the estimated food intake was calculated from tables of food composition rather than by analysis.

The balances obtained during the periods of controlled intake suggest that a daily magnesium intake of more than 280 mg and perhaps as much as 320 mg would have been needed to insure equilibrium in all of the young women in the present study. On the basis of reports in the literature and the results of this study, a magnesium requirement of about 300 mg daily seems indicated for women.

ACKNOWLEDGMENTS

The authors wish to express appreciation for the cooperation of the students who served as subjects and for the technical assistance of George Odell, Hazel Fox, Loana Norris and Kathleen Stitt.

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