Serum Magnesium and Serum Cholesterol Changes in Man

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A RELATIONSHIP between magnesium and serum cholesterol was observed in 1933 by McCollum and his associates in their classic work on magnesium deficiency in the dog.[1]

Two years ago, Bersohn and Oelofse[2] reported that South African Bantus have higher serum magnesium and lower serum cholesterol levels than Europeans. Moreover a significant negative correlation between magnesium and cholesterol levels in serum was found in a group of forty-seven Europeans. No data are given by Bersohn and Oelofse about the magnesium content of the diet eaten by their subjects.

More recent observations[3,4] failed to confirm the findings of the South African workers. Experimental work on animals indicates a possible relationship between magnesium and atherosclerosis[5–8] but no apparent effect of dietary magnesium on serum cholesterol concentration.

Controlled dietary experiments conducted in this laboratory gave an opportunity to study the changes in serum cholesterol and serum magnesium levels in different dietary situations intended to produce changes in the serum cholesterol levels with and without changes in magnesium intake.

The results of two experiments are reported.

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EXPERIMENTAL

The details of the two experiments have been reported elsewhere.[9,10] The subjects in experiment 1 were twenty-two men of forty-two to sixty-two years of age, schizophrenic residents of the Hastings State Hospital. After two weeks on a low fat (LF) diet, providing on the average 3,260 calories per day, and containing 34 gm. of fat (9.5 per cent of the total caloric intake) half of the men were fed with the experimental diet OO, and the other half were given diet SO for another two weeks. The diets were then reversed for another two-week period.

The experimental diet OO was made by substituting 100 gm. of olive oil per day for 900 cal. of simple carbohydrate in the LF diet. The mean caloric content of this diet, adjusted to maintain calorie equilibrium in these men, was 3,380 cal. per day and contained 134 gm. of fat corresponding to 36.3 per cent of the total calories.

The experimental diet SO was made by substituting 32 gm. of a mixture of 47.2 per cent safflower oil and 52.8 per cent oleostearine for 288 gm. of carbohydrate in the LF diet so as to match the OO diet in respect to saturated and polyene fats but containing 67.9 gm. less of monoene fats. The mean caloric content of this diet was 3,190 cal. per day and the total fat content 65.1 gm. corresponding to 18.3 per cent of the calories.

In experiment 2, twenty-eight subjects were used including the men in experiment 1. The duration of the experiment was sixteen weeks. In the first two weeks the men were given a controlled house diet (CHD) which corresponded to the usual American diet and had a proportion of fat calories close to 40 per cent

TABLE I
Serum Magnesium and Cholesterol Levels (mg. per 100 ml.) in Experiment 1

Men	Nov. 12–14		Nov. 26–27		Dec. 10–12	
	Magnesium	Cholesterol	Magnesium	Cholesterol	Magnesium	Cholesterol
	LF Diet		SO Diet		OO Diet	
A1	1.90	130	1.97	154	1.95	181
A2	2.22	166	2.12	170	2.24	168
A3	1.81	127	1.88	132	1.86	140
A4	2.04	182	2.12	180	2.07	190
A5	2.08	169	2.10	165	1.98	194
A6	1.84	136	1.96	142	1.90	150
A7	2.12	196	2.04	224	2.08	226
A8	2.00	187	1.97	166	2.00	199
A9	2.16	211	1.95	215	2.05	207
A10	2.26	156	2.10	140	2.17	143
A11	2.04	165	2.06	183	2.04	184
Mean	2.043	165.9	2.024	170.1	2.031	180.2
Standard error of mean	±0.044	±8.2	±0.025	±8.9	±0.034	±2.2
	LF Diet		OO Diet		SO Diet	
B1	2.18	170	1.94	186	1.98	186
B2	2.14	148	2.05	163	2.08	185
B3	1.98	139	2.05	140	1.98	131
B4	2.18	152	2.32	140	2.16	174
B5	2.24	149	2.02	148	2.09	156
B6	2.39	133	2.24	150	2.34	148
B7	2.58	156	2.28	188	2.38	208
B8	2.19	144	2.23	174	2.16	170
B9	2.00	128	2.19	142	2.01	138
B10	2.46	152	2.22	180	2.16	186
B11	2.22	190	2.04	173	2.07	212
Mean	2.233	151.0	2.144	162.2	2.128	172.2
Standard error of mean	±0.055	±5.2	±0.038	±5.7	±0.040	±8.1
Mean for 22	2.138	158.7	2.084	166.1	2.080	176.4
Standard error of mean for 22	±0.040	±4.9	±0.026	±5.2	±0.028	±4.2

NOTE: LF = low fat; SO = safflower-oleostearine; OO = olive oil.

and a mean caloric value of 3,200 cal. per day. This diet was given again for another two weeks at the end of the experiment. Two diets were used during the two experimental periods of six weeks each. The two experimental diets were equivalent to the CHD as to total caloric value, but diet I was rich in fruit, fresh vegetables, and legumes, while diet A had a higher proportion of sugar and lactose than diet I.

Both diets I and A were of lower fat content than the CHD. Each of these two diets was used at two different levels of fat content. For the object of the present paper however these fat differences will not be considered, and the results obtained with both levels of fat

TABLE II

Differences in the Magnesium and Cholesterol Levels of the Serum Corresponding to Changes in the Diet; Mean Values for Twenty-Two Men

Diet Comparison	No.	Δ Magnesium			Δ Cholesterol		
		Mean (mg. %)	Standard Error (mg. %)	P	Mean (mg. %)	Standard Error (mg. %)	P
LF *minus* OO	22	0.050	±0.028	0.09	−12.7	±3.5	0.0015
LF *minus* SO	22	0.061	±0.024	0.015	−12.7	±3.8	0.003
LF *minus* (OO + SO)	44	0.056	±0.018	0.004	−12.5	±2.9	0.001

will be considered together. The administration of the diets was made according to the usual reversal or switchback design, that is to say, half of the men received diet I and the other half diet A for six weeks, and the diets were reversed in the following period.

Blood samples for analysis of magnesium and cholesterol were taken twice at the end of three and six seeks during the experimental periods as well as at the end of the CHD periods.

METHODS

Serum cholesterol levels were measured by the Anderson and Keys modification of Abell's method.[11]

Serum magnesium levels were determined by the method of Orange and Rhein adapted to the Coleman spectrophotometer.[12]

A standard prepared by dilution of dry human plasma was used throughout. The magnesium content of this plasma was established by repeated analysis made during the duration of the experiment. The mean value of all these different analyses was taken as standard value to calculate the magnesium content of the unknown serum samples. The diets were collected and analyzed as described by Keys, Anderson and Grande.[9] The magnesium content of the diets in experiment 2 was measured by applying the method of Orange and Rhein to the ash.

RESULTS

The cholesterol and magnesium data of experiment 1 are given in Table I.

There was an increase in serum cholesterol levels when the men changed from the low fat diet to either the OO or SO diets. A small decrease in serum magnesium level was observed at the same time. The statistical analysis of the results are given in Table II. The change in the magnesium level was statistically significant when all the values for the two series of dietary comparisons (LF minus OO, and LF minus SO) were pooled (Table II).

No significant correlation was found ($r = -0.099$) between the magnesium and cholesterol values. Also no significant correlation was found between changes in cholesterol and changes in magnesium, the correlation coefficient for the forty-four pairs of changes being $r = 0.17$.

The results of experiment 2 are given in Table III. The serum cholesterol and magnesium values are the means of duplicate estimations made on four samples of serum from each man for each dietary period. The CHD values were taken at the end of the first and last CHD periods and the values for the other dietary periods correspond to samples taken after three and six weeks of subsisting on the diet (two samples on each occasion). The highest cholesterol value was observed when the men were receiving the CHD; the lowest with diet I. The mean changes in magnesium and their probability level are given in Table IV with the changes in cholesterol.

COMMENTS

The changes of magnesium content of the serum observed were small, and in most cases

TABLE III*
Serum Magnesium and Cholesterol Levels (both in mg. per 100 ml.) in Experiment 2

Subjects	Diet					
	CHD (287 mg.)		I (407 mg.)		A (360 mg.)	
	Magnesium	Cholesterol	Magnesium	Cholesterol	Magnesium	Cholesterol
W1	2.24	220	2.12	167	2.24	172
W2	2.11	200	2.02	171	2.20	181
W3	2.08	206	2.00	144	2.13	150
W4	1.98	262	1.92	200	1.97	229
W5	2.04	230	1.99	166	2.18	185
W6	2.09	178	2.04	139	2.11	160
W7	2.28	232	2.30	177	2.44	189
X1	2.07	165	2.10	120	1.96	131
X2	1.91	208	2.04	148	1.95	176
X3	2.13	197	2.18	154	2.10	184
X4	2.08	154	2.16	118	2.08	138
X5	1.88	168	2.10	126	2.03	142
X6	2.08	273	2.10	240	2.03	236
X7	2.24	174	2.28	137	2.24	156
Y1	2.20	246	2.09	185	2.24	193
Y2	1.84	205	1.91	146	1.84	159
Y3	2.32	258	2.26	206	2.46	222
Y4	2.04	181	1.98	149	2.10	166
Y5	1.95	222	1.93	183	1.93	200
Y6	2.08	234	2.04	190	2.06	234
Y7	2.04	229	2.08	198	2.02	209
Z1	2.13	200	2.12	183	2.15	209
Z2	1.82	190	1.88	139	1.87	148
Z3	2.18	234	2.34	176	2.27	204
Z4	2.01	223	2.11	174	2.02	188
Z5	2.29	195	2.29	120	2.32	158
Z6	2.21	253	2.29	194	2.27	202
Z7	2.21	231	2.26	176	2.11	190
Mean	2.090	213	2.104	165	2.118	183
Standard error of mean	±0.025	±5.87	±0.025	±5.62	±0.029	±5.54

* The magnesium content of the diet (mg. per day) is given for each diet at the top of the corresponding column CHD = controlled house diet; diet I = Italian type diet; diet A = American type diet.

TABLE IV
Changes in Serum Cholesterol and Magnesium Levels in Experiment 2; Mean Values for Twenty-Eight Men

Dietary Change	Cholesterol	Magnesium	
	Mean Change (mg. per 100 ml.)	Mean Change (mg. per 100 ml.)	P
A *minus* I	18	+0.014	0.5
CHD *minus* I	48	−0.014	0.37
CHD *minus* A	30	−0.028	0.035

not significant statistically. In the first experiment the magnesium content of the diets is considered to have been constant, since the difference in the diets consisted in the substitution of sugar for fat. In this experiment, the cholesterol changes were small, but significant and the correlation analysis showed that there was no significant association between cholesterol and magnesium changes.

In experiment 2, the changes in cholesterol were more marked (Table III) but the changes in magnesium were not significant (Table IV). The lowest level of magnesium was

observed during the CHD periods, when the cholesterol values were highest, but the highest magnesium level (diet A) did not correspond to the lowest cholesterol value.

No correlation was found between the magnesium content of the diet and the magnesium level. Diet I had the highest magnesium content (407 mg. per day), but the serum magnesium values were lower than with diet A, which had a slightly lower magnesium content (360 mg. per day).

It is known that only a small proportion of dietary magnesium is absorbed[13] and that deprivation of dietary magnesium for periods of twenty-two and twenty-seven days in man fails to affect the serum magnesium level.[14] Whether very long periods of magnesium deprivation can produce changes in serum magnesium levels is questionable.

The data of the present experiments, together with the publication of Brown et al.[3] and of Jankelson et al.[4] seem to indicate that changes in serum cholesterol levels are not associated with changes in magnesium levels.

SUMMARY

The relationship of changes in serum magnesium concentration to changes in serum cholesterol concentration was studied in controlled dietary experiments in man. Changes in serum cholesterol levels were induced by interchanging isocalorically various amounts and kinds of dietary fats and carbohydrates. In one experiment in which there was a significant increase in serum cholesterol concentration the mean serum magnesium level decreased slightly. The "within-men" correlation between magnesium and cholesterol changes was not statistically significant. In a second experiment with even greater changes in serum cholesterol levels no significant changes in serum magnesium levels were observed. It is concluded that no systematic relationship existed between changes in serum magnesium and serum cholesterol levels under the conditions of these dietary experiments.

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