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Original article

Obesity and hypomagnesemia

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ABSTRACT

Background: Whether low serum magnesium is an epiphenomenon related with obesity or, whether obesity *per se* is cause of hypomagnesemia, remains to be clarified.
Objective: To examine the relationship between body weight status and hypomagnesemia in apparently healthy subjects.
Methods: A total of 681 healthy individuals aged 30 to 65 years were enrolled in A cross-sectional study. Extreme exercise, chronic diarrhea, alcohol intake, use of diuretics, smoking, oral magnesium supplementation, diabetes, malnutrition, hypertension, liver disease, thyroid disorders, and renal damage were exclusion criteria. Based in the Body Mass Index (BMI), body weight status was defined as follows: normal weight (BMI <25 kg/m^2); overweight (BMI ≥25 < 30 BMI kg/m^2); and obesity (BMI ≥30 kg/m^2). Hypomagnesemia was defined by serum magnesium concentration ≤0.74 mmol/L. A multiple logistic regression analysis was used to compute the odds ratio (OR) between body weight status (independent variables) and hypomagnesemia (dependent variable).
Results: The multivariate logistic regression analysis showed that dietary magnesium intake (OR 2.11; 95%CI 1.4–5.7) but no obesity (OR 1.53; 95%CI 0.9–2.5), overweight (OR 1.40; 95%CI 0.8–2.4), and normal weight (OR 0.78; 95%CI 0.6–2.09) were associated with hypomagnesemia. A subsequent logistic regression analysis adjusted by body mass index, waist circumference, total body fat, systolic and diastolic blood pressure, and triglycerides levels showed that hyperglycemia (2.19; 95%CI 1.1–7.0) and dietary magnesium intake (2.21; 95%CI 1.1–8.9) remained associated with hypomagnesemia.
Conclusions: Our results show that body weight status is not associated with hypomagnesemia and that, irrespective of obesity, hyperglycemia is cause of hypomagnesemia in non-diabetic individuals.

1. Introduction

Obesity, characterized by a high risk for insulin resistance, metabolic glucose disorders, type 2 diabetes, and cardiovascular disease, is a growing health problem worldwide [1,2].

Magnesium, an essential cofactor involved in enzymatic pathways of energetic metabolism plays an important role in glucose and lipid metabolism [3,4]; with this regard, it has been reported that low dietary magnesium intake and hypomagnesemia are strongly associated with increased risk for developing glucose metabolic disorders [5–8].

Recent studies have linked obesity with low serum magnesium levels, supporting the statement that magnesium deficiency is among causes of developing cardiovascular diseases in obese individuals [9,10]. In addition, because obesity usually is related with hypomagnesemia, it has been suggested that obesity deteriorates the magnesium status, particularly among women, which contributes to impairment of insulin action [10].

However, the relationship between obesity and magnesium status is uncertain; whether low serum magnesium is an epiphenomenon related with obesity or, whether obesity *per se* is cause of hypomagnesemia, remains to be clarified. On this regard, the objective of this study was to examine the relationship between body weight status and hypomagnesemia in apparently healthy subjects.

2. Material and methods

With the approval of the protocol by the Mexican Social Security Institute Research Committee, and after obtaining the subjects' informed consent, a cross-sectional study was carried out.

Participants were recruited from the general population of Durango, city at northern Mexico. Sampling strategy was based in public invitation to apparently healthy subjects to participate in the study.

Apparently healthy men and non-pregnant women aged 30 to 65 years were eligible for inclusion at study. Extreme exercise, chronic

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diarrhea, alcohol intake (equal to or more than 20 and 30 g per day, for women and men, respectively), use of diuretics, smoking, oral magnesium supplementation, diabetes, malnutrition, hypertension, liver disease, thyroid disorders, and renal damage were exclusion criteria.

Based on Body Mass Index (BMI), participants were allocated in the following groups: 1) Normal-weight, 2) Overweight, and 3) Obesity [11].

Sample size was estimated based on a statistical power of 80% with a 0.05 alpha value, and combined prevalence of normal-weight (29.5%) and hypomagnesemia (35%) [12,13]. The required sample size was of at least 125 individuals per group.

2.1. Definitions

Body weight status was defined according the World Health Organization criteria [11], as follows: Normal weight (BMI <25 kg/m^2); Overweight (BMI ≥25 < 30 BMI kg/m^2); and Obesity (BMI ≥30 kg/m^2).

Hypomagnesemia was defined by serum magnesium concentration ≤ 0.74 mmol/L (1.8 mg/dL).

Hyperglycemia was defined by the presence of fasting plasma glucose (FPG) ≥5.6 < 7.0 mmol/L and/or 2-h post-load glucose levels ≥7.8 < 11.1 mmol/L.

Normoglycemia was defined by fasting plasma glucose <5.6 mmol/L and plasma glucose levels 2-h postload <7.7 mmol/L). Metabolic glucose disorders were categorized as impaired fasting glucose (IFG) (fasting plasma glucose levels ≥5.6 < 7.0 mmol/L), impaired glucose tolerance (IGT) (plasma glucose levels 2-h postload ≥7.7 < 11.1 mmol/L), and IFG + IGT [14].

2.2. Measurements

The BMI was calculated as weight (in kilograms) divided by height (in meters) squared. Waist circumference (WC) was measured with a flexible steel tape with subjects in standing position; the anatomical landmarks were the midway between the lowest portion of the rib cage and iliac crest.

The technique for measurement of blood pressure was the recommended in the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure [15].

Percent body fat was measured by bioelectric impedance methods (Omron BF 300, Vernon Hills Illinois, USA).

Dietary magnesium intake was estimated based on 24 h recall questionnaire to compile information about quantity, frequency, and type of food intake.

2.3. Assays

Venous blood samples were drawn after 8–10 h of overnight fasting to determine plasma glucose, serum magnesium, and lipid profile. A 75-g load of glucose was then administered and venous blood samples were drawn 2 h later to determine 2-h post-load plasma glucose levels.

Serum magnesium levels were measured by colorimetric methods; the intra- and inter-assay variations were 1.3 and 1.8%, respectively.

Plasma glucose levels were measured using the glucose-oxidase method. The intra-assay and inter-assay coefficients of variation for glucose measurements were 1.1% and 1.12%, respectively.

Serum triglycerides were measured enzymatically by spectrophotometric methods. HDL-cholesterol fraction was obtained after precipitation by phosphotungstic reagent. The intra- and interassay coefficients of variation were 1.6% and 2.9% for triglycerides, and 1.3% and 2.1% for HDL-cholesterol.

All laboratory measurements were performed using a clinical chemistry autoanalyser (A15 biosystems, Barcelona, Spain).

2.4. Statistical analysis

Differences between the groups were assessed using unpaired Student t test (Mann–Whitney U test for skewed data) for numeric variables, and the Chi-squared test for testing differences between proportions.

ANOVA one-way with posthoc Bonferroni test was used to compare mean differences between more than two groups. Skewed numerical data were transformed by Log*n* to obtain a symmetrical distribution.

In order to explore the association between body weight status and hypomagnesemia, a staggered analysis was performed. In the first stage, participants were categorized according body weight status, in the second stage by sex and, finally, in the third stage according serum magnesium status. In all stages, a multiple logistic regression analysis was used to compute the odds ratio (OR) between body weight status (independent variables) and hypomagnesemia (dependent variable). All variables that in the bivariate analysis showed significant statistical differences between the study groups were introduced into logistic regression analysis as covariables.

A p value <0.05 defined the level of statistical significance. Data analysis was performed using the SPSS 15.0 statistical package (SPSS Inc., Illinois USA 1998).

3. Results

A total of 188 (27.6%) men and 493 (72.4%) women were enrolled (N = 681); of them, 146 (21.4%), 214 (31.4%), and 321 (47.1%) were allocated into groups with normal-weight, overweight, and obesity.

Table 1
Anthropometric and biochemical characteristics of the target population, according weight status (N = 681).

	Normal weight	Overweight	Obesity	P value
N (%)	146 (21.4)	214 (31.4)	321 (47.1)	
Age, years	40.7 ± 11.9	41.8 ± 11.0	42.1 ± 10.5	0.09
Body mass index, kg/m^2	22.6 ± 2.0	27.7 ± 1.4	35.0 ± 5.0	<0.0005* ** †
Waist circumference, cm	79.7 ± 8.2	91.8 ± 9.5	106.7 ± 12.9	<0.0005* ** †
Total body fat, %	30.0 ± 7.6	35.0 ± 6.0	42.6 ± 6.9	<0.0005* ** †
Systolic blood pressure, mmHg	107.0 ± 13.0	116.5 ± 13.7	120.9 ± 15.5	<0.0005* ** †
Diastolic blood pressure, mmHg	65.9 ± 8.7	71.7 ± 9.7	73.9 ± 9.7	<0.0005* ** †
Fasting glucose, mmol/L	4.7 ± 0.7	5.0 ± 0.8	5.1 ± 0.8	<0.0005* **
2-h post-load glucose, mmol/L	5.1 ± 1.4	5.9 ± 1.7	6.5 ± 1.8	<0.0005* ** †
HDL-c, mmol/L	1.4 ± 0.4	1.1 ± 0.3	1.1 ± 0.3	<0.0005* **
Triglycerides, mmol/L	1.4 ± 0.8	2.1 ± 1.9	2.0 ± 1.2	<0.0005* **
Dietary magnesium intake, mg/d	415.8 ± 95.6	350.2 ± 101.4	317.2 ± 71.0	<0.0005* **
Serum magnesium, mmol/L	0.82 ± 0.14	0.80 ± 0.13	0.78 ± 0.12	0.22

* p < 0.05 between normal weight and obesity groups.
** p < 0.05 between normal weight and overweight groups.
† p < 0.05 between overweight and obesity groups.

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