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Magnesium Status In Apparently Healthy Adult Nigerians: Association With Degree Of Obesity

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Abstract

Magnesium deficiency is reported to be associated with increased risk of chronic diseases including insulin resistance and type 2 diabetes mellitus; however its prevalence among the general population in our setting has not been well studied. We aimed to determine the prevalence of magnesium deficiency, as measured by plasma magnesium level, and its relationship with body weight status in a group of apparently healthy adult Nigerians. A cross-sectional study involving 120 apparently healthy adults aged 18 years and above. The study subjects were categorized according to BMI into two groups: 48 overweight/obese subjects (BMI ≥ 25kg/m^2) and 72 normal weight subjects (BMI < 25kg/m^2). Plasma magnesium level was measured and hypomagnesemia was defined as plasma magnesium < 0.75mmol/L. There was 11.7% overall prevalence of hypomagnesemia. The prevalence of hypomagnesemia was greater among overweight/obese compared to normal weight subjects. Plasma magnesium levels were significantly lower in the overweight/obese subjects as compared to the normal weight subjects (0.77 ± 0.05 vs. 0.83 ± 0.11 mmol/L, $p < 0.05$). An inverse association was observed between plasma magnesium levels and degree of obesity as measured by BMI ($r = -0.23$, $p < 0.05$). We conclude that magnesium deficiency is relatively common among the study subjects; with obesity being a significant risk factor. We recommend further studies that will determine the clinical significance and health implications of that in our setting. We also recommend large scale study that will establish an evidence-based local reference interval that will allow more accurate assessment of the prevalence of magnesium deficiency among our local population.

Keywords: *Magnesium; Health; Obesity; Nigeria*

INTRODUCTION

Magnesium is the second most abundant intracellular cation (Swaminathan, 2003). It is an essential micronutrient, serving as a cofactor for over 300 biochemical reactions in carbohydrate and protein metabolisms (Altura, 1991; Ryan, 1991). Direct association between alterations in magnesium metabolism and chronic diseases, including cardiovascular diseases, hypertension and cancer, was reported in previous studies (DelGobbo et al. 2013; Zhang et al. 2016; Kieboom et al. 2016; Jeroen et al. 2015; Ismail et al. 2016). It was also reported that lower circulating level of magnesium is associated with increased risk of insulin resistance and type 2 diabetes mellitus (Gunther, 2010; Barbagallo et al. 2007).

Magnesium balance in the body is controlled by interplay between intake, exchange with bone and renal excretion (Swaminathan, 2003). Reports from nutrition surveys in different parts of the world have shown that large proportions of adults have less than adequate magnesium intakes (World Health Organization, 2009; Institute of Medicine, 1997). In Nigeria, the recent increase in the prevalence of obesity (Chukwuonye et al. 2013), increase in consumption of refined processed foods, high amount of sugar and phosphate in carbonated drinks and increase in the consumption of demineralised (soft) water may have a negative effect on the magnesium status of the population (Abdullahi and Abdullahi, 2014). The amount of magnesium loss during refining and processing of food is significant. For example, wheat to white flour (82%), rice to polished rice (83%) and corn to starch (97%) (Marier, 1986).

Reports on the prevalence of low magnesium status in general population are available from studies in different parts of the world; ranging from 1.7% in rural Australia (Simmons et al. 2010), 4.6% in Iran (Syedmoradi et al. 2011), 14.5% in Germany (Schimatschek and Rempis, 2001) and up to 42% among apparently healthy university students in Brazil (Hermes et al. 2014). There is limited information on the extent of magnesium deficiency in Nigerian general population. The aim of the present study was therefore to describe the frequency and distribution of magnesium deficiencies among apparently healthy adult Nigerians and to examine its relationship with body weight status, with the aim of identifying opportunities for intervention.

MATERIALS AND METHODS

Study Design:

This is a cross-sectional, hospital-based study that involved one hundred and twenty (120) apparently healthy adults who presented to the general outpatient clinic of the Gombe State Specialist Hospital, Gombe, Nigeria and Federal Teaching Hospital, Gombe, Nigeria, for routine medical check-up and/or premarital screening and blood donors. All study subjects are Nigerians of African descent and living in Gombe State. We excluded subjects with clinical or biochemical evidence of diabetes mellitus, hypertension or any other illness. Subjects that smokes cigarette or ingest alcohol, pregnant and breastfeeding mothers were also excluded from the study. The study protocol was approved by the health research ethics committees of the Gombe State Ministry of Health, Gombe and Federal Teaching Hospital, Gombe. Informed consent was obtained from all study subjects.

History and physical examination were performed in each of the study subjects and recorded at the time of blood sample collection. Body weight (to the nearest 0.1kilogram) and height (to the nearest centimeter) were measured with the study subjects wearing light clothes and without shoes or headgear. Measurements were done using a weighing scale and wall-mounted stadiometer.

Body Mass Index (BMI) was calculated as weight (in kilograms) divided by height in meters squared and expressed as kg/m^2. Blood pressure was measured (in duplicates) from the right arm in sitting position using a mercury sphygmomanometer.

Blood sample collection and analysis

Blood samples collected were analysed at the Chemical Pathology laboratory of the Gombe State University/Federal Teaching Hospital, Gombe. Venous blood samples were collected in heparin bottles and immediately centrifuged. The separated plasma was then stored at -20^0C until analysis. Plasma magnesium was analysed using a colometric assay kit (Agappe Diagnostics Limited, India). Haemolysed samples were excluded from analyses. Hypomagnesemia was defined as plasma total magnesium < 0.75 mmol/L (Costello, 2016).

Statistical analysis

Statistical analyses were carried out using Statistical package for social sciences (SPSS) version 20.0. All the quantitative variables were examined for outliers and normality of distribution was determined using Kolmogorow-Smirnov test. A logarithmic transformation was used to improve the normality of distribution of plasma magnesium. All the quantitative data are presented using measures of central tendency and dispersion. Mean differences of plasma magnesium between groups was compared using t-test. Partial correlation was used for correlation analyses and adjustment of confounders. Qualitative data were expressed as frequency and percentage. A probability level of $p < 0.05$ (two-sided) was used to determine statistical significance.

RESULTS

A total of one hundred and twenty (74 men and 46 women) subjects were recruited in the study, the demographic characteristics of the subjects were presented in Table 1. The mean age of all the participants was 38.9 ± 6.5 years and the mean BMI was 23.9 ± 3.7 kg/m^2. There was no significant difference between body weight status, as measured by BMI, of males and females subjects (24.10 ± 3.5kg/m^2 vs. 23.5 ± 4.0 kg/m^2, $p = 0.382$). Male subjects were significantly older than female subjects (41.5 ± 5.9 years vs. 34.7 ± 5.2 years, $p < 0.05$).

Table 1: Clinical and biochemical profiles of the study subjects

Parameters	All subjects	Male (m ± SD)	Female (m ± SD)	*p*-value*
Sample size (n)	120	74	46	
Age (years)	38.9 ± 6.5	41.5 ± 5.9	34.7 ± 5.2	0.000
Body mass index (kg/m^2)	23.9 ± 3.7	24.1 ± 3.5	23.5 ± 4.0	0.382
Systolic BP (mmHg)	117 ± 8.1	117 ± 7.1	115 ± 9.6	0.225
Diastolic BP (mmHg)	78.2 ± 5.0	78.5 ± 4.6	77.6 ± 5.7	0.339
Fasting PG (mmol/L)	5.2 ± 0.6	5.2 ± 0.7	5.2 ± 0.6	0.866
Plasma magnesium (mmol/L)	0.81 ± 0.09	0.83 ± 0.11	0.77 ± 0.06	0.002

M= mean; SD= standard deviation; BP= blood pressure; PG= plasma glucose
*between male and female groups

To examine the impact of body weight status on the plasma level of magnesium, the study subjects were categorized in to normal weight (BMI < 25kg/m^2) and overweight/obese (BMI ≥ 25kg/m^2). The biochemical characteristics of the two groups are presented in Table 2 and Figure 1. The plasma magnesium levels of men and women of normal weight and overweight/obese groups were compared. Women had lower plasma magnesium compared to men regardless of body weight status (Table 2). Overweight/obese subjects had lower plasma magnesium than normal weight subjects in both men and women (Table 2 and Figure 1).

Table 2: Clinical and biochemical profiles of the study subjects in relation to body mass index

	All subjects	Males(m ± SD)	Females(m ± SD)	*p*-value*
BMI <25kg/m^2				
Sample size (n)	72	43	29	
Plasma magnesium (mmol/L)	0.83 ± 0.11	0.86 ± 0.13	0.78 ± 0.06	0.005
BMI ≥25kg/m^2				
Sample size (n)	48	31	17	
Plasma magnesium (mmol/L)	0.77 ± 0.05	0.78 ± 0.05	0.75 ± 0.04	0.030

M= Mean; SD= Standard deviation ; BMI= body mass index; Ns= not significant
*between male and female groups

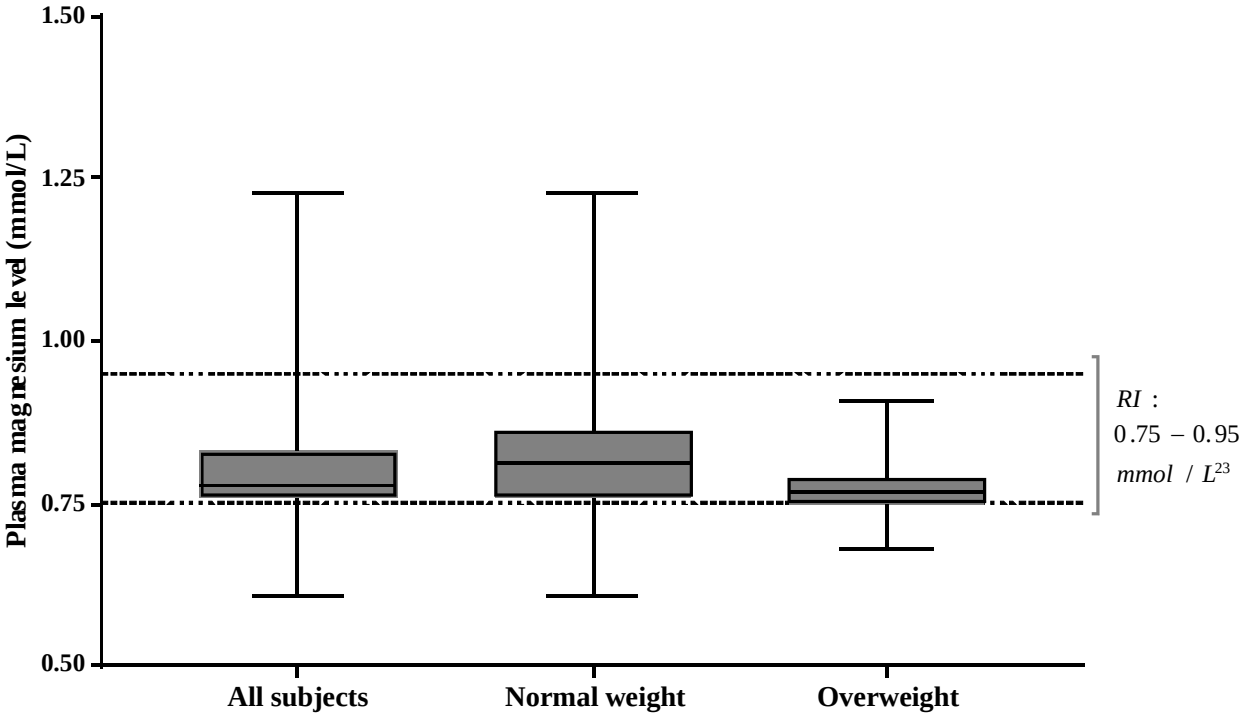

Figure 1. Plasma magnesium levels among the study subjects. Box-whiskers plot showing minima, first quartiles, medians, third quartiles and maxima.
RI, reference interval

The overall prevalence of hypomagnesemia was 11.7% (Table 3). The proportion of obese women with hypomagnesemia (29.4%) was higher compared to that in the normal weight women (10.3%), obese men (9.7%), and normal weight men (7.0%).

Table 3. Prevalence of Hypomagnesaemia according to the relevant demographic characteristics

Body mass index	Hypomagnesemia number (%) All subjects (n=120)	Males (n=74)	Females (n=46)
<25kg/m^2(72)	6/72 (8.3%)	3/43 (7.0%)	3/29 (10.3%)
>25kg/m^2(48)	8/48 (16.7%)	3/31 (9.7%)	5/17 (29.4%)

BMI, body mass index, *Overall prevalence: 14/120 (11.7%)*

A statistically significant inverse relationship was observed between plasma magnesium levels and degree of obesity among the study subjects (r = -0.23, $p < 0.05$). (Table 4, Figure 2). The observed relationship between plasma magnesium levels and age among the study subjects was not statistically significant (r = 0.11, p = 0.240) (Table 4).

Table 4. Correlation between magnesium levels and clinical parameters

Parameters	All (n=120)		Males (n=74)		Females (n=46)	
	r	*p-value*	*r*	*p-value*	*r*	*p-value*
Age (years)	0.11	0.240	-0.01	0.918	-0.15	0.317
BMI (kg/m^2)	-0.23	0.013	-0.28	0.016	-0.26	0.077
FBG (mmol/L)	-0.10	0.297	-0.21	0.072	0.26	0.076

r= correlation coefficient; FBG= fasting blood glucose; BMI= body mass index; Ns= not significant

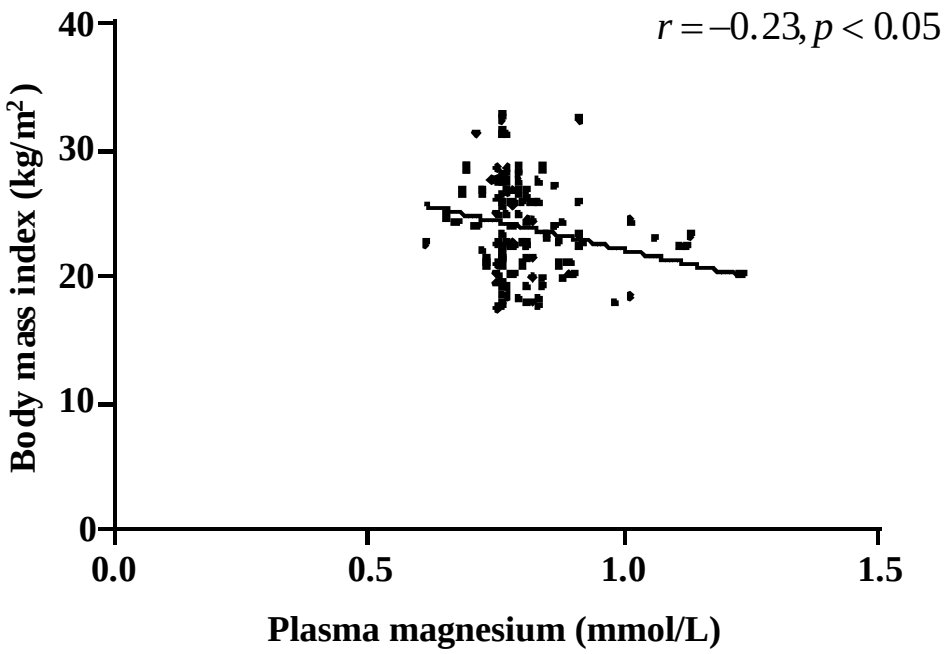

Figure 2. Correlation between body mass index and plasma magnesium among the study subjects

DISCUSSION

We examined the frequency of magnesium deficiency among apparently healthy adult Nigerians and its relationship with body weight status. We observed an overall prevalence of magnesium deficiency as determined by the plasma magnesium level to be 11.7% with higher proportion among overweight subjects in both sexes. We also found lower mean plasma magnesium levels in overweight compared to normal weight adults regardless of gender. Mean plasma magnesium level was lower in women than men regardless of body weight status.

Previous studies have reported prevalence of hypomagnesemia among healthy individuals ranging from 1.7% among rural population in Australia (Simmons et al. 2010) to 42% among university students in Brazil (Hermes et al. 2014). The wide range of the reported prevalence might be explain by the heterogeneity of the study population, such as differences in age, gender proportion, race, body weight status and nutritional status, differences in the assay methods used in analysis of plasma magnesium and definition of hypomagnesemia used in the various studies. Magnesium content of drinking water and diet might also contribute. Studies involving overweight and obese individuals and done in urban setting generally reported higher prevalence.

Our findings are also in agreement with previous reports where it was found that increased body weight is associated with increased incidence of magnesium deficiency. Inverse relationship between plasma magnesium level and body mass index was reported in a study involving healthy adults and children (Wei et al. 2016). Many other studies reported a significant decreased in intracellular and serum magnesium levels among overweight/obese individuals (Fan et al. 2017; Jose et al. 2012; Bertinato et al. 2015; Takaya et al. 2003; Huerta et al. 2005). However, the findings of Guerrero-Rumero et al. (2016) did not reveal a significant association between body weight status and hypomagnesemia.

There has been a recent increase in the prevalence of obesity and in the consumption of processed/refined foods, carbonated drinks and de-mineralized bottle and sachet water especially in urban centres in our setting (Chukwuonye et al. 2013; Abdullahi and Abdullahi, 2014). While refined foods and de-mineralized water are depleted of magnesium, carbonated soft drinks contain a lot of sugar, caffeine and phosphoric acid, with are all associated with enhanced renal excretion of bly

magnesium (Johnson, 2001; Jahnen-Dechent and Ketteler, 2012), therefore might contributes to the high prevalence of magnesium deficiency observed in our setting. Magnesium deficiency may also be seen in obesity despite adequate intake of magnesium in diet, possibly due to decreased gastrointestinal absorption of magnesium or enhanced renal excretion. High level of leptin, insulin resistance and hyperglycemia often found in obese individuals are reported to be associated with increased urinary excretion of magnesium (Barbagallo and Dominguez, 2015).

Magnesium deficiency is associated with a number of chronic diseases including type 2 diabetes mellitus and hypertension (DelGobbo et al. 2013; Zhang et al. 2016; Kieboom et al. 2016; Jeroen et al. 2015; Ismail and Ismail, 2016; Gunther, 2010; Barbagallo and Dominguez, 2007), which are prevalent in our setting.

Limitations

Plasma total magnesium was measured as a marker of magnesium status in this study. Although low plasma magnesium level usually indicates systemic magnesium deficiency, it may not accurately reflect intracellular magnesium level. The various studies quoted used different methods for assessment of magnesium status. That might have limited comparison of results between those studies.

CONCLUSIONS

We conclude that magnesium deficiency is relatively common among the study subjects; with obesity being a significant risk factor. We recommend further studies that will determine the clinical significance and health implications of that in our setting. We also recommend large scale study that will establish an evidence-based local reference interval that will allow more accurate assessment of the prevalence of magnesium deficiency among our local population.

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Conflict of interest: Nil

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