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Low Serum Magnesium Level is Associated with Hypertension in Bangladeshi Adults

Shihab Md. Rezoyanur Rahman[1, *], A. K. M Shahidur Rahman[2], Amit Kumar Pramanik[3], Rokshana Begum[4], Khandoker Abdur Rahim[5], Mst. Shaila Yesmin[4], Mohammad Monzurul Alam Bhuiyan[4], Mohammad Tanvir Islam[6], Mahfuja Rahman[7], Md. Saiful Islam[4], Tuhin Sultana[4]

Abstract

Background: Hypertension is a global health epidemic which is the leading cause of mortality and morbidity in adult population. Trace element deficiencies are linked to the development of hypertension and its complications. Serum magnesium is a potential biomarker for prediction of magnesium status in body. One of the major homeostatic functions of magnesium is to regulate blood pressure (BP).

Objective: This study was aimed to evaluate the association of serum magnesium with hypertension in Bangladeshi adult population.

Methods: This cross-sectional study was conducted at Department of Laboratory Medicine, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh from March 2020 to February 2021. A total of 100 adults (age ≥18 years) were enrolled purposively following selection criteria. Of them, 50 were diagnosed cases of hypertensive patients and rest 50 were normotensive healthy subjects as control group. Both hypertensive and normotensive group were selected according to blood pressure (BP) measurement and history taking. Their anthropometric measurements were done and body mass index (BMI) was calculated accordingly. Estimation of serum magnesium was done by automated biochemistry analyzer (BECKMAN COULTER, AU680), using the principle of photometric technique. All data were analyzed and compared by statistical tests.

Results: The mean(±SD) age was found 46.9±12.7 years in hypertensive individuals and that was 43.1±8.5 years in normotensive individuals. Male were predominant in both groups. Majority of the hypertensive patients were found over-weight. Mean(±SD) serum magnesium level was 1.73±0.24 mg/dl in hypertensive group and that was 2.02±0.19 mg/dl in normotensive group. It was observed that, mean(±SD) serum magnesium level was significantly lower in hypertensive group compared to control group ($p<0.001$). In hypertensive group, serum magnesium had significant moderate negative correlation with systolic blood pressure (SBP) ($r=-0.475$, $p<0.001$) and diastolic blood pressure (DBP) ($r=-0.410$, $p=0.003$).

Conclusion: The present study showed that low serum magnesium level is associated with hypertension in Bangladeshi Adults. Determination of serum magnesium may be helpful for the better management of hypertension and to reduce hypertension associated complications.

Keywords: Adult Population; Blood Pressure; Hypertension; Serum Magnesium

Affiliation:

[1]Department of Pathology and Blood Transfusion, Gaibandha General Hospital, Gaibandha, Bangladesh

[2]Department of Nephrology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh

[3]Department of Transfusion Medicine, Rajshahi Medical College Hospital, Rajshahi, Bangladesh

[4]Department of Laboratory Medicine, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh

[5]Department of Orthopaedic surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh

[6]Department of Internal Medicine, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh

[7]Department of Biochemistry, Bangladesh Medical College, Dhaka, Bangladesh

***Corresponding author:**
Shihab Md. Rezoyanur Rahman, Department of Pathology and Blood Transfusion, Gaibandha General Hospital, Gaibandha, Bangladesh,

E-mail: shihabbcs33@gmail.com

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Introduction

Hypertension is a condition characterized by persistently elevated pressure in the blood vessels [1]. Hypertension is defined as having a systolic blood pressure ≥140 mmHg and/or a diastolic blood pressure ≥90 mmHg on two separate occasions [2]. According to World Health Organization (WHO), about 1.13 billion adult people worldwide have hypertension [3]. In South Asia, prevalence of hypertension was ranged from 17.9% to 33.8% in adult population [4]. Hypertension is divided into two classes: primary or essential hypertension and secondary hypertension [1]. Majority of the patients suffer from primary or essential hypertension of unknown etiology [1]. High salt intake, lack of trace elements (zinc, magnesium, and potassium) in diet, lack of physical activity, smoking and stress are the risk factors for primary or essential hypertension [5]. Only 5-10% patients have secondary hypertension which is influenced by pre-existing chronic diseases [6]. Hypertension is a significant risk factor for a variety of cardiovascular diseases, cerebrovascular disease, and chronic kidney disease [7].

Trace elements are recognized as necessary for optimal human health and well-being [5, 7, 8]. Trace elements have an impact on fluid and electrolyte balance, as well as acid-base balance and neuromuscular functions [8]. Magnesium (Mg) is the fourth most abundant mineral in human and plays an important physiological role in the body [9]. Magnesium contributes to the synthesis of numerous proteins in our body and functions as a cofactor in a number of body's enzymes [9]. Magnesium plays a key role in homeostasis by regulating blood pressure (BP) [9]. Magnesium has modulating effects on vascular tone and reactivity, acts as a calcium channel antagonist to stimulate production of prostacyclin and nitric oxides [9]. These vasodilator substances then cause endothelin dependent and independent vasodilation [10]. Magnesium deficiency is associated with altered glucose homeostasis, atherosclerotic vascular disease, myocardial infarction, osteoporosis, migraine, asthma [11, 12]. Serum magnesium concentrations can predict an increased cardiovascular mortality [13]. Low serum magnesium level results in vasoconstriction, increased peripheral resistance and finally progress to hypertension [14, 15, 16]. Magnesium deficiency is associated with development of essential hypertension and dyslipidemia [5, 7, 11-15]. Prospective cohort studies and clinical trials found magnesium supplementation has blood pressure lowering effects [5]. Magnesium reduces blood pressure by improving vascular stiffness, reducing vascular resistance and lowering circulatory volume [5, 7]. It was reported that, magnesium supplementation may be beneficial as a therapeutic strategy in hypertensive individuals to reduce complications [5, 7, 17, 18]. This study was aimed to evaluate possible association of serum magnesium with hypertension in Bangladeshi adults.

Materials and Methods

Study design

This cross-sectional study was conducted at Department of Laboratory Medicine, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh from March 2020 to February 2021. This research protocol was approved by the institutional review board (IRB), BSMMU, Dhaka, Bangladesh.

Study population

A total of 100 Bangladeshi adults (age ≥18 years) of both sexes were enrolled by purposive sampling method following selection criteria. Of them, 50 were diagnosed cases of hypertensive patients (group I) and rests 50 were age matched normotensive healthy subjects as control group (group II). In this study, newly diagnosed hypertensive patients and old cases of hypertension with or without drugs were included. Hypertensive patients with any co-morbidity (like- diabetes mellitus, heart disease, cerebrovascular disease, renal/hepatic impairment, malignancy etc), patients having obesity, patients with recent infection, pregnant and lactating women, subjects receiving magnesium supplements and patients receiving medication influencing serum magnesium level (such as- thiazide and loop diuretics, aminoglycosides, amphotericin B, long term use of proton pump inhibitors, cyclosporine, cisplatin etc) were excluded from this study.

Study procedure

All the study populations were selected from out-patients department (OPD), Department of Medicine, BSMMU, Dhaka, Bangladesh. Informed written consent was taken from each study subject prior to enrollment. Both hypertensive and normotensive group were selected according to blood pressure measurement and careful history taking. Their anthropometric measurements were done and body mass index (BMI) was calculated accordingly. Then their baseline investigations such as- serum lipid profile, fasting plasma glucose, HbA1C, serum creatinine and serum ALT were done.

Blood pressure (BP) measurement

In case of new patients, two readings from separate day or home reading for three consecutive days with average reading helped us in the diagnosis of the patients. For blood pressure (BP) measurement, the subjects were asked to sit relaxed in an armed chair for 15 minutes in a quiet room with comfortable room temperature. The mercury manometer was set at his/her heart level. It was necessary that abstinence from caffeine ingestion before 30 minutes of measurement of BP. Then blood pressure (BP) was recorded in all subjects using a standard sphygmomanometer having a cuff size of 25 cm × 12.5 cm. The BP was recorded 2 times by auscultatory method, and the mean value was taken for analysis. Those who were already diagnosed previously as a case of hypertension were

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included with present BP measuring along with elaborative drugs and lifestyle history (exercise, calorie intake etc).

Blood sample collection, processing and analysis

With all aseptic precaution 6 ml venous blood was collected from each study subjects. About 2.0 ml venous blood was collected into plastic red colour screw-capped plain tube without anticoagulant for serum, 2.0 ml into EDTA tube for whole blood and 2.0 ml into ash colour screw capped tube containing sodium fluoride anticoagulant for plasma. Vial was labeled with the patient's identification number, name of investigations, date and time of collection. Collected blood sample was kept in upright position for 30 minutes. Blood was centrifuged at 3000 rpm for 5 minutes. Then serum and plasma sample was collected in a sample cup or eppendorf and marked accordingly. Separated serum was stored in -20˚C temperature until analysis was done in Department of Biochemistry and Molecular Biology, BSMMU. Serum magnesium was measured in automated biochemistry analyzer (BECKMAN COULTER, AU680) by using the principle of photometric technique.

Reference value

The normal reference value for serum magnesium level (1.82-2.43 mg/dl) used in this study was according to the Biochemistry Laboratory, Department of Biochemistry and Molecular Biology, BSMMU, Dhaka, Bangladesh.

Statistical analysis

All collected data were checked and verified thoroughly to reduce inconsistency. Then data were edited, coded and entered into computer. Data was analyzed by computer-based software program Statistical Package for Social Sciences (SPSS) for windows version 26. Results of the analysis were expressed as mean ± standard deviation (SD) and frequency with percentage. Unpaired t-test, Chi-squared Test (χ^2) and Pearson's correlation coefficient test were performed for the statistical analysis of data. A p value <0.05 was considered as the statistically significant value.

Results

This cross-sectional study was intended to evaluate the association of serum magnesium with hypertension among Bangladeshi adult population. The sample size was 100. Among them 50 individuals were in hypertensive group (Group I) and 50 healthy normotensive individuals were in control group (Group II). Both groups were selected according to clinical history, blood pressure measurement and laboratory reports. Data were collected through a pre-designed data collection sheet.

The mean(±SD) age was 46.9±12.7 years for hypertensive group and that was 43.1±8.5 years in control group (p=0.080). In both groups maximum participants were in 31-40 years age group (Table 1). In group I; 33(66%) patients were male and 17(34%) patients were female, in group II; 27(54%) patients were male and 23(46%) patients were female (Figure 1).

In this study, patients in hypertensive group had significant overweight compared to control group (p=0.017). But, obese individuals (BMI ≥25 kg/m^2) were excluded from the study (Table 2).

It was observed that, mean(±SD) systolic blood pressure (SBP) [139.6±16.9 mmHg versus 115.1±8.8 mmHg] and mean(±SD) diastolic blood pressure (DBP) [96.2±12.7 mmHg versus 76.7±7.1 mmHg] were significantly higher in hypertensive group compared to control group (p<0.001) (Table 3).

Table 1: Comparison of age among the study groups (N=100)

Age (years)	Group I (n= 50) No. (%)	Group II (n= 50) No. (%)	p value
20-30	2(4)	0(0)	
31-40	20(40)	24(48)	
41-50	12(24)	17(34)	
51-60	7(14)	7(14)	
>60	9(18)	2(4)	
Total	50(100)	50(100)	
Mean±SD	46.9±12.7	43.1±8.5	0.080 ns
Range	20 – 65	20 - 65	

Figures in the parentheses indicate the corresponding percentage, Unpaired student t-test was performed to obtain the p value, ns= not significant

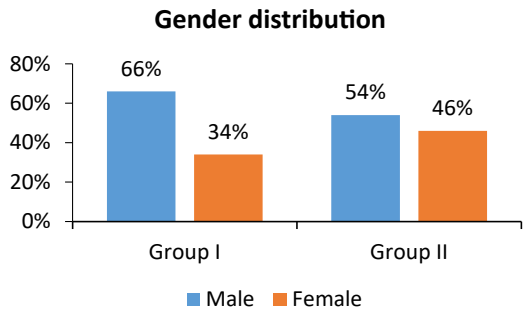

Figure 1: Gender distribution between the groups (N=100)

Table 2: Distribution of the study population by body mass index (BMI) (N=100)

BMI (kg/m^2)	Group I (n=50) No. (%)	Group II (n=50) No. (%)	p value
Normal BMI (18.5-22.9 kg/m^2)	10(20)	21(42)	0.017 s
Overweight (23.0-24.9 kg/m^2)	40(80)	29(58)	
Total	50(100)	50(100)	

Figures in the parentheses indicate corresponding percentage, Chi-squared Test (χ^2) was performed to obtain the p value, s = significant

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Data analysis revealed that, the mean(±SD) serum magnesium level was 1.73±0.24 mg/dl in hypertensive group and that was 2.02±0.19 mg/dl in control group. Mean serum magnesium level was found significantly low in hypertensive group (p<0.001) (Table 4).

We found that serum magnesium level (S. Mg) had significant moderate negative correlation with systolic blood pressure (SBP) (r= -0.475, p<0.001) and diastolic blood pressure (DBP) (r= -0.410, p= 0.003) in hypertensive group (Table 5).

Figure 2 showing that serum magnesium had significant moderate negative correlation with systolic blood pressure (SBP) in hypertensive group (r= -0.475, p<0.001) (Figure- 2).

Figure 3 displaying that serum magnesium had significant moderate negative correlation with diastolic blood pressure (DBP) in hypertensive group (r=-0.410, p= 0.003) (Figure 3).

Table 3: Comparison of blood pressures between the groups (N=100)

Blood pressures (BP)	Group I (n= 50) Mean±SD	Group II (n= 50) Mean±SD	p value
Systolic blood pressure (mmHg)	139.6±16.9	115.1±8.8	<0.001[s]
Diastolic blood pressure (mmHg)	96.2±12.7	76.7±7.1	

Data were expressed as mean±SD, Unpaired student t-test was performed to obtain the p value, s= significant

Table 4: Comparison of serum magnesium level between the groups (N=100)

Variable	Group I (n= 50) Mean±SD	Group II (n= 50) Mean±SD	p value
Serum magnesium level (mg/dl)	1.73±0.24	2.02±0.19	<0.001[s]

Data were expressed as mean±SD, Unpaired student t-test was performed to obtain the p value, s= significant

Table 5: Correlation of serum magnesium and with blood pressures [systolic blood pressure (SBP) and diastolic blood pressure (DBP)] in hypertensive group (N=50)

Variable		SBP (mmHg)	DBP (mmHg)
Serum magnesium (mg/dl)	r-value	-0.475	-0.41
	p-value	<0.001*	0.003*

SBP= systolic blood pressure, DBP= diastolic blood pressure, *significant

Discussion

Hypertension is a complex condition in which multiple factors and mechanisms interact to cause cardiovascular and cerebrovascular complications [1, 19]. Hypertension is a global health epidemic that is the leading cause of mortality and morbidity worldwide [2-3, 19]. It was reported that, deficiencies of trace elements are closely related with development of hypertension and associated complications [19,20]. Magnesium is the most abundant divalent intracellular cation in the human body and the second most abundant intracellular ion after potassium [19]. Magnesium deficiency is associated with development and adverse clinical outcome of essential hypertension [17, 19-20]. Serum magnesium is a potential biomarker for prediction of magnesium status in the body [17]. Estimation of serum magnesium in hypertensive patients may be helpful for management of hypertension. In this background current study was aimed to evaluate the association of serum magnesium with hypertension among Bangladeshi adult population. A total of 100 adults (age ≥18 years) were enrolled in this study. Of them, 50 were diagnosed cases of hypertensive patients and rests 50 were age matched normotensive healthy subjects as control group. Both hypertensive and normotensive/control group were selected according to blood pressure measurement and history taking along with relevant investigations. Mean(±SD) age in hypertensive group (Group I) was 46.9±12.7 years and that was 43.1±8.5 years in control group (Group II) (p= 0.080). In this study, male patients were predominant in both groups and this finding was consistent with previous studies [16, 18, 21]. It was observed that, 80% individuals were overweight in Group I and that was 58% in Group II. Overweight individuals were significantly higher in hypertensive group compared to normotensive group (p=0.017). In this context several reports revealed that there is significant relationship between BMI with hypertension [19-21,22, 23]. They found respondents with BMI more than normal (overweight or obese) had a higher risk of developing hypertension compared with respondents who had a normal BMI [19-23]. Some studies found micronutrient deficiencies were associated with obesity [20, 22].

The blood pressures of the study population were calculated separately as systolic blood pressure (SBP) and diastolic blood pressure (DBP). Mean(±SD) systolic blood pressure (SBP) was 139.6±16.9 mmHg in hypertensive group and that was 115.1±8.8 mmHg in control group; on the other hand, mean(±SD) diastolic blood pressure (DBP) was 96.2±12.7 mmHg in hypertensive group and that was 76.7±7.1 mmHg in control group. The mean blood pressures (both SBP and DBP) of the hypertensive cases were significantly higher than controls (p<0.001). This finding was comparable with similar previous studies [6, 17, 24, 25]

In this current study, it was observed that mean(±SD) serum magnesium level was 1.73±0.24 mg/dl in hypertensive

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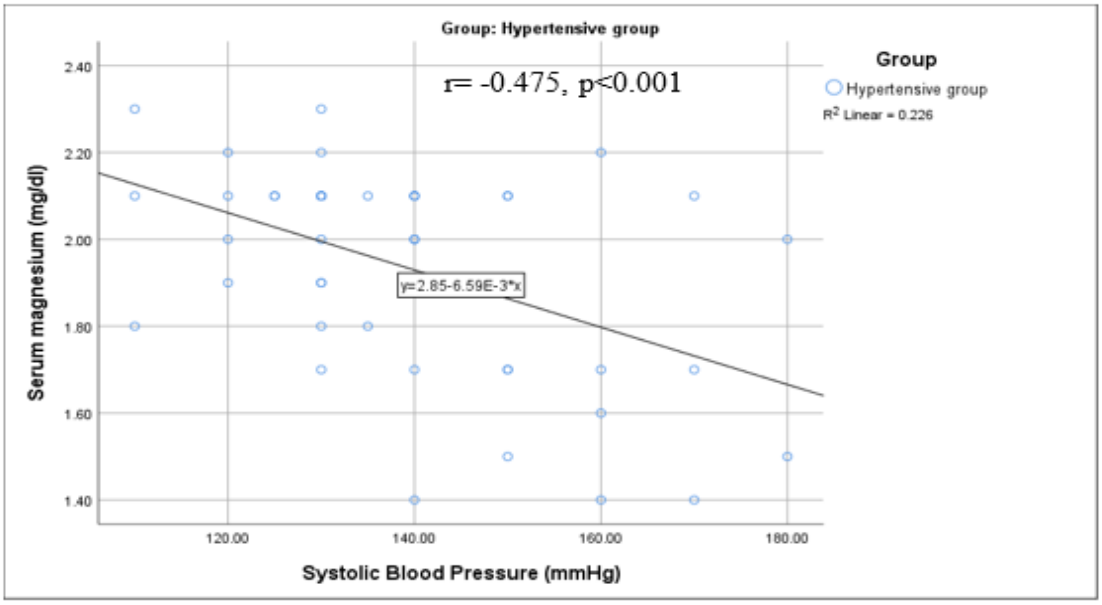

Figure 2: Scatter diagram showing the correlation of serum magnesium with systolic blood pressure (SBP) in hypertensive group (n= 50)

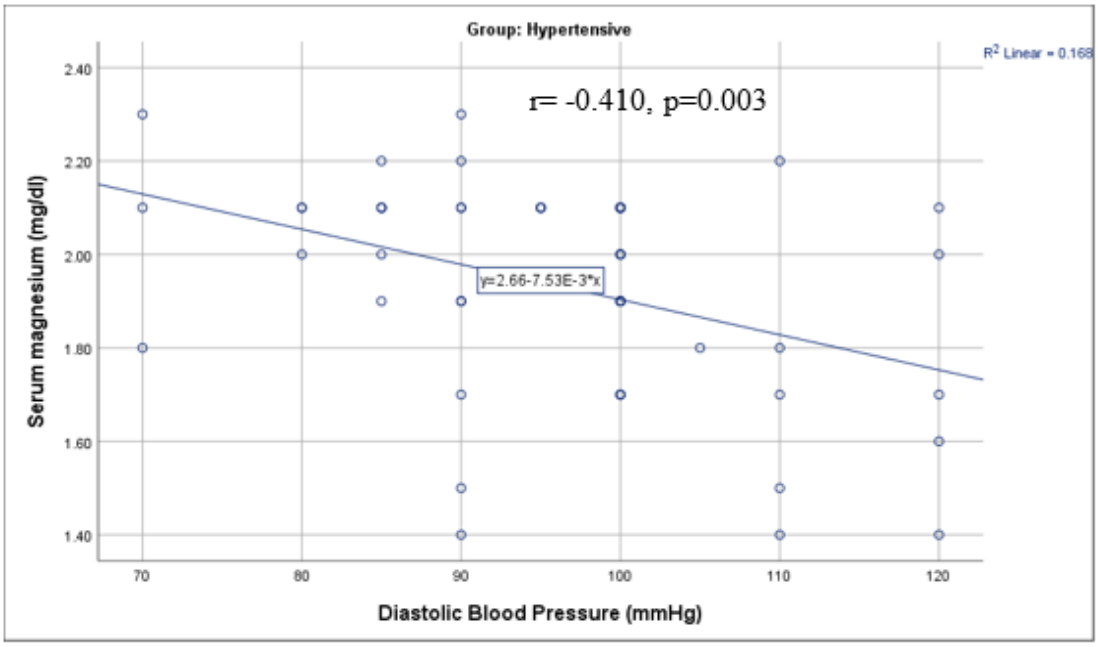

Figure 3: Scatter diagram showing the correlation of serum magnesium with diastolic blood pressure (DBP) in hypertensive group (n= 50)

group and that was 2.02±0.19 mg/dl in normotensive group. Mean serum magnesium level was found significantly lower in hypertensive group than control group (p<0.001). Rekha *et al.* found that, the mean serum magnesium level in normotensive controls was 2.068±0.4515 mg/dl but it was 1.5560±0.40320 mg/dl in stage 1 hypertensive patients and 1.3920±0.4081 mg/dl in stage 2 hypertensive patients, there was a significant low serum magnesium levels between these hypertensive groups (p<0.05) [26]. Touyz *et al.* found that mean serum magnesium level in normotensive controls was 2.28±0.17 mg/dl while it was 1.97±0.17 mg/dl in hypertensive patients, the difference was statistically significant (p<0.001) [27]. In accordance, Han *et al.* in a metanalysis also found similar findings [28]. Results of these previous studies were consistent with this current study [26-28].

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Pearson's correlation coefficient test was done to observe the correlation of serum magnesium with blood pressures (SBP and DBP) in hypertensive group in present study. Serum magnesium had significant moderate negative correlation with SBP (r= -.475, p<0.001) and DBP (r= -.410, p=0.003). In this series, Rekha *et al.* found a similar negative correlation of serum magnesium with systolic blood pressure (r= -.615, p<0.001) and diastolic blood pressure (r= -.553, p<0.001) among hypertensive patients [26]. Similarly, Ohira *et al.* also found an inverse relationship between serum magnesium with systolic blood pressure (p<0.001) [29]. Therefore, finding of this current study was supported by couple of related previous studies [26, 29, 30].

This study documented that the mean serum magnesium level was significantly lower in hypertensive group than normotensive/control group. Pearson's correlation coefficient test revealed that serum magnesium had significant moderate negative correlation with systolic blood pressure (SBP) and diastolic blood pressure (DBP). Therefore, low serum magnesium level was associated with hypertension in Bangladeshi adult population.

Conclusion

This study concluded that serum magnesium level is significantly low in hypertensive Bangladeshi adults. Low serum magnesium level has an inverse relationship with hypertension among adult Bangladeshi population. Estimation of serum magnesium may be considered for better management of hypertension.

Limitations of the study

It was a single center study with a relatively small sample size. In this study detailed dietary habit of the study population was not noted. Besides, longitudinal follow-up study to observe the effect of magnesium supplementation in hypertensive individuals was not done.

Recommendations

Further multicenter study with large sample size should be done to identify the optimum cut off value for serum magnesium in hypertensive patients. Long-term follow up studies are recommended for the evaluation of serum magnesium in hypertensive individuals.

Conflicts of interest

The authors declare that they have no conflicts of interest related to the research, authorship, or publication of this article.

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