National Journal of Physiology, Pharmacy and Pharmacology

RESEARCH ARTICLE

# Correlation of serum magnesium levels with blood pressure in normotensives and hypertensives

**Rekha S, Jeyabanu Murugiah, Raajaseharan S R**

Department of Physiology, KMCH Institute of Health Sciences and Research, Coimbatore, Tamil Nadu, India

**Correspondence to:** Jeyabanu Murugiah, E-mail: jeyabanustalin2007@gmail.com

**Received:** July 02, 2019; **Accepted:** July 24, 2019

## ABSTRACT

**Background:** Among the non-communicable diseases, hypertension claims a number one risk factor for many diseases such as heart diseases and stroke. One of the main homeostatic functions of magnesium is the regulation of blood pressure (BP). Hence, it is necessary to study the level of magnesium in hypertensive people to know the relationship between serum magnesium and BP. **Aims and Objectives:** The aim of the study was to estimate and compare the serum magnesium level in controls and hypertensives and to study the correlation of serum magnesium levels with controls and hypertensives. **Materials and Methods:** The BP was recorded 2 times by auscultatory method, and the mean value was taken for analysis. Out of 75 subjects; 25 subjects with Stage 1 hypertension were grouped as Group A and 25 subjects with Stage 2 hypertension were grouped as Group B according to Joint National Committee Criteria and 25 subjects with normal BP act as controls (Group C). The serum magnesium was estimated in them using Calmagite method. **Results:** In the age- and sex-adjusted groups, the intergroup comparison of serum magnesium was done using analysis of variance and $P < 0.05$ was considered as statistically significant. Pearson's correlation was done to study the correlation between serum magnesium and BP. **Conclusion:** Because the present study clearly shows that low serum magnesium is associated with high BP, measures should be taken to enrich our diet with magnesium. Apart from diet, magnesium supplementation can also be given for the reduction of BP.

**KEY WORDS:** Magnesium; Hypertension; Joint National Committee Criteria; Diet

## INTRODUCTION

"The greatest wealth is health;" nowadays, in the modernized and computerized world to become wealthier is easy but to become healthier is really a big task. In the past, the world has faced challenges as complex as those now ascribed by a trio of threats: First, the undernutrition and the unfinished agenda of infections; second, the increasing global burden of non-communicable diseases; and third the complications arising from globalization itself, like the ill-effects of climate changes.[1] Before the antibiotic era, communicable diseases had its dominant role but with the advent of new efficient antibiotics, communicable diseases are now no more a big problem. Since there is an increase in the prevalence of diseases such as stroke, cardiovascular diseases, hypertension, diabetes, and cancer, non-communicable diseases are now projected as a global health crisis.[2] The world health organization's global status report[3] (2010) states that non-communicable diseases are the leading cause of worldwide deaths contributing to 60%. In India, the situation is very grim. In 2005, total mortality of 53% and 44% of daily adjusted life years lost was attributed by non-communicable diseases. By 2030, the total mortality by non-communicable diseases would be 67% in India.[3]

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| **Website:** www.njppp.com | Quick Response code |
| **DOI:** 10.5455/njppp.2019.9.0725624072019 | |

The alarming rise in the magnitude of non-communicable diseases demands urgent attention.[3] Recently, the world health organization identified six risk factors[4] within the non-communicable diseases for deaths. The six risk factors[4] are hypertension; impaired glucose tolerance; tobacco usage; dyslipidemia; lack of physical activity and obesity. Of the above-said risk factors, hypertension is responsible for the 13% of total deaths in the world followed by tobacco usage (9%); impaired glucose tolerance (6%); physical inactivity (6%), and obesity (5%). Among the non-communicable diseases, hypertension claims a number of first because of the following reasons; the most common chronic condition, major risk factor for heart disease and stroke, accounts for the most drug prescriptions, and throughout the world, it is the number one attributable risk for deaths.[5] Hypertension is one of the main components of an important syndrome called metabolic syndrome. Metabolic syndrome if present, in an individual increases the risk of cardiovascular diseases.

According to Hippocrates, "Let food be thy medicine, and medicine be thy food," thus, dietary habits contribute much in the pathogenesis of non-communicable diseases. In the diet apart from carbohydrates, proteins, and fat; minerals also play an important role in the minerals, magnesium is always least considered. However, magnesium has its own medicinal value. Magnesium is an essential mineral, found abundantly in legumes, nuts, whole grains, and leafy green vegetables. Magnesium is involved in the synthesis of many proteins, and it also acts as a cofactor in certain enzymes in our body. In the human body, magnesium plays key role in hundreds of physiological processes to maintain homeostasis. One of the main homeostatic functions of magnesium is the regulation of blood pressure (BP).[6] National Health and Nutrition Examination Survey – (1999-2000) suggests that suboptimal intake of dietary magnesium will affect the pathways of metabolism and inflammation ultimately leading to the clinical manifestation of hypertension, Type 2 diabetes mellitus, metabolic syndrome and cardiovascular diseases.[6] Since hypertension is the major risk factor for cardiovascular diseases and stroke, there should be well-devised approach to know the factors involved in the pathogenesis and to prevent hypertension. Hence, it is necessary to study the level of magnesium in hypertensive people to know the relationship between serum magnesium and BP for the future dietary intervention and supplementation to control the increase in BP in spite of the pharmacological therapy.

### Aims and Objectives

The aim of the study is to estimate the serum magnesium level in controls, Stage 1 and Stage 2 hypertensives and to study the correlation of serum magnesium levels among them. A total of 75 subjects of age group 30–50 were included in the study. The 50 subjects with newly diagnosed as hypertensives were selected from the hypertension Outpatient Department of Coimbatore Medical College Hospital, Coimbatore, after obtaining the Institutional Ethical Committee. Apparently, 25 healthy individuals attending master health check-up and those having normal BP were taken as controls. According to the joint national committee seven criteria[5] [Table 1] of the 75 subjects;

- Twenty-five subjects with Stage 1 hypertension (systolic pressure 140–159 mm Hg and diastolic BP 90–99 mm Hg) were grouped as Group A;
- Twenty-five subjects with Stage 2 hypertension (systolic pressure more than 160 mm Hg and diastolic BP than 100 mm Hg) were grouped as Group B;
- Twenty-five subjects with normal BP (systolic pressure <120 mm Hg and diastolic BP <80 mm Hg) were grouped as Group C.

Newly diagnosed essential hypertensives act as study group and age-matched healthy normotensive individuals act as a control group in the study. Individuals with any other medical disorders that predisposes to secondary hypertension such as diabetes mellitus, renal problems, liver diseases, obesity, alcohol, drug dependence and also those taking drugs containing magnesium or under magnesium supplementation or the drugs that may produce hypomagnesemia such as loop and thiazide diuretics, antibiotics such as gentamicin, amphotericin, and proton pump inhibitors were excluded from the study.

## MATERIALS AND METHODS

A detailed pro forma was used to obtain a detailed history, to record the vital parameters, and to measure the anthropometric indices. Portable weighing machine was used to record the body weight in kilograms and stadiometer was used to measure the standing height in centimeters. Standardized mercury sphygmomanometer was used to record the BP. The study was approved by the Institutional Ethical Committee. The subjects were explained about the procedure and informed consent was obtained. A detailed history was elicited from them to rule out diabetes mellitus, renal, and kidney diseases and to rule out the causes of secondary hypertension. The subjects were asked to stand erect with their arms relaxed at their side and with feet together. Using a portable standard weighing machine, weight in kilograms was recorded and using a stadiometer, height in centimeters was measured

**Table 1:** Classification of BP for adults ages 18 years and older by Joint National Committee seven[5]

| Category | Systolic BP (mm Hg) | DiastolicBP (mm Hg) |
|---|---|---|
| Normal | <120 and | <80 |
| Prehypertension | 120–139 and | 81–89 |
| Hypertension | | |
| Stage 1 | 140–159 or | 90–99 |
| Stage 2 | ≥160 | ≥100 |

BP: Blood pressure

by asking the subject to stand erect, and the vertical height was measured. Body mass index (BMI) was calculated using the Quetelet's index: BMI = Weight (in kg)/Height (in $m^2$). First, the subjects were asked to sit relaxedly for 15 min in a quiet room with comfortable room temperature. The subject should be seated in a quiet room in an armed chair with the arm and back supported and the legs uncrossed. The mercury manometer should be at his/her heart level. It is necessary that there should be abstinence from caffeine ingestion before 30 min of measurement of BP. Then BP was recorded in all subjects using a standard sphygmomanometer having a cuff size of 25 cms × 12.5 cms. The BP was recorded 2 times by auscultatory method, and the mean value was taken for analysis. Antecubital vein in the front of the forearm was selected for venous blood collection. The skin over the vein was sterilized with a cotton swab. A disposable sterile needle fitted with 10 ml syringe was introduced into the vein and desired amount of blood was collected. The serum was separated from the blood by subjecting the blood to centrifuge of revolutions 3000 rpm for 5 min. Serum magnesium was estimated using Calmagite method. In all 75 subjects, urine routine examination was done by lab reader method to rule out albuminuria.

## RESULTS

In the age- and sex-adjusted groups, the intergroup comparison of serum magnesium was done using analysis of variance. $P < 0.05$ was considered as statistically significant. To study the correlation between serum magnesium and BP, Pearson's correlation was done. According to Table 2, in Group B, the serum magnesium level is lower when compared to Groups A and C. The Group A is having lower magnesium level than the control group. Among these groups, Group B is having the lowest magnesium level, and Group A is having lower magnesium level, and the difference is statistically significant. From Table 3, it is found that there exists a negative correlation between serum magnesium level and the values of systolic BP and diastolic BP. The negative correlation of serum magnesium with these parameters is statistically significant as $P < 0.01$. The BMI of Group A and Group B is higher than Group C and it is statistically significant [Table 4].

**Table 2:** Comparison of serum magnesium between the groups

| Groups | Mean±Standard deviation (serum magnesium) | *F* value | *P* value |
|---|---|---|---|
| A | 1.5560±0.40320 | 17.49 | 0.0001* |
| B | 1.3920±0.4081 | | |
| C | 2.068±0.4515 | | |

*The parameters is statistically significant as *P* value is less than 0.01

**Table 3:** Correlation of serum magnesium with BP

| Correlation of serum magnesium with | *q* value | *P* value |
|---|---|---|
| Systolic BP | −0.615 | 0.0003* |
| Diastolic BP | −0.553 | 0.0001* |

BP: Blood pressure.*The parameters is statistically significant as *P* value is less than 0.01

**Table 4:** Comparison of BMI between the groups

| Groups | Mean±Standard deviation (BMI) | *F* value | *P* value |
|---|---|---|---|
| A | 24.2160±0.5225 | 13.58 | 0.0004* |
| B | 24.3680±1.1433 | | |
| C | 23.2000±0.8036 | | |

BMI: Body mass index. *The parameters is statistically significant as *P* value is less than 0.01

## DISCUSSION

The present age- and sex-matched study shows that serum magnesium level is lower in hypertensive subjects when compared to the normotensive subjects. The mean serum magnesium level in control is 2.068 ± 0.4515 while it is 1.5560 ± 0.40320 in Stage 1 hypertensive and 1.3920 ± 0.4081 in Stage 2 hypertensives. Since $P < 0.05$, there is a significant difference in serum magnesium level between the groups. When compared to the normotensive subjects, the serum magnesium level is lower in Stage 1 hypertensives, and when compared to the Stage 1 hypertensive subjects, the serum magnesium level is lower in Stage 2 hypertensives. Hence, it is evident from the results that BP increases the serum magnesium level decreases. This negative correlation of serum magnesium with systolic and diastolic BP is also statistically significant ($P < 0.01$) between the groups.

Resnick *et al*. reported that in essential hypertension, there is a continuous negative correlation of serum magnesium with plasma renin activity ($r = -0.60$, $P < 0.001$).[7] Ferdousi *et al*. reported in their study that the serum magnesium level (mg/dl) was significantly lower in 30 offsprings of essential hypertensive parents when compared to the 30 age- and sex-matched offsprings of normotensive parents (1.90 ± 0.210 vs. 2.13 ± 0.366, $P < 0.01$) and also he found that the erythrocyte magnesium level (mg/dl) was lower in cases when compared to controls (4.46 ± 0.699 vs. 5.43 ± 0.775, $P < 0.001$).[8] In the present study also, there is a negative correlation exists between serum magnesium and BP. In the present study, even though within normal ranges, the BMI (24.2160 ± 0.5225 vs. 24.3680 ± 1.1433 vs. 23.2000 ± 0.8036, $P < 0.05$) of Stage 1 and Stage 2 hypertensives was significantly higher than the normotensive subjects. The results are similar to the findings of the study conducted by Ohira *et al*. In his study, he found that there exists an inverse relationship between serum magnesium with systolic BP and BMI.[9]

In the present study, the sample size is small, and only serum magnesium is estimated. Intracellular magnesium level estimation would have helped in a better understanding of the correlation between magnesium and hypertension. In people with hypertension, estimation of magnesium level should be done routinely since the deficiency can be easily corrected by magnesium supplementation. Future studies should involve a large sample size to emphasize the importance of magnesium in hypertension. Simultaneously, we can do an estimation of serum magnesium levels in hypotensives to find the correlation of BP and magnesium levels.

## CONCLUSION

Essential hypertension is a multifaceted complex disease, whose etiology remains unknown. The principal hemodynamic defect in hypertension is the elevated peripheral resistance, which is attributed mainly to the alteration in the vascular tone and endothelial dysfunction. Magnesium gains its importance by mediating these processes involving in the regulation of normal BP. There are various proposed mechanisms by which magnesium deficiency results in hypertension. Along with nitric oxide (NO); magnesium alters the vascular tone by influencing the smooth muscle and endothelium functions. Any alteration in the magnesium concentration leads to changes in the NO production and release, which in turn by modifying the calcium concentration causes an alteration in the arterial smooth muscle tone. Many experimental animal studies have shown that magnesium increases the production of prostacyclin and NO which, in turn, promotes both endothelin dependent and independent vasodilation.[10] Low serum magnesium levels augment the reactivity of the arterial system to the vasopressor substances and promote vasoconstriction, decreases the response to vasodilators, elevation of peripheral resistance, and finally leading to a rise in BP. Added to this magnesium improves insulin sensitivity and also has protective anti-inflammatory and antioxidant property. It also plays a key role in reducing the cholesterol level in our body. Haenni *et al*. found that after magnesium infusion, there is an increased endothelium-dependent vasodilation, and hence, this study confirms the relationship between the metabolism of magnesium and alteration in the endothelial function.[11] Because the present study clearly shows that low serum magnesium is associated with high BP, measures should be taken to enrich our diet with magnesium. Apart from diet, magnesium supplementation can also be done for the reduction of BP.

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**How to cite this article:** Rekha S, Murugiah J, Raajaseharan SR. Correlation of serum magnesium levels with blood pressure in normotensives and hypertensives. Natl J Physiol Pharm Pharmacol 2019;9(10):1017-1020.

**Source of Support:** Nil, **Conflict of Interest:** None declared.