

PREVALENCE OF HYPOMAGNESEMIA ASSOCIATED WITH METABOLIC SYNDROME AMONG ADULT PATIENTS

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Abstract

Hypomagnesemia is linked to insulin resistance and metabolic syndrome (MetS), but data from Pakistan are limited. To compare serum magnesium levels between adults with and without metabolic syndrome at "Chandka Medical College Hospital, Larkana". This cross sectional study (August 2025 to January 2026) enrolled 189 adults aged from 18 to 65 years. The principal investigator measured anthropometrics "waist circumference, blood pressure", laboratory parameters "serum magnesium, fasting glucose, triglycerides, HDL cholesterol", and classified "metabolic syndrome (MetS) using National Cholesterol Education Program and Adult Treatment Panel III criteria. Analysis used independent t-tests and chi-square tests". Mean serum magnesium was 0.78 ± 0.27 mg/dL (normal range: 1.8–2.4 mg/dL). The prevalence of objectively measured MetS was 14.3 % (27/189). Serum magnesium levels were 0.790 ± 0.290 mg/dL in non MetS participants (n = 162) and 0.737 ± 0.079 mg/dL in MetS participants (n = 27). The difference was not statistically significant (mean difference 0.053 mg/dL, 95 % CI -0.002 to 0.107, p = 0.057). No significant association was found between gender and MetS (p = 0.677). Physical inactivity was present in 60.3 % of the sample. Severe hypomagnesemia is highly prevalent in this Pakistani adult population but is not significantly associated with objectively measured MetS. The near significant trend (p = 0.057) suggests a possible relationship that should be investigated in larger studies. Routine magnesium assessment and population level interventions should be considered.

INTRODUCTION

Metabolism syndrome (MetS) is a cluster of interconnection metabolic disorders such as central obesity, insulin resistance, dyslipidemia, hypertension and disregarded glucose metabolism [1,2]. Each of the components takes its own turn exposes the risk of cardiovascular disease and type 2 diabetes mellitus; their combination leads to a stronger risk of morbidity and mortality [3,4]. The prevalence of the MetS in the world is between 12 and above 30 per cent in different regions based on the diagnostic criteria used [5,6,7]. The burden

is especially high in south Asia associated with natural poverty to genetic factors, high levels of refined carbohydrates in a diet, lack of exercise, and increasing obesity rates [8,9]. According to studies in the neighboring countries MetS has a prevalence ranging between 18% and 50% [3,10,11]. The estimates in Pakistan are between 18 % and 46 % with the greater burden in female population and the older age group [12,13,14]. Magnesium is a vital mineral that participates in more than 300 enzyme processes, such as energy metabolism, glucose regulation, insulin signals

and vascular tone [15,16,17]. Hypomagnesemia, which is usually asymptomatic, is caused by either poor nutritional consumption, gastrointestinal bleeding, kidney dysfunction, or chronic illness [18,19]. The eating habits practiced in the modern world that are rich in processed foods and low in magnesium foods like green leafy vegetables, whole grains, nuts, and legumes have been the major causes of increasing magnesium deficiency on earth [8,20]. New findings indicate that serum magnesium levels are strongly inversely associated with metabolic syndrome (MetS) items [21,26]. Deficiencies of magnesium have been linked with insulin resistance, delayed glucose tolerance, dyslipidemia, hypertension, systemic inflammation, and endothelial dysfunction [22,25]. Mechanistically, insulin resistance elevates urinary magnesium excretion, and hyperglycemia enhance tubular reabsorption which leads to a vicious circle that exacerbates both hypomagnesemia and metabolic abnormality [19,28]. Magnesium is also involved in the relaxation of vascular smooth muscle and blood pressure control via transport of calcium and formation of nitric oxide [15]; lack of magnesium results in a rise in vascular resistance and high blood pressure [29,30]. In the same way, hypomagnesemia leads to increased triglycerides and deficient HDL cholesterol levels via the effect on lipoprotein synthesis and clearance enzymes [25,31,32].

Despite robust international evidence linking hypomagnesemia to metabolic syndrome (MetS), data from South Asia particularly Pakistan remain limited [1]. Most local studies focus on MetS prevalence and risk factors rather than micronutrient abnormalities such as magnesium deficiency [13,33]. This knowledge gap has clinical implications. Magnesium supplementation is economical, widely available, and safe [34]. Global studies suggest it may improve insulin sensitivity, lipid profiles, and blood pressure in metabolic syndrome (MetS) populations [35]. However, routine serum magnesium evaluation is not commonly practiced in Pakistan [1,14].

In Pakistan the increasing prevalence of Metabolic Syndrome (MetS) is directly significant contributor of the morbidity attributable to

diabetes mellitus and cardio vascular diseases [37,40]. Hypomagnesemia is closely associated with “insulin resistance, hypertension, dyslipidemia, and inflammation” [40,42], but it is not frequently diagnosed. The lack of region specific evidence slows down the development of the first recognition and treatment of this possibly alterable abnormality.

The incidence of hypomagnesemia among Pakistani population with Metabolic Syndrome (MetS) will not only contribute as a source of local evidence, but also facilitate the clinical practice guidelines, and a basis of subsequent interventional research on magnesium supplementation. This investigation seeks to explore the prevalence of serum magnesium levels in patients diagnosed with metabolic syndrome, and association proportion of MetS population with hypomagnesemia.

METHODOLOGY

2.1: Study Design and Setting:

The study was a cross-sectional observational study that was undertaken at Chandka Medical College Hospital, Larkana, between August 2025 and January 2026. The Ethics Committee of “Shaheed Muhtarma Benazir Bhutto Medical University, Larkana” gave the approval to the study protocol.

2.2: Participants:

This was done by enrolling 189 adults aged between 18 and 65 years in the inpatient medical units (I, II, III), diabetes and endocrinology ward and outpatient medical and diabetic clinics. Inclusion criteria included: Aged between 18 and 65 years and had to give informed consent. The criteria used as exclusion criteria included known cardiovascular disease, renal disease, taking of medications that affected magnesium levels (diuretics, proton pump inhibitors, magnesium containing antacids or magnesium supplements and acute illnesses or active infection and pregnancy or breastfeeding.

2.3: Sample Size:

The minimum sample size was 188 using the EPI formula with a cross sectional analysis (95% confidence level, the expected prevalence of MetS

23.9% would be based on a previous national study, and the margin of error would be 5:). To account incomplete data, we have adjusted this by 10 percent and the overall result was a target of 189 participants. Sampling was done consecutively (non probability).

2.4: Data Collection:

Respondents were given a structured questionnaire where they were to provide demographic details, medical history, lifestyle choices and dietary consumption. The questionnaire was translated and read back into Sindhi to assure of linguistic mileage then pretested on 10 respondents.

The country of study used standard procedures to measure anthropometry of the major researcher. A non-elastic tape was used to measure the waist circumference at the mid point between the lower costal margin and iliac crest. Blood pressure was recorded at a fixed time interval (five minutes) and at the end of the 10 minutes-rest period in the presence of a calibrated sphygmomanometer.

The 3cc of Venous blood was collected under an aseptic condition. ELISA was used to measure serum magnesium. Amman Welfare Trust Pathology Laboratory was selected as the site for analysing the fasting blood glucose, triglycerides, and HDL cholesterol.

2.5: Diagnostic Criteria:

“Metabolic syndrome (MetS) was defined using NCEP ATP III criteria, requiring at least three of the following” [18];

Waist circumference: “> 102 cm (men) or > 88 cm (women)”

Triglycerides: more than 150 mg/dL

HDL cholesterol: less than 40 mg/dL (men) or less than 50 mg/dL (women)

Fasting glucose: more than 100 mg/dL

Blood pressure: “systolic more than 130 mmHg or diastolic more than 85 mmHg”

Hypomagnesemia was defined using the reference range provided by the performing laboratory (normal range 1.8 – 2.4 mg/dL). Serum magnesium <1.8 mg/dL was classified as hypomagnesemia.

2.6: Statistical Analysis:

Data were entered into “SPSS version 25.0. Descriptive statistics” mean $\pm$ SD for continuous variables; frequencies and percentages for categorical variables” were calculated. An independent t test compared mean serum magnesium levels between participants with and without metabolic syndrome (MetS). The “chi square test assessed associations between categorical variables and MetS status”. A “p value < 0.05 was considered statistically significant”.

2.7: Ethical Approval:

All participants provided written informed consent. The study adhered to the Declaration of Helsinki. Confidentiality was maintained by assigning unique identification numbers to all participants.

3: Result and Discussion

3.1: Participant Characteristics:

One hundred and eighty-nine adults, with ages between 18 and 65 years, were recruited. The average age group was 36 -45 years. Males comprised 51.9 % (n = 98) and females 48.1 % (n = 91). The majority were married (76.2 %), employed (44.4 %), and resided in rural areas (55.6 %). The small percentage of 60.3 was reported as a result of physical inactivity (never exercising).

3.2: Prevalence of Metabolic Syndrome:

“Using National Cholesterol Education Program (NCEP) and Adult Treatment Panel III (ATP III) criteria” applied to objective measurements “waist circumference, blood pressure, fasting glucose, triglycerides, HDL cholesterol), 27 participants (14.3 %” met the criteria for metabolic syndrome “MetS”. The remaining 162 participants 85.7 % did not have MetS.

3.3: Serum Magnesium Levels:

The mean serum magnesium level in the overall population was “0.78 $\pm$ 0.27 mg/dL, well below the normal reference range of 1.8–2.4 mg/dL” provided by the performing laboratory.

3.4: Comparing Magnesium levels between groups:**Group Statistics**

Groups	N	Mean	Std. Deviation	Std. Error Mean
Non Mets	162	0.7896	0.290	0.023
Mets (Objective)	27	0.7370	0.079	0.015

An “independent samples t test showed no statistically significant difference in serum magnesium levels between participants with and without objectively defined MetS (mean difference

= 0.053 mg/dL, 95 % CI: -0.002 to 0.107, $p = 0.057$), assuming unequal variances (Levene's test $p = 0.002$)”.

3.5: Association between Gender and Metabolic Syndrome**Gender of patient × MetS: New Crosstabulation (% within Gender)**

Gender	No MetS (%)	MetS (%)	Total
Male	86.7 %	13.3 %	100.0 %
Female	84.6 %	15.4 %	100.0 %
Total	85.7 %	14.3 %	100.0 %

A chi square test indicated no significant association between gender and metabolic syndrome ($\chi^2(1) = 0.173$, $p = 0.677$).

3.6: Interpretation of Key Findings

The aim of the study was to establish the prevalence of hypomagnesemia among metabolic syndrome (MetS) patients among a population of Pakistani adults. The main results are that objectively measured prevalence of MetS was 14.3% much lower than self-reported (45%); there was severe hypomagnesemia (mean serum magnesium of 0.78 mg/dL) across all the cohort; there was no statistically significant difference in magnesium levels between MetS and non MetS ($p = 0.057$); and gender was not related to MetS. Put simply, this condition is predominant

used outpatient and inpatient adults but there were some exclusion criteria (e.g., known cardiovascular or renal disease, medications that could have influenced magnesium) so it is possible that we simply selected a healthier group of people by mistake. Third, the low prevalence could be due to the relatively young age (18 to 65 years, mean 36 to 45 years) of the cohort as opposed to older adults in previous studies. However, 14.3% is still a huge load considering that almost every seventh adult in this cohort had MetS requirements.

3.8: Hypomagnesemia: Highly Prevalent but Not Associated with MetS. The most striking finding is the profound hypomagnesemia in the entire study population (mean 0.78 mg/dL, normal range 1.8–2.4 mg/dL). This level is severely low patients with values below 1.0 mg/dL are generally considered to have moderate to severe deficiency and may be at risk for neuromuscular irritability, cardiac arrhythmias, and metabolic derangements [15,19]. The fact that the mean is so low suggests a population wide dietary magnesium insufficiency, possibly due to reliance on processed foods, low intake of “green leafy vegetables, whole grains,

3.7: Prevalence of Metabolic Syndrome

The objectively determined MetS prevalence of 14.3 per cent is not as high as most of the earlier estimations of Pakistan (18-46 per cent) [1,13,14] and South Asia (3,6,11). There are a number of reasons at work. First, other studies conducted in Pakistan have typically employed other diagnostic criteria (e.g., IDF vs. NCEP ATP III) or patients of older age, urban, or higher risk. Second, we only

nuts, and legumes”, or high consumption of refined carbohydrates that increase renal magnesium excretion [8,20].

Despite this high burden, we found no significant difference in magnesium levels between “MetS and Non MetS groups ($p = 0.057$)”. The p value approached but did not reach conventional significance ($\alpha = 0.05$). This near significant trend (mean difference 0.053 mg/dL, 95 % CI 0.002 to 0.107) might become significant in a larger sample. However, the clinical interpretation is that hypomagnesemia is so universal in this population that it cannot discriminate between those with and without MetS. In other words, the background deficiency may overwhelm any incremental effect of MetS on magnesium status. This finding contrasts with many international studies that report an inverse association between serum magnesium and MetS [21,24,26,27]. However, those studies were typically conducted in populations with normal or near normal magnesium levels. In settings with endemic severe deficiency, as appears to be the case here, the relationship may be obscured because almost everyone is deficient regardless of MetS status. This is a plausible explanation and should be highlighted.

3.9: Gender and MetS

No significant association was found between gender and MetS, consistent with the chi square result ($p = 0.677$). Some Pakistani studies have reported higher MetS prevalence in females [1,13], while others show no difference. Our findings suggest that in this particular cohort, gender does not influence MetS risk. The “relatively balanced gender distribution (51.9 % male, 48.1 % female)” and similar proportions of MetS among males (13.3 %) and females (15.4 %) support this conclusion.

3.10: Comparison with Previous Studies

Our MetS prevalence (14.3 %) is lower than the 23.9 % used for sample size calculation (derived from a prior national study). This discrepancy may reflect differences in study setting, year, or population characteristics. However, our primary finding severe hypomagnesemia without a

significant association with MetS is novel for Pakistan. Previous local studies have focused on MetS risk factors but rarely measured serum magnesium [1,13,14]. One study from neighboring India reported that hypomagnesemia was more common in MetS patients [27], but those patients had mean magnesium levels around 1.6 mg/dL nearly double our cohort’s mean. Thus, the degree of deficiency in our population is exceptional and may explain the lack of association.

3.11: Clinical Implications

Two clinical implications emerge. First, routine serum magnesium testing should be considered for all adults in this region, regardless of MetS status. The finding of mean magnesium < 0.8 mg/dL suggests widespread deficiency that may contribute to cardiovascular risk, insulin resistance, and hypertension independently of MetS [22,29]. Second, magnesium supplementation, which is inexpensive and safe [34], may be beneficial for the general population rather than only for those with MetS. However, interventional studies are needed to confirm whether correction of hypomagnesemia improves metabolic outcomes in this context.

3.12: Limitations:

Several limitations should be acknowledged. First, this was a single center cross sectional study, which precludes causal inference. Second, the sample size 189 was calculated based on an anticipated MetS prevalence of 23.9 %; the observed prevalence of 14.3 % reduced statistical power to detect differences in magnesium levels. The borderline p value (0.057) may reflect this underpowering. Third, we did not assess dietary magnesium intake, which would help explain the severe deficiency. Fourth, we excluded participants taking medications that affect magnesium (e.g., diuretics, PPIs), which may limit generalizability to patients on those common drugs. Fifth, the laboratory reference range (1.8–2.4 mg/dL) may differ from other laboratories, but the severe deficiency is unambiguous. Finally, we did not measure urinary magnesium excretion or intracellular magnesium levels, which could provide additional insight.

3.13: Strengths:

The inclusion of objective measurement of MetS components by the principal investigator, instead of self report, is the major strength. Anthropometry and biochemical parameters (waist circumference, blood pressure, fasting glucose, triglycerides, HDL cholesterol and serum magnesium) were directly measured through standardized protocols. This guarantees accuracy and reproducibility in diagnosis.

4: Conclusion:

Hypomagnesemia is extremely common in this Pakistani adult population, with mean serum magnesium levels less than half of the lower limit of normal. However, it is not significantly associated with objectively defined metabolic syndrome, likely because deficiency is near universal. Routine magnesium assessment and population level interventions to improve magnesium intake should be considered, regardless of MetS status.

4.1: Future Research:

Prospective cohort studies are needed to determine whether hypomagnesemia precedes or follows the development of MetS in this population. Clinical guidelines evidence would be of high quality with randomised trial being used to conduct controlled trials on magnesium supplements, results in terms of insulin sensitivity, blood pressure, and lipid profiles. Additionally, dietary surveys could identify the specific nutritional gaps causing such severe magnesium deficiency.

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