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The prevalence of hypomagnesaemia among college students and its significant association with high BMI

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Abstract

This study intends to explore the widespread nature of hypomagnesaemia among college students at Jazan University and test possible link with some anthropometric attributes like their ages, height, weight & body mass index (BMI). A total of 134 student volunteers had participated in this study aged between 18 and 24 years. The research was carried out at college of applied medical sciences at Jazan University, Jazan province, southern-west Saudi Arabia, between November 2023 and January 2024. Blood sample were collected from all participants and subjected to serum magnesium analysis based on a colorimetric method. The frequency of hypomagnesaemia cases were 18 (13.4%) and hypermagnesemia was 6 (4.5%). Serum magnesium level showed a statistically significant negative correlational relationship with BMI (Pearson's coefficient r=-0.201; p-value= 0.019). Furthermore, obese subjects (BMI>30) showed lower levels of serum magnesium compared to normal BMI category (BMI=18-25) that was statistically significant; p-value=0.0023. The research provides the prevalence of hypomagnesaemia in college student's population. The study also reported a direct link between obesity and low serum magnesium levels. Additional analysis with a greater sample size is required to support these discoveries.

Subject Classification: *Primary11H60, Secondary 26A24.*

Keywords: *Magnesium, Hypomagnesaemia, Body mass index, Obesity, Jazan province, Saudi Arabia.*

1. Introduction

Magnesium (Mg^{2+}) is a crucial mineral that plays a key role in the overall health and well-being of the human body. It plays a role in various biochemical reactions and is essential for the optimal operation of various organ systems. Magnesium is the 4th most prevalent mineral in our body and is found widespread in bones, muscles, and other tissues. The importance of magnesium in human physiology was recognized as early as the 19th century when it was identified as an essential nutrient [1]. Since then, extensive research has given insight on the various functions of magnesium and its impact on human health. Magnesium serves as a coenzyme for hundreds of catalysts engaged in energy generation, DNA replication, protein synthesis, and muscle contraction [2]. It plays a vital role in the synthesis of adenosine triphosphate (ATP) in the TCA cycle and electron transfer pathway, the body's primary energy molecule. Without adequate magnesium levels, energy production within cells would be compromised, leading to fatigue and decreased physical performance.

Moreover, magnesium is involved in protein synthesis, which is essential for tissue repair, growth, and maintenance [3]. It helps as a cofactor in the synthesis of DNA and RNA, as well as the assembly of proteins, enzymes, and other molecules necessary for cellular function [4]. It works in association with calcium to regulate the contraction and relaxation of muscles [5]. Magnesium acts as a natural calcium channel blocker, preventing excessive calcium from entering muscle cells and causing sustained contraction. This balance is crucial for proper muscle function and helps prevent muscle cramps and spasms caused by excessive intracellular calcium [6].

The nervous system relies on magnesium for proper functioning. It plays a crucial role in nerve signaling, neurotransmitter release, and maintaining the delicate balance between excitation and inhibition [7]. Adequate magnesium levels maintain healthy neurological function, while deficiencies may contribute to conditions like migraines, mood disorders, and impaired cognitive function [8].

In addition, magnesium is an integral partof bone health. It is involved in bone formation and mineralization, working alongside calcium, vitamin D and parathyroid hormone [9]. Adequate magnesium levels are necessary for optimal bone density, reducing the risk of osteoporosis and fractures [10].

Magnesium (Mg^{2+}) Deficiency

Magnesium deficiency is a condition of low magnesium in the body. Because magnesium is found predominately in the tissues, blood magnesium level may not necessarily reflect the entire body magnesium content. However, low blood magnesium or hypomagnesaemia can be used as a reliable indicator for possible magnesium deficiency [11]. The normal plasma levels of magnesium ranges roughly between 1.9 - 2.5 mg/dL that is 0.85 to 0.95 mmol/L. Plasma magnesium levels < 1.8 mg/dL (0.74 mmol/L) considered as low magnesium or hypomagnesaemia. Levels < 1.25 mg/dL are considered as severe hypomagnesaemia despite its importance, magnesium deficiency is relatively common causing significant impact on health and well-being, with certain populations being at a higher risk. Scientific research has shown that inadequate magnesium levels can lead to various health conditions and illnesses [12]. Factors like poor dietary intake, certain medical conditions, alcoholism, and certain medications can lead to magnesium deficiency [13]. Identifying the indications and clinical signs of magnesium deficiency is vital for timely intervention and ensuring adequate magnesium intake.

A study published in the Journal of the American College of Nutrition investigating the prevalence of magnesium deficiency in the United States found that approximately 48% of the population had inadequate magnesium intake from food sources alone [14]. This highlights the extent of magnesium deficiency which is a big public health concern. Magnesium insufficiency has been linked to development of cardiovascular disorders as shown by the meta-analysis of prospective cohort studies published in the journal atherosclerosis demonstrated that low magnesium levels were associated with a heightened risk of suffering from stroke and coronary heart disease [15]. Another research published in the American Journal of Clinical Nutrition discovered a reverse correlation between magnesium intake and risk of developing hypertension [16].

Furthermore, magnesium deficiency has been linked to musculoskeletal disorders as seen in the study published in the Journal of the American Geriatrics Society which revealed that decreased magnesium levels were linked to a heightened risk of osteoporosis and fractures in postmenopausal women [17]. Another research issued in the Journal of Clinical Endocrinology and Metabolism reported that magnesium supplements enhanced muscle performance and reduced muscle cramps in individuals with magnesium deficiency [18].

In addition, magnesium deficiency has been associated with mental health disorders as seen in the review published in the journal PLOS One which showed that low magnesium levels correlated with a heightened risk of depression [19]. Another research published in the Journal of Neural Transmission reported that magnesium supplements improved symptoms in patients with major depressive disorder [20].

The above studies highlight the importance of maintaining adequate magnesium levels in the body. While magnesium deficiency can have deleterious effects on health, supplementation or dietary adjustments can help address the deficiency and prevent development of associated risks.

Obesity and Magnesium deficiency: Obesity is a multifaceted metabolic disorder characterized by an excess of adipose tissue deposition. It is a global health issue linked with several health complications, such as diabetes, cardiovascular disease, and hypertension leading altogether to what is called metabolic syndrome [21]. Evolving researches suggest a potential relationship between obesity and magnesium deficiency. Several studies have observed lower magnesium levels in individuals with obesity. A study published in the journal Biological Trace Element Research found that obese individuals had significantly lower serum magnesium levels compared to non-obese individuals [22, 27]. Similarly, a research published in the journal Nutrition & Metabolism reported lower magnesium levels in obese individuals compared to non-obese [23].

Magnesium deficiency in obesity may be attributed to several factors including excessive adipose tissue may lead to increased urinary excretion of magnesium, resulting in lower magnesium levels in the body [24] as well as inadequate consumption of magnesium-rich foods, which is commonly observed in individuals with poor-quality diets, can contribute to magnesium deficiency in obesity [25].

The association between obesity and magnesium deficiency is complementary. On one hand, magnesium deficiency could result in the onset of obesity. Magnesium plays a crucial role in glucose metabolism and insulin signaling. Insufficient magnesium levels can lead to insulin resistance and subsequent weight gain [26].

On the other hand, obesity itself may lead to magnesium deficiency. Adipose tissue releases inflammatory cytokines that can impair magnesium homeostasis [27]. Furthermore, conditions associated with obesity like diabetes and metabolic syndrome are associated with increased urinary magnesium excretion and reduced magnesium absorption [28].

Addressing magnesium deficiency in individuals with obesity may have significant benefits. Magnesium supplementation has been associated with improvement in insulin sensitivity, glucose metabolism, and lipid profiles in obese individuals [29][41].

Obese individuals often have lower magnesium levels compared to non-obese individuals. Magnesium deficiency in obesity may be influenced by factors like increased urinary excretion, inadequate dietary intake and inflammation. Addressing magnesium deficiency in individuals with obesity may have potential metabolic benefits. However, more research is required to examine the mechanisms and clinical implications of this relationship.

Obesity in Saudi Arabia

Obesity represents a significant public health issue in the Kingdom of Saudi Arabia. Recent decades have seen a swift rise in the occurrence of obesity in the country, leading to a number of health and economic implications [30]. A study done in Saudi Arabia has found the prevalence of obesity reaching alarming levels, with estimates ranging from 35% to 45% among adults [31]. The occurrence of obesity is greater among women in comparison to men, and it is particularly prevalent among children and adolescents [32].

Quite a few elements contribute to the elevated prevalence of obesity in Saudi Arabia including urbanization and lifestyle changes that led to decreased physical activity levels and increased consumption of unhealthy diets, characterized by high-calorie foods, saturated fats, and sugary beverages [33]. Moreover, cultural factors like inactive lifestyles and customary dietary practices also exert a significant influence in the emergence of obesity.

The consequences of obesity in Saudi Arabia are monumental including the onset of persistent illnesses such as type 2 diabetes, cardiovascular disorders and specific type of cancers. The burden of ailments related to obesity imposes a substantial strain on the healthcare infrastructure and contributes to the escalation of healthcare expenditures in the nation [42].

Keeping in mind the consequences of obesity, the Saudi government has implemented various initiatives and programs to address it including educational campaigns to raise awareness about healthy eating habits and the importance of physical activity. Additionally, policies have been implemented to promote healthier food choices like introduction of sugar taxes and restrictions on advertising unhealthy foods [43].

However, conquering obesity requires a comprehensive, multifaceted approach. It involves not only individual behavior change but also creating an environment that supports healthy lifestyles, including access to nutritious foods and opportunities for physical activity. Collaboration between government, educators, healthcare professionals and the community are crucial for the effectiveness of strategies for preventing and managing obesity.

Aim of the Study

Our study investigated the prevalence of hypomagnesaemia among Jazan University college students. We also examined the relationship between low plasma magnesium and overweight or obesity in this study group.

Methodology

Study participants

In this cross-sectional study, 134 students (male/female) volunteered providing samples for our collection at medical laboratory department, college of applied medical sciences, at Jazan University, between November

2023 and January 2024. Participants were Saudi Arabian citizens aged between 18 and 24years. We excluded non-Saudi students, people with chronic illnesses, or who were morbidly obese and pregnant women.

Ethics

All participants provided their informed consent to their involvement in the investigation. This study obtained authorization from the local Research Ethics Committee at Jazan University under the reference number (REC-45/06/929) on January 4, 2024 and adhered to the ethical principles oulined in the Declaration of Helsinki.

Collecting blood samples:

Each participant provided 5-mL of venous blood in a lithium heparin tube using an aseptic technique. The sample is left to clot for 30 minutes and then the plasma was separated through centrifugation at 4000 RPM for five minutes. The samples were either analyzed immediately for magnesium or stored at freezer (-20^{0}C) for later analysis within three days.

Magnesium Measurement

The plasma magnesium was assessed using MAGNESIUM liquicolor Photometric Colorimetric Test for Magnesium with Lipid Clearing Factor (LCF) (Human diagnostic worldwide, Germany). The assay principle was based on the ability of magnesium ions to generate a purple-colored combination with xylidyl blue in an alkaline state. The absorbance of the produced color quantified spectrophotometrically at specified wavelength of 520 nm and 25C. The increased absorbance was directly proportional to magnesium level present in the sample. Glycoletherdiamine-N, N, N′, N′-tetraacetic acid (GEDTA) was employed as masking chemical for calcium ions.

Statistical analysis

We conducted all statistical analyses using graph Pad Prism 10 software (San Diego, CA, USA). Continuous variables were provided as mean ± standard deviation (SD) while categorical data were displayed as absolute numbers with their percentages. All data underwent normality testing using the D’Agostino & Pearson test. All data of weight, height, BMI, and magnesium passed the normality test (p-value>0.05), except for age did not pass the test (p-value<0.0001). To test the correlation between serum magnesium level and other anthropometric attributes of the study population like age, height, weight and BMI, Pearson's correlation coefficient was calculated at 95% confidence intervals. Comparison between mean was carried out using one-way analysis of variance (ANOVA) coupled with uncorrected Fisher's least significant difference (LSD) multiple comparison test at a 95% confidence level.

The statistical significance level was set to $p<0.05$.

Results

Table 1 illustrates the measured demographic baseline attributes and serum magnesium measurements of all participants. The number of male volunteers was higher than females because the study was performed principally in the male campus. The average body mass index (BMI) of the study population was 24.22±5.18 which is within the expected normal range among college students. The distribution of subjects with normal serum magnesium (Mg^{2+}) (1.9-2.6 mg/dL), hypomagnesaemia (<1.8 mg/dL), and hypermagnesemia (>2.6 mg/dL) demonstrated on Figure 1. Among the studied group (total, n=134), 110 (82.1%) subjects had normal serum magnesium level, 18 subjects (13.4%) showed low serum magnesium or hypomagnesaemia, and only 6 students (4.5%) are with high serum magnesium or hypermagnesemia.

In order to determine any association between serum magnesium levels and other parameters such as age, weight, height or BMI, Pearson's

Table 1
Baseline attributes of the study participants

Variable	Mean±SD (Total *n*=134)
Gender *n* (%)	
Male	96 (71.6)
Female	38 (28.4)
Age at presentation (years)	21.49±2.32
Weight (kg)	67.8±17.14
Height (cm)	166.7±8.88
BMI (kg/m^2)	24.22±5.18
Serum Magnesium (mg/dL)	2.142±0.24

Data represent means ± standard deviation (SD) unless stated otherwise. BMI- body mass index.

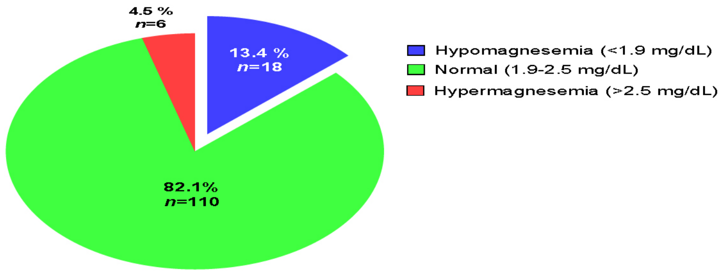

Figure 1

Distribution of serum magnesium level.

Table 2

Pearson's correlation coefficient between serum magnesium level and other parameters.

Parameter	Correlation Coefficient (r)	p-value
Age	0.093	0.286
Weight (kg)	-0.193	*0.026**
Height (cm)	-0.054	0.532
BMI (kg/m^2)	-0.201	*0.019**

coefficient of correlation (r) was calculated between magnesium levels and these parameters. The data showed that magnesium had a statistically significant negative connection with weight (r=-0.193, p-value=0.026) and body mass index (r=-0.201, p-value= 0.019) in Table 2. Magnesium correlation with either age (r=0.093, p-value= 0.286) or height (r=-0.054, p-value=0.532) were not statistically significant.

To further evaluate the correlation between BMI and obesity, the participants were divided based on their BMI grade into: underweight (BMI less than 18), normal weight (BMI between 18 and 25), overweight (BMI between 25 and 30), and obese (BMI greater than 30) and the mean of serum magnesium for each group plotted graphically (Figure 2). The difference between means were tested using one-way analysis of variance (one-way ANOVA) coupled with uncorrected Fisher's least significant difference (LSD) multiple comparison test to compare between the control group (BMI=18-25) and the other BMI categories. ANOVA analysis reported a statistically significant difference between means of all BMI categories (p-value=0.024). Pos-hoc multiple comparison showed a statically significant reduction in magnesium levels in obese group

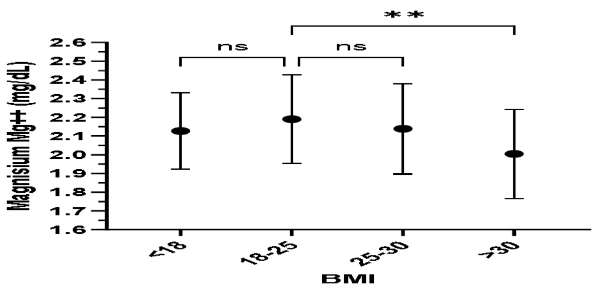

Figure 2

Comparison between serum magnesium levels in different BMI categories

The data are reported as mean and standard deviation (SD). BMI is body mass index; ns= Not statistically significant; **= p-value <0.001.

(BMI>30); p-value=0.0023, compared to the control group. Comparison between the underweight (BMI<18) and overweight (MBI=25-30) groups to the control normal group showed no significant difference; p-value= 0.323 and 0.313 respectively.

Discussion:

The current research examines the correlation between serum magnesium levels & various parameters, with a focus on body mass index (BMI) among university students. To scrutinize these findings, various relevant studies conducted worldwide specifically in Asia have been analyzed as well as existing researches within the Kingdom of Saudi Arabia (KSA) were also compared.

Global Perspective:

Studies worldwide have explored the complex relationship between magnesium levels and BMI, supporting the current study's findings [34] identified a comparable negative correlation between magnesium levels and BMI in diverse populations. [35]. Called attention to consistent patterns of magnesium's inverse association with BMI across different continents. These global findings emphasize the absoluteness of the magnesium-BMI relationship observed in the current study.

Asian Perspective:

In Asia which has different dietary pattern compared to Western countries, researches had revealed similar trends. Studies in Japan [36, 37] demonstrated a negative connection between magnesium levels and BMI, in accordance with the current study's observations. They also shed light to the consistency of magnesium-BMI relationship across diverse populations and suggest the importance of cultural and regional factors.

Saudi Arabian Perspective:

The Kingdom of Saudi Arabia represents a unique population due to cultural and dietary differences. Very few studies particularly exploring magnesium levels in relation to BMI in Saudi Arabia were found, highlighting a substantial gap in research. However, certain broader research on magnesium deficiency in the Saudi population [38][39] and its association with metabolic health provided an indirect support for the current study's findings. Further investigation is warranted to explain and clarify the specific dietary factors influencing magnesium status in the Saudi population.

Discussion of Current Study:

The current research's results are in line with global trends, emphasizing the inverse relationship between magnesium levels and BMI. The higher prevalence of low magnesium levels in the obese group supports established evidences [17, 35] . The study's focus on university students provides comprehension into a specific demographic, but one should be cautious when generalizing it to broader population.

Potential Mechanisms:

The negative correlation between magnesium levels and BMI observed in various studies raises questions about potential mechanisms. Magnesium is engaged in myriad physiological processes, such as glucose metabolism and insulin sensitivity [17]. Further research could explore these mechanisms, providing a deeper understanding of how magnesium influences body weight.

Implications for Public Health:

Understanding the relationship between magnesium levels and BMI has incriminations for public health, especially in regions with a rising prevalence of obesity [40]. Providing dietary strategies to ensure an adequate intake of magnesium may contribute to obesity prevention and management. Public health interventions should consider promoting magnesium-rich foods as part of a balanced diet.

Conclusion

The current study offers valuable insights into the relationship between serum magnesium levels and BMI among university students. While consistent with worldwide as well as Asian trends, the study also highlights the need for more specific research within the unique population of Saudi Arabia. These findings highlight the significance of taking into consideration regional and cultural factors when interpreting magnesium-BMI associations and suggest directions for future research to explore the underlying mechanisms and potential interventions.

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