

A Comparison of Serum Magnesium and Blood Sugar Levels between Obese and Normal-Weight Adolescents

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Abstract

Background: In recent years, there has been a sharp rise in the prevalence of obesity across all age groups, which poses a serious threat to public health. Numerous micronutrients, including magnesium, are deficient in obese people. Magnesium is a vital cofactor for hundreds of enzyme systems and is involved in the metabolism of sugars, proteins, and lipids. Obesity is one of the most significant risk factors associated with the development of glucose intolerance, cardiovascular disease, high blood pressure, and hyperlipidemia. Given the recent rise in obesity at young ages, this study aimed at comparing serum magnesium and blood sugar levels between obese and normal-weight adolescents.

Methods: In this case-control study, fifty-seven 12-18-year-old obese and overweight adolescents (BMI above 85% as the case group) and normal-weight adolescents (BMI between 65% and 85% as the control group) were selected randomly from high schools across Birjand. Upon recruitment and assignment of participants, blood samples were collected and serum magnesium and glucose levels were measured. SPSS 15 software was utilized to analyze the collected data.

Results: Age and gender distributions were similar between the case and control groups ($P > 0.05$). The mean serum magnesium concentration was significantly lower in the case group than in the control group ($P < 0.05$). The mean blood sugar level in the case group was significantly higher than that in the control group ($P < 0.05$). There was no correlation between blood glucose and magnesium in the two groups ($P > 0.05$).

Conclusion: The mean serum magnesium concentration of overweight and obese adolescents is lower than that of normal-weight children. Therefore, serum Mg may serve as an early biomarker for predicting obesity-related diseases. Further research is required to evaluate the precise role of magnesium in obesity prevention and to establish the causal relationship between obesity and magnesium deficiency.

Key Words: Fasting Blood Sugar, Magnesium, Obesity, Overweight. Children.

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1- INTRODUCTION

Obesity is a serious threat to public health as the prevalence of obese and overweight children and adults has been increasing rapidly and globally in recent years (1). Over the past 30 to 40 years, childhood and adolescent obesity has evolved into a serious problem. Environmental and genetic factors contribute to childhood obesity, including increased caloric intake, drug use, and endocrine, genetic, and chromosomal factors. Obesity in parents is particularly predictive of childhood obesity (2). Some studies have recognized childhood and adolescent obesity as a risk factor for adult obesity (2). It is known that childhood overweight and obesity have a significant impact on physical and mental health. Notably, 42 million infants and toddlers worldwide were overweight or obese in 2013. In case the current trend continues, there will be approximately 70 million overweight or obese children by 2025. Obesity in children is associated with cardiovascular risk factors, such as dyslipidemia, insulin resistance, blood pressure, and atherosclerosis indicators (3).

Magnesium (Mg) is the fourth most abundant cation in the human body and the second most important intracellular ion. It serves as an essential cofactor for hundreds of enzyme systems and plays a role in the metabolism of sugars, proteins, and lipids (4). Mg ions have a well-established function in the physiological regulation of vascular smooth muscle activity and cardiac muscle. Mg is a required cofactor in all ATP transfer reactions and regulates the activity of glycolysis' rate-limiting enzymes. In addition, Mg modulates the cellular activity of numerous plasma membrane and ion transport pump mechanisms (5) and can function as a weak calcium channel blocker, modulating calcium channel activity in heart cells and resulting in vasodilation (6). An Mg metabolism disorder has been linked to

numerous diseases, including cardiovascular disorders, insulin resistance, type 2 diabetes, and hypertension (7). Mg plays multiple physiological roles in processes such as parathyroid metabolism, cardiovascular system, nerve cell stability, nerve conduction, and adenosine phosphate complex function (7). Moreover, it is found in a variety of foods, including whole grains, nuts, green leafy vegetables, and legumes (8).

Some studies have demonstrated that obese and overweight individuals have lower serum Mg levels than normal-weight individuals (9-12). However, data on children are scarce both globally and domestically in Iran.

This study seeks to examine the connection between serum Mg levels and obesity and other factors in light of the essential role of the Mg ion in the human body and the alarming rise in childhood and adolescent obesity caused by changes in diet and exercise habits, particularly in urban societies. This was accomplished by comparing obese children and adolescents with normal-weight children and adolescents in the province of South Khorasan. Given the prevalence of obesity in society, there is optimism that an effective step can be taken to prevent this disease based on the findings of this study.

2- MATERIALS AND METHODS

A cross-sectional case-control study was conducted on adolescents aged 12 to 18 studying at schools across Birjand, Iran, in 2021. The participants with a BMI above the 85th percentile of the CDC standard were selected at random as the case group (obese and overweight), while adolescents with a BMI between the 65th and 85th percentiles of the CDC standard were recruited as the control group. The study excluded adolescents with chronic diseases, including diabetes, cardiovascular disease history, congenital

heart disease, renal failure, liver disease, and glandular disease.

Sample size was estimated based on the findings of Hassan et al. (9), as well as the formula for comparing two averages, to be fewer than 10 individuals per group. Given the possibility of attrition, 31 members were considered for each group. Ultimately, the study was completed with 26 adolescents in the case group and 31 in the control group.

After the study protocol was approved and the code of ethics was obtained, adolescents were evaluated based on their height, weight, age, and gender. The weight of adolescents was measured with barefoot and minimal clothing, by the use of a German Seca scale with an accuracy of 50 grams. In a standard manner, their height was also measured using a measuring tape with an accuracy of 0.1 centimeters while they were barefoot and standing. After calculating the BMI of eligible adolescents, they were assigned to case and control groups. Six cc of blood were collected from fasting participants in clot tubes containing no anticoagulant. Roche kits via the ECL (electrochemiluminescence) technique were employed to assess Mg and blood sugar parameters.

2-1. Data analysis

After collecting, coding, and recording the data in SPSS (version 15) software, the data were analyzed using the most appropriate statistical tests. The

independent t-test and chi-square test were utilized, given the normality of data distribution. The level of significance was set at the 0.05 level.

3- RESULTS

This study included 57 adolescents aged 12 to 18, with 31 in the obese and overweight group and 26 in the normal-weight group. In the case group, the mean age was 13.9 ± 1.9 years, and in the control group, it was 14.6 ± 2.4 years ($P = 0.24$). In terms of gender frequency distribution, the case group comprised 15 boys (48.4%) and 16 girls (51.6%), while the control group comprised 13 boys (50%) and 13 girls (50%) ($P = 0.73$). So, the age and gender distributions of the two groups were comparable.

A statistically significant difference ($P < 0.001$) was observed between the case and control groups' mean BMIs. The mean FBS of overweight and obese adolescents was significantly greater than that of normal-weight adolescents ($P = 0.004$). In addition, the mean Mg levels of obese and overweight adolescents were significantly lower than those of normal-weight adolescents ($P = 0.002$) (**Table 1**).

The correlation coefficient between blood sugar and Mg was estimated as $R = 0.05$ and $P = 0.81$ in the obese and overweight group and $R = 0.09$ and $P = 0.67$ in the normal-weight group. Neither group exhibited a significant correlation between blood sugar and Mg ($P < 0.05$).

Table-1: Comparing the mean scores of variables in case and control groups

Variables	Case (n = 31)	Control (n = 26)	Statistical test results	P-value
BMI	26.4 ± 3.5	18.9 ± 3.4	t = 11.7	<0.001
FBS	94.1 ± 6.3	87.9 ± 9.1	t = 3	004
Mg	1.85 ± 0.12	2 ± 0.21	t = 3.3	0.002

4- DISCUSSION

Obesity is a multifactorial disease with complex pathophysiology that is epidemically spreading. Numerous researchers have conducted studies on the obesity epidemic in accordance with the socioeconomic conditions of various nations. Mg has been proposed as an important micronutrient that regulates enzyme processes and glucose metabolism and, therefore, plays a significant role in determining individuals' weights (10).

In our study, the average Mg levels of obese and overweight adolescents were significantly lower than those of their normal-weight counterparts. In a study by Hassan et al., serum Mg levels were significantly lower in the overweight and obese group than in the normal weight group. A significant inverse relationship was observed between serum Mg concentration and BMI (9). Similarly, in another study conducted by Huerta et al., serum Mg levels in obese children were significantly lower than in the control group ($P = 0.009$), and serum Mg levels were inversely related to fasting insulin levels. In addition, it was suggested that serum Mg deficiency in obese children might result from decreased Mg intake (13).

Another study by Jose et al., in the same way, revealed that overweight children have lower Mg serum levels than normal-weight children. This study, further, found that low serum Mg levels can exacerbate insulin resistance in obese children and increase their risk of developing type 2 diabetes and cardiovascular diseases as adults (14).

According to a cohort study by Yakinci, in addition to other micronutrients, such as copper and zinc, serum levels of Mg are reduced in obese children (15). In another study, Bertinato et al. discovered a negative correlation between serum Mg levels and BMI in healthy adults and

children (16). According to a further study, obese children and adults have low Mg levels in their blood despite consuming a diet rich in mg-containing foods (35).

The decrease in Mg in overweight and obese adolescents may be caused by a reduction in Mg absorption from the intestine or an increase in Mg excretion. Mg absorption in the intestine can be inhibited by consuming excessive amounts of calcium or fat. Tea consumption in our community is largely attributable to dietary preferences. Moreover, the consumption of carbonated soft drinks rich in phosphorus has increased, which can interfere with the absorption of essential nutrients, including Mg. It is also important to note that most fast foods are poor sources of Mg and that children who consume more fast food are more prone to obesity, as demonstrated by an Iranian study (17-18).

Various studies have also examined how dietary Mg intake and serum Mg levels are associated with insulin resistance and type 2 diabetes in adult men, women, and children (19, 20). A study found that obese adolescents have fewer minerals (zinc, mg, and calcium) than normal-weight adolescents, which may contribute to insulin resistance (18). In a 2020 study, Chutia et al. explains that Mg is a crucial cofactor in glucose metabolism and a second messenger in insulin action. Therefore, hypomagnesemia in type 2 diabetic patients may account for their increased insulin resistance (21).

Some studies have a different perspective. According to Guerrero-Romero et al., there is no direct correlation between obesity and hypomagnesemia; rather, hyperglycemia and insufficient Mg intake are responsible for hypomagnesemia, regardless of obesity (22). Obesity, diabetes, and metabolic syndrome can, in the majority of cases, coexist (23).

It is still debatable whether Mg supplements play a role in the prevention or treatment of obesity and related diseases. In a randomized, double-blind, placebo-controlled trial conducted on obese subjects by Rodriguez-Moran, Mg supplementation significantly improved metabolic profile and blood pressure (24). Another study demonstrated that supplementing chromium with Mg leads to a greater reduction in insulin resistance than using its ion alone (25).

A randomized interventional study found that Mg supplementation improved cardiovascular health in overweight and obese adults (26). Numerous studies on humans and animals have demonstrated that Mg supplementation enhances insulin-mediated glucose disposal and insulin secretion (27-29).

In our study, the mean FBS of adolescents who were overweight or obese was significantly greater than that of adolescents of normal weight. Consistent with this finding are the findings of a 2010 study by Hashemipour, which indicated that high FBS was quite prevalent among obese adolescents (30). In a 2020 study on the association of serum Mg deficiency with insulin resistance in type 2 diabetes mellitus, Chutia et al. found that the case group (type 2 diabetes) had higher FBS and lower Mg concentrations than the control group. (31).

Additionally, Chahkandi et al. reported a high prevalence of FBS and prediabetes among adolescents in the city of Birjand, Iran, a red flag that calls for the attention of health officials (32).

Obesity, type 2 diabetes, and metabolic syndrome are interrelated conditions associated with chronic inflammatory conditions. In metabolic diseases, hypomagnesemia caused primarily by unhealthy diets contributes to the development of an inflammatory milieu that exacerbates the metabolic disorder.

Mg supplementation appears to have a corrective effect on this vicious cycle, although it is currently unclear whether Mg's beneficial effects result from a direct impact on metabolic pathways, an indirect impact on inflammation, or both (23).

Children who are overweight or obese have an elevated risk of remaining obese as adults. This increases the risk of various ailments, particularly diabetes and cardiovascular diseases. In light of the global prevalence of obesity, type 2 diabetes, and metabolic syndrome, modifying poor eating habits and subsequently taking Mg supplements may be a low-cost but effective measure for preventing the onset and progression of these conditions.

Despite studies indicating a correlation between serum Mg levels and obesity, additional research is required to determine the precise role of Mg and whether obesity is associated with low Mg intake or serum Mg levels. Besides, the effect of a micronutrient such as Mg on preventing obesity-related complications should be further investigated.

5- CONCLUSION

Compared to adolescents of normal weight, those who are overweight or obese have lower serum Mg and higher blood sugar levels. Therefore, serum Mg may serve as an early biomarker for predicting obesity-related diseases (diabetes and cardiovascular risks).

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7- CONFLICT OF INTEREST

None.

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