Med. J. Cairo Univ., Vol. 89, No. 2, June: 529-533, 2021
www.medicaljournalofcairouniversity.net

Serum Magnesium Level and Inflammation in Obese Medical Students at Ain Shams University

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Abstract

Background: Chronic systemic low-grade inflammation is a key feature of obesity because of adipose tissue inflammation with overexpressed pro-inflammatory cytokines. Magnesium (Mg) deficiency is one of the pathophysiological links between inflammation and obesity. Detection of factors contributing to obesity are therefore fundamental strategy in obesity management.

Aim of Study: To determine the relationship between the serum level of Mg, dietary intake of Mg and inflammation among a sample of Medical Ain Shams students.

Subjects and Methods: The current study is a descriptive study of 60 medical students divided into two equal groups. Group 1 includes normal weight students with BMI between 18.5-24.9kg/m^2 and group 2 includes obese students with BMI ≥30kg/m^2.

Results: There was a significant increase in BMI, Waist Circumference (WC), Waist Hip Ratio (WHR), C-Reactive Protein (CRP), and decrease in serum Mg and dietary intake of Mg in the obese group compared to normal weight group. Moreover, BMI, WC, and WHR were positively correlated with CRP and negatively correlated with serum Mg. Serum Mg and dietary intake of Mg were negatively correlated with CRP.

Conclusion: Our study may lend an additional support to the positive relationship between obesity and inflammatory status. Also, it confirms the negative relationship between obesity/inflammatory stress to Mg status in this subset of obese students as compared to normal weight students in Faculty of Medicine, Ain Shams University.

Key Words: *Obesity – Inflammation – C-reactive protein – Magnesium status.*

Introduction

OBESITY, defined as a Body Mass Index (BMI) ≥30kg/m^2, affects over one third of the world's population. If secular trends continue, it is estimated that 20% of the world's adult population will be obese by 2030. The globally expanding obesity termed as "Globesity" and its associated health problems increase the economic and health burden [1].

Chronic systemic low-grade inflammation is a key feature of obesity that acts as a critical link between obesity and obesity-associated disorders [2]. Adiposopathy, which is an adipose tissue inflammation, and pathogenic qualitative adipose tissue changes as a resultant of adipocyte hypertrophy, plays an important role in inflammation with the overproduction of proinflammatory markers [3].

Serum concentrations of several inflammatory markers including C-Reactive Protein (CRP) are elevated in obese individuals **[4]**. Liver has a crucial role in synthesis and release of CRP as it drains free fatty acids and the circulating triacylglycerol promoting release of cytokines as IL-6 by adipose tissue, which acts as an essential trigger for hepatocyte expression and release of CRP **[5]**.

In Egypt, obesity is increasing at an alarming rate upon the changing of the Egyptians' lifestyle patterns including food pattern consumption, food habits and nutrient intake of high caloric food **[6]**. Unhealthy dietary pattern and its components are pointed to be important contributors to the inflammatory state associating obesity.

Specific nutrients as magnesium (Mg) play a crucial role in inflammation associating obesity. Mg is an essential mineral found in many foods, including whole grains, green leafy vegetables, legumes, and nuts. The recommended dietary allowance of this mineral is 400-420 and 310-320 mg/day for adult men and women, respectively. Studies revealed decreased serum Mg level as well

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as a low Mg-containing diet in obese children and adults [7,8]. Mg deficiency activates the proinflammatory milleu in obese individuals who often consume diets rich in fat and sugar and deficient in Mg, which make them prone to deficient Mg status that induces chronic low-grade inflammation [9]. Thus, detection of factors contributing to obesity are therefore a fundamental strategy in obesity management.

Subjects and Methods

Type of study: Descriptive study.

Study setting: The study was conducted at Ain Shams University (ASU) Hospitals.

Study period: 3 months, onset in September 2017.

Sampling method: This study was performed on simple random sample.

Sample size: 60 students, control group (30 students) and case group (30 students), were included in this study.

Age: Age group ranges from 19 to 25 years.

Gender: No sex predilection.

Inclusion criteria:

- *Group 1:* Control (normal weight) group: Students with BMI between 18.5-24.9kg/m^2.
- *Group 2:* Case (Obese) group: Students with BMI ≥30kg/m^2.

Exclusion criteria:

- Students on non-steroidal anti-inflammatory drugs, corticosteroids, statins, hormonal therapy, or immunosuppressive drugs.
- Students with autoimmune diseases or other inflammatory disease.

Consent: A written informed consent was obtained from each student after explaining the aim of the study & all the procedures that were done. Privacy & confidentiality were concerned. Approval was obtained from the ethical committee. The study was conducted according to the stipulations of the ASU Ethical and Scientific Committee.

Study method: Convenience sample.

Study tools: Using the data supplied by the participants project.

Physical examination: Anthropometric data: Weight, height, body mass index, waist, waist hip ratio.

Investigations:

Serum magnesium level was estimated using ELITech Magnesium Calmagite kit (ELITech Clinical Systems, SAS, 61500 SEES France). hs CRP was estimated by CRP hS enzyme-linked immunosorbent assay using precheck kit (USA). Dietary magnesium intake was computed and assessed through the food composition analysis software according to Egyptian Food Composition tables was prepared by National Nutrition Institute [10].

Statistical analysis:

The collected data was coded, tabulated, and statistically analyzed using IBM SPSS statistics (Statistical Package for Social Sciences) software version 22.0, IBM Corp., Chicago, USA, 2013. Data were described using the mean ± Standard Deviation (SD).

Quantitative data are tested for normality by Shapiro-Wilk test to apply parametric test (Student *t*-test) or non-parametric tests (Mann-Whitney). A probability level of less than or equal to 0.05 was considered significant. A probability level of less than or equal to 0.01 was considered highly significant. Spearman correlation coefficient was used to assess the correlation between the measured parameters.

Results

Statistical results:

Descriptive statistics of the studied subjects:

Table (1): Demographic and anthropometric characteristics of studied groups.

Measure / Parameters	Normal weight (N=30)	Obese (N=30)	Significance
Age (years):			
Mean ± SD	21.5±1.9	22.3±1.7	*t*=–1.784
Range	18.0-24.0	18.0-25.0	*p*=0.079
BMI (kg/m^2):			
Mean ± SD	21.2±3.0	33.6±3.2	U=–6.730
Range	18.2-24.4	30.0-35	*p*=0.000*
Waist circumference (cm):			
Mean ± SD	76.4±5.4	99.9±9.1	U=–6.753
Range	70.0-90.0	90.0-119.0	*p*=0.000*
Waist hip ratio:			
Mean ± SD	0.70±0.06	0.89±0.08	*t*=–2.476
Range	0.65-0.94	0.89-1.04	*p*=0.016*

t : Independent-Samples *t*-test.
U : Mann Whitney test (Chi-Square value).
* : $p<0.05$: Is significant but $p>0.05$: Is not significant.

The study included 30 normal weight students in group 1 with mean age 21.5 ± 1.9, while group

2 included 30 obese students with mean age 22.3± 1.7. Significant difference was observed between both groups regarding BMI, WC, and waist hip ratio (Table 1).

Table (2): Serum CRP (mg/L) among the studied groups.

Parameters \ Measure	Normal weight (N=30)	Obese (N=30)	Significance
Serum CRP (mg/L):			
Mean ± SD	2.6± 1.3	9.5±0.7	U=–6.926
Range	0.5-5.5	7.7-10	p=0.000*

U: Mann Whitney test (Chi-Square value).
* : p<0.05: Is significant.

Table (2) shows significant difference observed between both groups regarding the serum CRP with mean 2.6± 1.3 in group 1 versus 9.5 ±0.7 in group 2.

Table (3): Serum Mg levels (mg/dl) among studied groups.

Parameters \ Measure	Normal weight (N=30)	Obese (N=30)	Significance
Serum Mg (mg/dl):			
Mean ± SD	2.15±0.22	1.6±0.12	U=–6.55
Range	1.8-2.4	1.5-1.9	p=0.000*

U: Mann Whitney test (Chi-Square value).
* : p<0.05: Is significant.

Table (3) shows a significant difference between studied groups regarding serum Mg level with mean 2.15±0.22 in group 1 versus mean 1.69 ±0.12 in group 2.

Table (4): Dietary Mg intake (mg/day) levels among the studied groups.

Parameters \ Measure	Normal weight (N=30)	Obese (N=30)	Significance
Dietary Mg intake (mg/day):			
Mean ± SD	343.1±44.4	282.45±42.3	U=–3.363
Range	309-420	230-350	0.001*

U: Mann Whitney test (Chi-Square value).
* : p<0.05: Is significant.

Table (4) shows a significant difference between studied groups regarding dietary Mg intake with mean 343.1 ±44.4 in group 1 versus mean 282.45 ± 42.3 in group 2.

Table (5) show that there was significant positive correlation between serum CRP and BMI, waist circumference and waist hip ratio as well as significant negative correlation with serum Mg level and dietary Mg intake among studied groups.

Table (5): Correlations of serum CRP with studied parameters among the studied groups.

Variables	CRP	
	ρ	p-value
BMI	0.787	0.000*
Waist circumference	0.745	0.000*
Waist hip ratio	0.257	0.042*
Serum Mg	–0.724	0.000*
Dietary Mg	–0.384	0.002*

ρ : Spearman Correlation (non-parametric).
*: p<0.05: Is significant.

Table (6): Correlations of serum Mg and dietary Mg with anthropometric measures among the studied groups.

Variables	Serum Mg		Dietary Mg intake	
	ρ	p-value	ρ	p-value
BMI	–0.715	0.000*	–0.304	0.016*
Waist circumference	–0.742	0.000*	–0.323	0.010*
Waist hip ratio	–0.320	0.011*	–0.078	0.541

ρ : Spearman Correlation (non-parametric).
*: p<0.05: Is significant but p>0.05: Is not significant.

Table (6) show that there was significant negative correlation between serum Mg and all anthropometric measures. There was significant negative correlation between dietary Mg with BMI and waist hip ratio.

Discussion

In the present study, regarding the anthropometric measurements, BMI, WC and WHR were significantly (p<0.05) higher in the obese group than the normal weight group. However, non-significant (p>0.05) difference was recorded in age between both studied groups.

BMI is regarded as an indirect general measure of fatness. It was a nearly consistent finding in different studies that BMI is correlated with direct measures of body fat **[11]**. WC and WHR are established surrogate measures of abdominal obesity **[12]**.

Results of the current study revealed a statistically significant (p<0.05) increase in hs CRP in the obese group rather than the normal weight group. Moreover, hs CRP is significantly correlated with BMI, WC and WHR. The hs CRP is robust marker of systemic inflammation, including subclinical inflammation. Earlier studies have demonstrated the associations between obesity and inflammatory cytokines as CRP using BMI, WC and WHR as underlying measure of adiposity **[13,14]**.

In agreement to our results, obesity has been linked to the low-grade systemic inflammation marker CRP where each degree of obesity was positively correlated to elevated CRP [5]. A review and meta-analysis published in 2013 identified 51 cross-sectional studies pointed to the direct correlation between obesity and CRP in in adults [4].

In state of obesity, the excess caloric intake represents the driving factor of inflammatory state which initiates deleterious remodeling of adipose tissue where obesity related inflammation is started and then exaggerated [15]. This eventually ends with a macrophage and lymphocyte recruitment in adipose tissue, overexpressed cytokine secretion, that collectively flares up a state of systemic inflammation [16].

Liver interacts with adipose tissue in triggering obesity related inflammation. In case of excess nutrient intake, the liver drains excess free fatty acids, and circulating triacylglycerol promoting the release of IL-6, IL-1 0 and TNF-a by adipose tissue [5]. Liver is regarded as the major source of CRP in response to most notably IL-6 and to a lesser degree IL-1 0 and TNF-a released by adipose tissue [17].

In the current study, results revealed a significant ($p<0.05$) decrease in serum Mg and dietary intake of Mg in the obese group compared to the normal weight group. Serum Mg was positively correlated to the dietary intake of Mg and negatively correlated with BMI, WC, WHR and hs CRP. Dietary intake of Mg was negatively correlated with BMI, WC and hs CRP.

Parallel to our results, in human studies, it was found that serum Mg is negatively affected by long term deficient dietary Mg intake [18]. A study conducted by Nielsen et al., [19] pointed that reduced Mg intake was positively correlated with CRP and body mass index in adults.

The inflammatory cascade associating defective Mg status in obese individuals is explained through activation of phagocytic cells, activation of nuclear transcription factor kappa B, activation of N-methyl-D-aspartate receptors and release of neurotransmitters, such as substance P. In this regard, the reduced intake of this mineral and its low serum concentration were strongly related to the increase in the plasma concentration of inflammatory biomarkers, such as CRP [20].

Conclusion:

Our study may lend an additional support to the positive relationship between obesity and inflammatory status. Also, it confirms the negative relationship between obesity/inflammatory stress to Mg status in this subset obese medical students as compared to normal weight medical students in Faculty of Medicine, Ain Shams University.

In the era of personalized and precision medicine, increasing our knowledge about the inflammatory nature of obesity and micronutrient malnutrition contributing to obesity provide new interventional approaches in obesity management.

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مستوى المجنيزيوم فى الدم والإلتهابات لدى طلبة الطب جامعة عين شمس

يعد الإلتهاب المزمن منخفض الدرجة هو سمة آساسية للسمنة بسبب إلتهاب الآنسجة الدهنية مع السيتوكينات المؤيدة للإلتهابات المفرطة. نقص المجنيزيوم هو آحد الروابط المرضية بين الإلتهاب والسمنة. لذلك فإن الكشف عن العوامل التى تسهم فى السمنة هو إستراتيجية آساسية فى علاج السمنة.

تهدف الدراسة إلى تحديد العلاقة بين مستوى المجنيزيوم فى الدم/المتناول الغذائى من المجنيزيوم والإلتهابات لدى عينة من طلبة الطب جامعة عين شمس.

\المواد والطرق: الدراسة الحالية عبارة عن دراسة وصفية ل ٦٠ طالب مقسمة إلى مجموعتين متساويتين. تشمل المجموعة ١ الطلاب ذوى الوزن الطبيعى مع مؤشر كتلة الجسم بين ١٨.٥–٢٤.٥كجم/م^{٢} والمجموعة ٢ تشمل الطلاب البدينين بمؤشر كتلة الجسم آكبر من ٣٠كجم/م^{٢}.

نتائج هذه الدراسة تشير إلى الزيادة فى مؤشر كتلة الجسم، ومحيط الخصر، ونسبة الخصر والوراك، CRP، وإنخفاض فى مستوى المجنيزيوم فى الدم المتناول الغذائى من المجنيزيوم فى مجموعة السمنة بدلاً من مجموعة الوزن الطبيعى. علاوة على ذلك، إرتبط مؤشر كتلة الجسم ومحيط الخصر، ونسبة الخصر والوراك إرتباطاً إيجابياً ب CRP وإرتباطاً سلباً لمستوى المجنيزيوم فى الدم المتناول الغذائى من المجنيزيوم ب CRP.

\الخلاصة: تقدم الدراسة دعماً إضافياً للعلاقة الإيجابية بين السمنة والحالة الإلتهابية. كما تؤكد على العلاقة السلبية بين السمنة/الإجهاد الإلتهابى وحالة المجنيزيوم فى هذه المجموعة الفرعية من الطلاب البدناء مقارنة بالطلاب ذوى الوزن الطبيعى فى كلية الطب جامعة عين شمس.