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Evaluation of Serum Magnesium in Obesity and Overweight and Normal Weight

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Abstract

The current study aimed to estimate of Magnesium Mg+ in adults in Obesity, Overweight and Normal weight and compare them and the relationship of magnesium with Body mass index BMI ,waist circumference WC and lipid profile Materials and Methods: This study included 100 people (29) 29% males and (71) 71% females whose ages were over 20 years old. They were Also divided according to nutritional status into obese group, overweight group and normal weight. The information required for the samples was recorded and BMI was measured, WC , Mg level and lipid profile were measured .Results: The results showed a decrease in the magnesium level in the obese as well as in the overweight and it was normal in the normal weight. The level of magnesium decreased in women and was higher in men in all feeding conditions, and the BMI of women was higher than that of men. The results of this work showed that there is an inverse negative relationship between Mg and each of BMI, WC, TCHO, TG ,LDL while the positive correlation between Mg and HDL.Conclusion: In finally, magnesium deficiency can be considered one of the factors that lead to obesity, and diseases associated with obesity.

***Keywords*:** Obesity, Overweight, Magnesium, Lipid profile.

1. Introduction

Obesity and overweight are a public health problem that exists around the world, and according to the World Health Organization report, it is the fifth leading risk factor for global deaths. Obesity in the world has tripled since 1975 and in 2016 there were more than 1.9 billion eight Ten years of age suffer from overweight and more than 650 million suffer from obesity. While more than 39% of adults were overweight and 13% were obese in 2016. There were 40 million children under the age of five who were overweight and obese in 2018. About 65% of the world's population lives in areas where There are more people due to overweight and obesity [1]. Obesity is a complex, multifactorial and preventable international disease. One 1/3 of the world's populace is overweight. The international occurrence of weight problems has extended with inside the beyond forty years, irrespective of gender, age, race, or socioeconomic status. If this growth continues, researchers estimate that via way of means of 2030. This wide variety will exceed 50% [2]. Overweight and obesity are associated with an increased incidence of chronic diseases such as type 2 diabetes, cardiovascular disease, cancer, high blood pressure, gallbladder disease, musculoskeletal disorders, and decreased health-related quality of life [3,4]. Excess fat is where excess fat accumulates inside the body, which leads to obesity to the extent that it will have a negative impact on health. a person is generally considered obese when their body mass index (BMI) which is the unit of measurement used in obesity is obtained by dividing a person's weight by the square of their height If the BMI is higher at 30 kg / m2, the range is defined as 25-30 kg/m2 overweight [5]. Micronutrients and macronutrients are an important factor in regulating different metabolic and metabolic processes and therefore have an effective role in the causes of obesity. Several studies are being conducted all over the world which clearly show a direct link between obesity and micronutrient deficiencies [6,7].

Magnesium is the fourth maximum considerable detail with inside the human body (Ca2 + > K + > Na + > Mg2 +) and the second one maximum considerable cation in the body cells after potassium. The human frame includes 760 mg of magnesium at start and this quantity will increase to five g at round 4-five months [8,9]. The normal concentration of magnesium in the blood ranges from 1.5-2.3 mg/dL

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(25), and its deficiency means a decrease in its serum concentrations to less than 1.7 mg/dL. The biological half-life of magnesium is about forty-two days in a normal human body [10]. Hypomagnesemia was defined as serum magnesium concentrations ≤ 1.8 mg/dL (≤0.74 mmol/L)[11] Magnesium is an essential cofactor for hundreds of enzymatic activities, acting as a coenzyme or cofactor for enzymes' basic components. Mg2+ is an important cofactor for kinases, just as it is for processes involving the Mg-ATP complex. As a result, Mg2+ is a limiting factor for numerous enzymes involved in carbohydrate and energy metabolism, and Mg2+ is required for macromolecule synthesis intermediate metabolism [12]. It was found that people who suffer from obesity and associated diseases such as metabolic syndrome and type 2 diabetes often have a deficiency of magnesium Mg2 + [13]. In three studies, the National Health and Nutrition Examination Survey (NHANES) found that Mg2+ deficiency was more prevalent in subjects with a BMI [14,15]. Mg2+ intake was decreased in 35% of French individuals with BMI>35 kg/m2 [16]The CARDIA 30-year study in over 5,000 subjects indicates that Mg2+ intake is inversely associated with obesity and C-reactive protein levels [17]. In addition to trials in animal models of induced obesity, Mg2 supplementation with magnesium + Inhibit fatty tissue buildup [18]. Also, human studies indicate an inverse association between Mg2+ magnesium intake and markers of obesity, such as BMI and waist circumference [19,20]. Positive high-density lipoprotein levels Serum magnesium has been found to have a significant negative correlation with TG and VLDL [21,22]. The present study aimed to reveal the role of magnesium in affected people who are overweight and overweight, as well as normal weight, by measuring cholesterol, triglycerides, high-density lipoproteins, low-density lipoproteins, body mass index and waist circumference, in addition to measuring the level of magnesium and comparing them with The aforementioned indicators for these people.

2. Method and Material

2.1. Study design

This study was designed in a private outpatient clinic for a period of approximately 12 months, after approval by the Scientific Research Ethics Committee of the University of Anbar ethicalapproval@uoanbar.edu.iq all personal details of the patients have been de-identified. Each patient provided written informed consent.

2.2. Samples study

The current study included 100 people of both sexes whose ages were over 20 years, the number of males was (29%) 29%, the number of females was (71) 71% and their information was recorded and then they were divided into three groups depending on the body mass index (normal weight group males 6 20.68% females 11 15.49% - the group of overweight males 9 31.04% and females 20 28.16% - and the obese group of males 14 48.28 and females 40 56.35%). People who take medicines.

2.3. Anthropometric measurements

Height, weight, and waist circumference were measured. The subjects of the study were wearing light clothes and without shoes, and the measurements were made using a digital scale. A non-flexible tape was attached to the wall to measure the length and the results were recorded to the nearest 0.1 kg, 0.1 cm and 0.5 cm, respectively. Body mass index was calculated as weight (in kilograms) divided by the square of height (in meters) (kg/m2). The readings were plotted and the weight status was considered normal, overweight or obese as mentioned above [23]. Waist circumference was measured using a flexible measuring tape, taking into account not to put pressure on the tissues, according to the recommendations of the World Health Organization, and after stopping the exhalation, the tape is placed at the midpoint of the space between the end of the rib cage and the upper end of the pelvis.

2.4.Biochemical test

Venous blood samples were obtained from the subjects of the study and after a fasting period ranging from 12-14 hours in order to measure chemical variables. Serum magnesium (Mg), total cholesterol (TCHO), high-density lipoprotein (HDL-C), and triglycerides were estimated (TG) was calculated by a dry chemistry analyzer (Fuji Dry-Chem; Fuji Photo Film, Japan). Low-density lipoprotein (LDL) was calculated using the formula [24, 25]. The normal values for the biochemistry variables were as follows: Serum magnesium concentration of 1.5 - 2.3 mg/dL 28.29; fasting TCHO <170 mg/dL; HDL > 45 mg/dL; LDL <110 mg/dL [26]; TG 150-199 mg/dL [27].

2.5.Statistical analysis

The data were statistically analyzed using (GraphPad prism 9.2.0.332) and the mean and standard deviation were calculated for all variables. The independent sample t-test was used to determine the significant differences and comparison by sex. The analysis of variance (ANOVA) one factor test was used to determine the differences between normal weight, overweight and obesity. The correlation coefficient to find the relationship between Mg with cholesterol, triglycerides, high-density lipoprotein, and low-density lipoprotein, WC, BMI for all tests, 95% confidence interval (CI) at significance level P-value < 0.05.

3. Results

This study was conducted on 100 adults and their age was more than 20 years, the number of males was 29 (29%) and the number of females was 71

(71%). Table (1) shows the results obtained from this study for the levels of Mg, TCHO, TG, HDL, LDL According to the nutritional status of males and females, WC and BMI are all statistically significant ($P < 0.05$) and Mg was lower in females compared to males in the normal weight condition. In the case of overweight, significant differences were found between males and females for all variables ($P < 0.05$)With the exception of TG, HDL had insignificant differences, and the level of Mg was lower in females compared to males as well and Mg was lower in obese females than in males, and it had significant difference (Table 1). Results were obtained after excluding sex for all variables. The serum magnesium levels of obese persons were less than overweight, while its level was normal in normal weight Table (2). The comparison was made between feeding conditions regardless of gender and showed significant differences ($P < 0.05$) except for TG and HDL, which were not significant. Magnesium levels decreased when BMI increased Table (3). The correlation between serum magnesium levels, body mass index, waist circumference, cholesterol, triglycerides, high-density lipoprotein and low-density lipoprotein was found by linear correlation with Pearson's coefficient, and the correlation was negative between magnesium ((TCHO r = - 0.671 P = 0.0001 (TG r = 0.0001) -0.2565 P = 0.0100) (LDL r = -0.707 P = 0.0001) (WC r = -0.458 P =0.0001) (BMI r = -0.5449 P = 0.0001) while the association with HDL was positive (HDL r = 0.4203 P =0.0001) Table(4).

Table 1 Comparison between males and females for Biochemical test and anthropometric measurement in Normal weight & Overweight & Obesity (t-test)

Parameter	Normal weight Mean SD±		*Mean difference*	*Confidence interval (95%)*		*p-Value*
	Male (35.29 %)6	Female (64.70%)11		Lower limit	Upper limit	
TCHO mg/dl	143±7.014	169.8±13.81	26.82	13.86	39.78	0.0005*
TG mg/dl	165.8 ±25.41	188.6 ±10.92	22.8	4.231	41.38	0.0194*
HDL mg/dl	1.633±47.67	37.36±5.537	-10.3	-15.3	-5.308	0.0005*
LDL mg/dl	3.887±62.17	94.73±12.41	32.65	21.33	43.79	0.0001*
WC cm	1.633±90.33	73.27±2.149	-17.06	-19.22	-14.91	0.0001*
Mg mg/dl	0.1044±2.432	1.752±0.02822	-0.6798	-0.7496	-0.6101	0.0001*
BMI kg/m2	0.5346±23.01	23.86±0.329	0.4889	0.4063	1.292	0.0010*
Parameter	Over weight Mean SD±		*Mean difference*	*Confidence interval (95%)*		*p-Value*
	Male (31.03%)9	Female (68.96%)20		Lower limit	Upper limit	
TCHO mg/dl	7.194±220.3	9.67±245.6	25.27	17.85	32.69	0.0001*
TG mg/dl	35.66±245.2	33.6±225	-20.22	-48.41	7.966	0.1526^{Ns}
HDL mg/dl	5.044±32.22	3.626±30.9	-1.322	-4.697	2.053	0.4258 ^{Ns}
LDL mg/dl	8.593±139.1	169.7±6.627	30.63	24.65	36.62	0.0001*
WC cm	2.224±85.22	91.6±2.371	6.378	4.46	8.295	0.0001*
Mg mg/dl	0.06346±2.136	1.638±0.02802	-0.4976	-0.532	0.4631-	0.0001*
BMI kg/m2	1.067±27.62	28.81±0.6699	1.188	0.5229	1.854	0.0011*
Parameter	Obesity Mean SD±		*Mean difference*	*Confidence interval (95%)*		*p-Value*
	Male (25.92%)14	Female (74.07%)40		Lower limit	Upper limit	
TCHO mg/dl	8.838±238.5	259.4±16.82	20.9	11.42	30.38	0.0001*
TG mg/dl	43.8±251.4	245.3±37.6	-6.107	-30.56	18.35	0.6184 ^{Ns}
HDL mg/dl	3.252±31.5	31.4±4.125	-0.1	-2.546	2.346	0.9349 ^{Ns}
LDL mg/dl	4.299±156.7	179±12.25	22.22	15.48	28.97	0.0001*
WC cm	4.653±100.6	107.3±10.24	6.704	0.9929	12.41	0.0223*
Mg mg/dl	0.0298±1.924	1.441±0.09203	-0.4835	-0.5341	-0.433	0.0001*
BMI kg/m2	1.077±33.43	36.39±5.361	2.962	0.04966	5.874	0.0464*

SD= Standard deviation NS=Non-significant, * significant at p value < 0.05,TCHO = Total cholesterol,TG= triglyceride HDL =High density lipoprotein, LDL =low density lipoprotein, WC = waist circumference, Mg =magnesium, BMI = body mass index.

Table 2 Demographic and clinical characteristics of normal Weight & Overweight and Obesity cases (gender excludes).

Parameters	Mean SD±			*Confidence interval (95%)*						*Minimum*			*Maximum*		
				Lower limit			Upper limit								
	Normal weight	Over weight	Obesity	Normal weight	Over weight	Obesity	Normal weight	Over weight	Obesity	Normal weight	Over weight	Obesity	Normal weight	Over weight	Obesity
TCHO mg/dl	**160.4** ± 17.58	237.8 ± 14.82	254 ± 17.68	151.3	232.1	249.2	169.4	243.4	258.8	134	212	219	192	270	293
TG mg/dl	180.6 ± 20.06	231.3 ± 34.93	246.8 ± 38.96	170.3	218	236.2	190.9	244.6	257.5	120	168	190	199	310	340
HDL mg/dl	41 ± 6.764	31.31 ± 4.072	31.43 ± 3.888	37.52	29.76	30.36	44.48	32.86	32.49	30	22	22	50	40	39
LDL mg/dl	83.24 ± 18.93	160.2 ± 16.09	173.2 ± 14.54	37.52	154.1	169.2	44.48	166.3	177.2	57	131.2	152	112.8	180.4	208.4
WC cm	79.29 ± 8.622	89.62 ± 3.774	105.5 ± 9.55	74.86	88.19	102.9	83.73	91.06	108.1	71	82	90	93	97	133
Mg mg/dl	1.992 ± 0.3407	1.792 ± 0.2378	1.566 ± 0.2285	1.817	1.702	1.504	2.167	1.883	1.628	1.71	1.6	1.25	2.6	2.21	1.97
BMI kg/m2	23.56 ± 0.5761	28.44 ± 0.971	35.62 ± 4.811	23.27	28.07	34.31	23.86	28.81	36.94	22.49	26.35	30.12	24.61	29.69	53.8

SD= Standard deviation NS=Non-significant, * significant at p value < 0.05 ,TCHO = Total cholesterol, TG= triglyceride HDL =High density lipoprotein, LDL =low density lipoprotein, WC = waist circumference, Mg =magnesium, BMI = body mass index.

Table 3 ANOVA one way between Normal weight & Over weight & Obesity(gender excludes).

Parameter	Normal weight& Overweight		*Confidence interval(95%)*				p-Value
	Mean SD±		Lower limit		Upper limit		
	Normal weight	Overweight	Normal weight	Overweight	Normal weight	Overweight	
TCHO mg/dl	160.4±17.58	237.8±14.82	151.3	232.1	169.4	243.4	0.0001*
TG mg/dl	180.6± 20.06	231.3±34.93	170.3	218	190.9	244.6	0.0001*
HDL mg/dl	41± 6.764	31.31±4.072	37.52	29.76	44.48	32.86	0.0001*
LDL mg/dl	83.24 ±18.93	160.2±16.09	73.5	154.1	92.97	166.3	0.0001*
WC cm	79.29±8.622	89.62±3.774	74.86	88.19	83.73	91.06	0.0002*
Mg mg/dl	1.992±0.3407	1.792±0.2378	1.817	1.702	2.167	1.883	0.0303*
BMI kg/m2	23.56±0.5761	28.44±0.971	23.27	28.07	23.86	28.81	0.0001*
Parameter	Normal weight& Obesity		*Confidence interval(95%)*				p-Value
	Mean SD±		Lower limit		Upper limit		
	Normal weight	Obesity	Normal weight	Obesity	Normal weight	Obesity	
TCHO mg/dl	160.4±17.58	254±17.68	151.3	249.2	169.4	258.8	0.0001*
TG mg/dl	180.6± 20.06	246.8±38.96	170.3	236.2	190.9	257.5	0.0001*
HDL mg/dl	41± 6.764	31.43±4.502	37.52	30.36	44.48	32.49	0.0001*
LDL mg/dl	83.24 ±18.93	173.2±14.54	73.5	169.2	92.97	177.2	0.0001*
WC cm	79.29±8.622	105.5±9.55	74.86	102.9	83.73	108.1	0.0001*
Mg mg/dl	1.992±0.3407	1.566±0.2285	1.817	1.504	2.167	1.628	0.0001*
BMI kg/m2	23.56±0.5761	35.62±4.811	23.27	34.31	23.86	36.94	0.0001*
Parameter	Obesity **&**Overweight		*Confidence interval(95%)*				p-Value
	Mean SD±		Lower limit		Upper limit		
	Overweight	Obesity	Overweight	Obesity	Overweight	Obesity	
TCHO mg/dl	237.8±14.82	254±17.68	232.1	249.2	243.4	258.8	0.0002*
TG mg/dl	231.3±34.93	246.8±38.96	218	236.2	244.6	257.5	0.1405Ns
HDL mg/dl	31.31±4.072	31.43±4.502	29.76	30.36	32.86	32.49	0.9933Ns
LDL mg/dl	160.2±16.09	173.2±14.54	154.1	169.2	166.3	177.2	0.0016*
WC cm	89.62±3.774	105.5±9.55	88.19	102.9	91.06	108.1	0.0001*
Mg mg/dl	1.792±0.2378	1.566±0.2285	1.702	1.504	1.883	1.628	0.0005*
BMI kg/m2	28.44±0.971	35.62±4.811	28.07	34.31	28.81	36.94	0.0001*

SD= Standard deviation NS=Non-significant, * significant at p value < 0.05,TCHO = Total cholesterol ,TG= triglyceride HDL =High density lipoprotein, LDL =low density lipoprotein, WC = waist circumference, Mg =magnesium, BMI = body mass index.

Table 4 Correlation coefficient between Serum magnesium level with anthropometric measurement and biochemistry parameters.

Parameter	Serum magnesium Mg	
	r-value	*p*-value
TCHO mg/dl	-0.671	0.0001*
TG mg/dl	-0.2565	0.0100*
HDL mg/dl	0.4203	0.0001*
LDL mg/dl	-0.707	0.0001*
WC cm	-0.458	0.0001*
BMI kg/m2	-0.5449	0.0001*

*= significant at p- value < 0.05,TCHO = Total cholesterol ,TG= triglyceride HDL =High density lipoprotein, LDL =low density lipoprotein,WC = waist circumference, Mg =magnesium, BMI = body mass index, r = Pearson correlation.

5. Discussion

The essential role of Mg in human health has been extensively studied and mentioned within the review by Fiorentini and colleagues. Mg acts as a communication part and substance in cell physiology, and its physiological state is regulated by the balance between internal organ absorption and nephritic excretion. Mg deficiency in the blood is maybe the foremost common solution imbalance. though magnesium deficiency is caused by inadequate dietary magnesium intake, magnesium deficiency is usually related to obesity, sort 2 diabetes, and metabolic syndrome. [28] Piuri et al. study provides interesting insights into the biochemical imbalances that occur when there is magnesium deficiency, and how altered metabolic pathways increase the risk of metabolic syndrome and type 2 diabetes as well as obese individuals [29]. In a systematic review study, and after analyzing the data, the study found the association of magnesium concentrations in the body with dyslipidemia and other disorders [30]. In patients with kidney disease, magnesium and lipids concentrations are associated with atherosclerosis, and according to another study, the carotid intima media has a thicker texture when triglyceride and LDL levels are high, but not when magnesium levels are high [31]**.** Magnesium Mg2 + and several enzymes are key pathways for glucose oxidation and are also required for the convert of B1 to thiamine diphosphate (TDP), an important coenzyme for oxidative processes in metabolism. It is important that TDP-dependent enzymes require Mg2 + in order to achieve optimal activation. Low intracellular concentrations. In the liver, a reduced Mg2 + -dependent pyruvate dehydrogenase activity and TDP can shift the glucose metabolism into the oxidative phase of the pentose phosphate pathway and this leads to an increased NADPH production. [32]. NADPH is an important redox cofactor for metabolic processes, including fatty acid biosynthesis, and therefore increased synthesis of triglycerides and low density lipoproteins, and hence greater accumulation of triglycerides in adipocytes which increases the extent of obesity and the risk of obesity Morbidity such as dyslipidemia, metabolic syndrome and type 2 diabetes [33,34] and in a study that indicated that the high concentration of triglycerides is linked to insulin resistance through the entry of free fatty acids into the liver and thus increase the storage of fat in adipose tissue, which leads to obesity [35,36]

On the other hand, recent studies have linked magnesium with kidney patients [37] and polycystic ovary syndrome [38] and hypothyroidism patients [39]. The proportion of magnesium in women was lower than in men in obesity and overweight, as studies conducted on groups showed Different populations show that 15-42% of ostensibly healthy adults have abnormal serum Mg levels. Magnesium deficiency is more common in women than in men, and the proportions are much higher in postmenopausal women and in individuals with obesity and type 2 diabetes [40, 41] If a study was conducted in North America and the concentration of magnesium in men was higher than in adult women aged 31-50 years, which indicates that women are more susceptible to magnesium deficiency [42], because women have lower intakes of magnesium, which exposes them to magnesium deficiency [43]and in A study conducted on postmenopausal women with osteoporosis and after a meta-analysis had lower serum magnesium levels compared to healthy controls [44].

Also, in a randomized study, increased magnesium intake in overweight and obese adults reduced arterial stiffness after 24 weeks of supplementation, thus reducing the risk of cardiovascular disease. [45]. Low levels of magnesium in the blood were also associated with people with cardiovascular disease, hypertension and diabetes compared to people without cardiovascular disease. Also, the relationship was inverse between magnesium and fasting serum insulin, glucose, systolic blood pressure, and smoking, and this is what Han and et al. study indicated. [46] This study also

found a negative relationship between the concentration of magnesium in the blood, total cholesterol and triglycerides, which agreed with the results of studies [47,48], while the relationship was positive with high-density lipoprotein [49]. In this study, the relationship was negative between magnesium and lipoprotein. In contrast, Randell et al. study reported a positive association between magnesium and LDL [48]. In addition, another study found a decrease in serum magnesium level in overweight or obese patients [50] In a study conducted on children, it was found that children with obesity and overweight have a lower level of magnesium in the blood compared to children of normal weight. [51]. This study indicated that there is a negative association between the level of magnesium in the blood, waist circumference and body mass index, and the results of this study are consistent with the study of Tharu et al. [52] It was also found that magnesium in the blood is negatively associated with obesity. Magnesium intake was also inversely associated with WC, body fat percentage, and BMI [53,54,55].

6. Conclusion

This study was designed to demonstrate the relationship of magnesium with obesity and overweight. The results of this study found a negative relationship between magnesium and obesity. And the level of magnesium in women was lower than in men in the case of obesity and overweight. The results of this study found that the level of magnesium decreased in people with obesity and was slightly higher in people with overweight compared to normal weight. Also, the results of the correlation analysis to and the existence of a negative relationship between magnesium Body mass index, waist circumference, cholesterol, triglycerides, and low-density lipoprotein. While the relationship was positive with high-density lipoprotein, and thus magnesium deficiency can be considered a vital indicator of obesity and its associated diseases. However, the relationship between magnesium, lipid levels and abnormal BMI needs further study to fully understand the relationship between them.

7. Conflicts of interest

The authors declare no conflict of interest in preparing this article.

8. Acknowledgements

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