Scientific Paper Titled:

Association and effects of serum calcium levels on Body Mass Index In Adults Sudanese people

العلاقة وتأثير مستوى مصل الكالسيوم على دليل كتلة الجسم في السودانيين البالغين بالتطبيق على عينة من مواطني ولاية الجزيرة

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ملخص الدراسة:

الخلفية: الكالسيوم عنصر غذائي ضروري للنمو والتطور الطبيعي. تهدف هذه الدراسة إلى تحديد و ربط مستوى الكالسيوم في الدم لدى البالغين الأصحاء مع مؤشر كتلة الجسم ما إذا كان هناك أي اختلاف بين الجنسين.

الطريقة: أجريت دراسة مقطعية خلال عام 2019 في ولاية الجزيرة على 534 بالغًا من كلا الجنسين. تم جمع ثلاثة مل من الدم في أنابيب مفرغة من الهيبارين وقياس الكالسيوم في الدم بطريقة القياس اللوني. تم قياس الوزن والطول ثم حساب مؤشر كتلة الجسم الوزن بالكيلوجرام مقسومًا على مربع الطول بالأمتار (كجم / م2. تم تحليل البيانات باستخدام الإصدار دلالة إحصائية. تم حساب مؤشر كتلة الجسم على أنه.

النتائج: تم تصنيف المشاركين في الوزن المنخفض ، الطبيعي ، زيادة الوزن والسمنة. كان متوسط مستويات الكالسيوم في الدم للمشاركين الذين يعانون من زيادة الوزن والسمنة 9.58 ± 0.68 و 9.75 ± 0.64 على التوالي للإناث و 9.42 ± 0.63 و 9.47 ± 0.62 على التوالي ، للذكور مقارنة بـ 9.43 ± 0.72 و 9.52 ± 0.79 للإناث و 9.26 ±. 0.67 و 9.35 ± 72.0 للذكور الذين يعانون من نقص الوزن ومؤشر كتلة الجسم الطبيعي ، على التوالي. مؤشر كتلة الجسم مرتبط إيجابياً ومعنوياً بمستويات الكالسيوم في الدم لدى الأشخاص الذين يعانون من السمنة المفرطة(r = 0.72 ، (P = 0.00

الخلاصة: خلصن الباحثون إلى أن الكالسيوم في الدم يرتبط إيجابيا بمؤشر كتلة الجسم في كلا الجنسين. يجب مراعاة المغذيات الدقيقة مثل الكالسيوم في علاج السمنة / زيادة الوزن.

Abstract:

background: Calcium is necessary nutrient for normal growth and development. This study aims to correlated serum calcium level in healthy adult with body mass index (BMI) and identify if there is any gender difference. **Materials and Methods:** A cross-sectional study was conducted during 2019 in Gezira state on 534 adults in both genders. Three ml of blood was collected in heparin vacuum tubes and serum calcium was measured by Calcium-O-C resolphthalein Complex one colorimetric method. Weight and height were measured and then BMI was calculated the weight in kilograms divided by height in meters squared (kg/m2). The data were analyzed by using SPSS version 23. P value < 0.05 was considered statistically significant. BMI was calculated as**. Results:** The participants were grouped into underweight, normal, overweight and obese. The mean serum calcium levels of participants with overweight an obese were 9.58± 0.68 and 9.75

± 0.64 respectively, for females and 9.42 ± 0.63 and 9.47 ± 0.62 respectively, for males as compared to 9.43 ± 0.72 and 9.52 ± 0.79 for females and 9.26 ± 0.67 and 9.35 ± 0.72 for males with underweight and normal BMI, respectively. BMI correlated positively and significantly with serum calcium levels in obese individual (r = 0.72, P = 0.00)

Conclusion: we concluded that the serum calcium is positively associated with BMI in both sexes. Micronutrients such as calcium should be considered in the management of obesity/overweight.

Keywords: *Body Mass Index, Calcium, Obesity*

Introduction:

Obesity is caused by several environmental factors such as sedentary life-style and excessive energy intake. (Wellen and Hotamisligil,2003) . Obesity has been referred to as a complex medical condition characterized by excess adipose tissue mass and body fat distribution that negatively effect on health and well-being. (Sunita and Puspa,2017). Obesity and overweight which according to the World Health Organization is defined as a body mass index (BMI) of ≥30 kg/m2 and ≥25 kg/m2, respectively, stand out amongthe non-transmissible chronic diseases because they are risk factors for other diseases such as dyslipidemia, cardiovascular diseases, diabetes, hypertension, and cancer .(Güngör,2014).

The essential challenge of obesity is an energy imbalance between caloric intake and energy expenditure.(Kamycheva, *et al*,2004) .It has been observed that an obese person can store over 70% of body mass as fat and is generally the result of both hypertrophy and hyperplasia of adipocytes.(Song and Sergeev,2012). Obesity arises from decreased physical activity, behavioral, social, environmental and genetic factors, urbanization, and modernization influences.(Akter, *et al*,2011). The prevalence of obesity has increased geometrically within the past three decades (Hill, *et al*,2005) and has been recognized as a worldwide epidemic by the World Health Organization in 1997. (Güngör,2014) Globally, one in six adults is obese and nearly 2.8 million individuals die every year due to overweight or obesity.(Pradeepa, *et al*,2015). Recent studies have suggested that some of the obesity-related illnesses, especially metabolic disorders, hypertension, and cardiovascular diseases are linked

by common defects in metabolism of some divalent cations including calcium and magnesium.(Güngör,2014;Rosolova, *et al*,2000).Calcium, the most abundant mineral in the human body, plays crucial roles in numerous physiological processes such as muscle contraction, hormones and neurotransmitter release, glycogen metabolism, cell proliferation and differentiation, blood clotting, nerve or sympathetic impulse transmission and structural support of the skeleton, and second messenger in several signaling pathways.(Ren, *et al*,2013) New evidence and review of earlier studies supports the view that calcium also plays a role in adipocyte lipid kinetics at the cellular level and in moderating fatness at the population level. Within adipocytes, intracellular calcium level alter the balance between lipid synthesis and breakdown, preferring lipogenesis when cytosolic calcium levels are high.(Shi, *et al*,2001). . When high quantities of calcium is consumed, it tends to bind to dietary fats, forming insoluble compounds, thereby reducing fat absorption and hence the amount of calories generated (Shahkhalili, *et al*,2001;Jacobsen, *et al*,2005) Researchers have also noted that intracellular calcium is modulated by calcitropic hormones such as parathyroid hormone (PTH) and 1, 25-dihydroxycholecalciferol and the levels of these hormones are increased by low dietary calcium intake, which enhances high levels of intracellular calcium in adipocytes. High levels of calcium in adipocytes stimulate lipogenesis and inhibit lipolysis. Levels of PTH and 1, 25-dihydroxycholecalciferol are decreased by high dietary calcium intake, so it lowers intracellular calcium, inhibits lipogenesis, and stimulates lipolysis.(Zemel, *et al*,2000;Zemel,2002) .An obesity gene expressed in human adipocytes called “agouti” has also been wont to explain the anti-obesity effect of dietary calcium. Agouti protein stimulates calcium influx (Kim, *et al*,1997) and promotes energy storage in human adipocytes by stimulating the expression and activity of fatty acid synthase and inhibiting lipolysis. Calcium channel agonists mimicked this action of agouti and it absolutely was inhibited by calcium channel antagonists.(Jones, *et al*,1996). Moreover, using a calcium channel antagonist (nifedipine) for 4 weeks, in transgenic mice overexpressing agouti, resulted in significant decreases in lipogenesis and in adipose tissue mass.(Kim, *et al*,1996). Therefore, the aim of our present study to correlate the serum calcium levels in normal healthy adult in both genders with BMI in Sudanese people.

Materials and Methods:

This is across sectional descriptive study conducted in the Gezira state, Sudan, from December, 2018- up to June, 2021).Study was conducted among 534 randomly selected adults mean age (24.67±4.82) who lived in Gezira State, Sudan. They were apparently healthy adults made up of 42.3% (226) were males and 57.7% (308) were females. Ethical approval was issued by the medical ethic committee of the University of Gezira. Written formal consent was obtained from each participant.

Exclusion criteria: All conditions that directly or indirectly affects serum calcium levels as well as BMI. Patients with genetic, endocrine, or syndrome causes of obesity were excluded. Preexisting hypertension, diabetes mellitus, cardiovascular disease, renal and liver disease, as well as patients on oral calcium and vitamin D supplements were excluded.

Anthropometrics measurement:

Weight was measured to the nearest 0.1 kg using a weighing scale (Soen Le, Germany). Height (in meters) was measured with each participant standing straight on a stadiometer without shoes to the nearest 0.5 cm.

BMI calculation:

The BMI was calculated as weight divided by square of height (kg/m^2). For adults, a BMI of less than 18.5 was classified as underweight, BMI of 18.5 to 24.9 as normal weight, BMI of ≥25.0 up to 30.0 was classified as overweight and BMI of ≥30.0 was classified as obese according to the World Health Organization criteria.(Pinhas-Hamiel, *et al*,2003).

Blood Sample collection:

The blood samples about 3 ml of venous blood [without a tourniquet because venous stasis can result in loss of fluid across the wall of the vein and a relative increase in protein-bound calcium], samples were collected in heparin vacuum tubes from each participant between 8:30 am -11 am and transferred to plain centrifuge tube, Serum separated by centrifuging blood for 10 minutes at 3000RPM. Serum was used for estimation of total calcium by Calcium-O-Cresolphthalein Complexone colorimetric method.

Reference range for laboratory tests (Murray et al 200)

Calcium serum 8.5-10.5 mg/dl (2.2-2.5 mmol/l)

Statistical analysis

Data obtained from this study were analyzed using the Statistical Package for the Social Sciences (IBM-SPSS) software for Windows, version 23.0, New York, USA. Numerical data were expressed as mean and standard deviation (SD). Qualitative data were expressed as frequency and percentage. Analysis of variance was done at ($P < 0.05$) level of significance. Chi-square, Students T-test, Pearson correlation and linear regression were used to estimate correlation between variables.

Result and Discussion:

Table (1) shows the distribution of body mass index according to gender in participants

Table (1) BMI in males and females

Type	BMI range	Male	Female
Under weight	<18.5	22	24
Normal	18.5-24.9	124	129
Over weight	25-29.5	46	96
obese	≥30.0	34	59
Total		226	308

Table (2) shows correlation between serum calcium level and body mass index:

Type	BMI range	Mean ±SD Calcium mg/dl		P value
		Male	Female	0.00
Under weight	<18.5	9.26 ± .67	9.43 ± .72	
Normal	18.5-24.9	9.35 ± .72	9.52 ± .79	
Over weight	25-29.5	9.42 ± .64	9.58 ± .68	
obese	≥30.0	9.47 ± .79	9.75 ± .64	

Table (2) shows the relationship between BMI and serum calcium levels of study participants .The mean serum calcium levels of participants with overweight and obese were 9.58± 0.68 and 9.75 ± 0.64 respectively, for females and 9.42 ± 0.63 and 9.47 ± 0.62 respectively, for males as compared to 9.43 ± 0.72 and 9.52 ± 0.79 for females and 9.26 ± 0.67 and 9.35 ± 0.72 for males with underweight and normal BMI, respectively. The mean serum calcium levels of individuals with overweight and obesity were significantly higher ($P < 0.05$) when compared to participants with underweight and normal BMI.

Correlation studies show that BMI correlated positively and significantly with serum calcium levels in obese individual ($r = 0.72$, $P = 0.00$).

These findings are in line with earlier studies (Shah and Chayhan,2016;Dalfardi, *et al*,2013;Landin-Wilhelmsen, *et al*,1995), which reported increased serum calcium level in obese individuals as well as a positive correlation between BMI and serum calcium. In contrast, other studies showed that, there were no significant differences in serum total calcium levels in obese and non-obese individuals.(Ipek, *et al*,2014;Mohamed,2012).

Table (3) Distribution of Total Calcium levels and BMI in all ages group of participants

Age	sex	N	Total calcium	P value	BMI	P value
			Mean ±SD		Mean ±SD	
20-24	Male	118	9.82±0.73	.01	24.46±4.91	.04
	Female	117	9.37±0.72		26.21±4.33	
25-29	Male	25	9.61±0.95		23.65±3.7	
	Female	30	9.33±0.76		25.70±3.91	
30-34	Male	11	9.52±0.89		22.61±6.51	
	Female	15	9.32±0.73		25.63±3.63	
35-39	Male	12	9.39±0.88		22.30±4.73	
	Female	17	9.31±0.47		24.95±4.62	

40-44	Male	9	9.37±0.35		21.17±5.36	
	Female	17	9.28±0.62		24.72±4.80	
45-49	Male	11	9.33±0.67		20.63±6.51	
	Female	15	9.23±0.31		24.06±4.20	
50-54	Male	22	9.31±0.68		20.61±3.7	
	Female	43	8.81±0.73		23.86±4.51	
55-60	Male	18	9.31±0.66		20.46±4.91	
	Female	54	8.63±0.74		22.85±4.21	
Total	534					

Our study shows the mean ± standard deviation of total Calcium levels and BMI at all ages. This mean that total calcium levels and BMI are affected by age in both gender. Also it show that the mean total calcium decrease with age. Regression analysis revealed that had significant age-related decreases in serum total calcium (r = -0.225, P = 0.04. This age- related pattern is similar to that described in other studies:

In the males we found a decrease in serum calcium with age that was almost identical to that reported by Kesteloot and Geboers (Kesteloot and Geboers,1982) and Christensson et al. (Christensson, et al,1976) In females we found that decreases in serum calcium with age is in the line of study performed by Bhale et al in an Indian (Nicolaysen, *et al*,1953) and study in kaduna state, Nigeria,(Achie, *et al*,2020) .

Conclusion:

This study has demonstrated a direct relationship between BMI and serum calcium level. Serum calcium should be considered in the assessment and management of obese/overweight individuals.

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