Some Trace Elements and Its Relation to obesity Among A Sample of Egyptian Children and Adolescents

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Abstract:

The threat of worldwide obesity in children is a reality and has become pandemic. Previously a concern of only developed countries, rapid, escalating rates of overweight children now dominate the public health concerns of middle- and low-income nations as well. In Egypt the prevalence of overweight and obesity in children has reached 20.5%. BMI is used as a screening tool to identify possible weight problems for children. The BMI of children changes with age and differs between the sexes, so must be considered in an age- and sex-specific way. Consequent to abnormal metabolism, micronutrient deficiencies are common in obese individuals across all age groups. Out of the trace elements, calcium, copper, iron, magnesium, and zinc are the most crucial cations required.

Aim:

The aim of this study is to assess some trace elements among obese children and adolescents and to detect correlation between each of zinc, copper, iron, magnesium and anthropometric measures of the obese children and adolescents.

Methodology:

This study was conducted on 40 obese children and adolescents who were attending Pediatric Obesity Clinic, Children's Hospital, Ain Shams University during the period from September 2011 to April 2012. Patients were compared to 40 healthy; age-, sex- and pubertal stage- matched children and adolescents serving as controls. Full history taking and full clinical examination were done. Blood samples were taken for measurement of sera level of Copper, Iron, Magnesium and Zinc.

Results:

Studying BMI SDS as risk factor for zinc, iron and magnesium deficiencies and elevated serum copper was done. A high BMI SDS was a significant risk factor for zinc deficiency and iron deficiency ($p \leq 0.05$), while it was highly statistically significant for magnesium deficiency and elevated serum copper level ($p \leq 0.001$).

Conclusion:

All trace elements were significantly lower among obese cases than normal controls except for copper which was significantly higher among cases than controls. Also A high BMI SDS was a significant risk factor for zinc deficiency and iron deficiency, while it was highly statistically significant for magnesium deficiency and elevated serum copper level.

Key words:

Obesity, Children, Trace Elements, iron, zinc, copper, magnesium.

Introduction

The definition of obesity may vary depending on the source of information, but most health care providers agree that, the individuals whose BMI exceeds the age-gender-specific 95th percentile are obese. Those with BMI between the 85th and 95th percentiles are overweight and are at increased risk for obesity related co-morbidities.[(1)]

Childhood obesity is often the result of interplay between many genetic and environmental factors. Polymorphisms in various genes controlling appetite and metabolism predispose individuals to obesity when sufficient calories are present. As such obesity is a major feature of a number of rare genetic conditions that often present in childhood.[(2)]

The worldwide prevalence of childhood overweight and obesity increased from 4.2% in 1990 to 6.7% in 2010. This trend is expected to reach 9.1%, or ’60 million, in 2020.[(3)] In Egypt the prevalence of overweight and obesity in children has reached 20.5%.[(4)]

BMI is used as a screening tool to identify possible weight problems for children. Centre for Disease Control and Prevention (CDC) and the American Academy of Pediatrics (AAP) recommend the use of BMI to screen for overweight in children beginning at 2 years old as it is inexpensive and easy to be performed.[5] The BMI of children changes with age and differs between the sexes, so must be considered in an age- and sex-specific way. In practice, this means comparing with population reference data using percentiles or standard deviation scores (SDS or 'Z' scores).[6]

Obesity is clearly a multifactorial condition, with many biological, genetic, social and environmental influences affecting its development.[7]

Trace elements are those elements present in the body in concentrations of less than 0.001% of total body weight. Fourteen trace elements have been recognized to be of nutritional importance to mammals. These include zinc, magnesium, iron, iodine, copper, cobalt, manganese, selenium, chromium, nickel, silicon, fluorine, vanadium, molybderum and tin.[8] Trace elements are involved in the development of obesity and its complications, but their status has seldom been studied in young obese.[9] Consequent to abnormal metabolism, micronutrient deficiencies are common in obese individuals across all age groups.[10]

Methodology:

This study was conducted on 40 obese children and adolescents who were attending Pediatric Obesity Clinic, Children's Hospital, Ain Shams University during the period from September 2011 to April 2012. Patients were compared to 40 healthy; age-, sex- and pubertal stage- matched children and adolescents serving as controls.

1. Inclusion Criteria Included:
   a. Age ranging from (6- 12) years old.
   b. Cases Of Simple Obesity.
2. Exclusion Criteria Included:
   a. Children with any associated medical illness
   b. History of intake of drugs interfering with serum zinc, iron, Copper and magnesium.
   c. obese children due to endocrinal or syndromic causes

All subjects were subjected to:

1. Full history taking; laying stress on age, sex and socioeconomic status: The socioeconomic status of each child was determined through the answers of a standard questionnaire. The questionnaire included income per person within the family, father's occupation, father's education and mother's occupation.[11]
2. Full clinical examination laying stress on:
   a. Anthropometric and auxologic measurements which include:
      - Weight which was measured with a digital scale in kilograms and to the nearest0.1 kg with the subjects standing motionless without shoes and with minimal clothing. Weight SDS was calculated according to the norms of Tanner et al.[12]
      - Height which was measured to the nearest0.1 cm on a wall mounted stadiometer also without shoes. Height SDS was calculated according to the norms of Tanner et al[12]

        BMI was calculated as follows: BMI= Mass (Kg)/ $(\text{Height (m)})^2$

        BMI SDS was calculated according to the norms of Cole et al.[13]
   b. Triceps and subscapular skin fold thickness together with calculation of their SDS's.
   c. Waist/Hip Ratio: The waist was measured simply at the smallest circumference of the natural waist, usually just above the belly button, and the hip circumference may likewise be measured at its widest part of the buttocks or hip. In case the waist is convex rather than concave, the waist may be measured at a horizontal level 1 inch above the navel.[14]
   d. Sexual maturity rating according to Marshall& Tanner.[15]
3. Laboratory Investigations: All subjects are instructed to fast (8- 10) h and the sample was taken in early morning to measure sera level of Copper (67- 147 µg/dl), Iron (53- 119 µg/dl), Magnesium (1.5- 2.3) mg/dl and Zinc (66- 144) µg/dl.[16]
4. Statistical analysis of data was done using SPSS v.15.

Results:

Patients were compared to 40 healthy; age-, sex- and pubertal stage- matched children and adolescents serving as controls.

Table (1): Comparison of sex distribution among cases and controls

Sex \ N (%)	Cases (N= 40)	Controls (N= 40)	X^2	P Value
Male	24 (60)	20 (50)	0.808	0.3687
Females	16 (40)	20 (50)		

The study included 24 male cases, 16 female cases, 20 female controls and 20 control females, the difference was insignificant, as in table (1).

Table (2): Comparison of clinical characteristics among cases and controls

Mean± SD (Range)	Cases (N= 40)	Controls (N= 40)	t	p
Age (Years)	9.25± 2.07 (6- 12)	9.28± 2.1 (6- 12)	0.06	0.94
Socioeconomic Score	133.8± 22.62 (78- 175)	121.9± 25.5 (45- 162)	2.20	0.03*
Height SDS	0.21± 0.95 (-0.66- 2.28)	0.067± 0.74 (-1.6- 1.82)	0.75	0.45
BMI (kg/m^2)	29.6± 4.5 (25.52- 42.79)	17.5± 1.62 (14.88- 20.74)	16	0.0001**
Bmi Sds	3.32± 0.64 (2.18- 4.59)	0.39± 0.51 (-0.8- 1.3)	22.64	0.0001**
Triceps skin fold thickness(mm)	21.9± 3.64 (16- 30)	9.4± 2.3) (7- 15)	18.36	0.0001**
Subscapular skin fold thickness (mm)	21.15± 3.64 (16- 35)	6.4± 1.6 (5- 11)	23.46	0.0001**
Waist Circumference (Cm)	87.18± 9.59 (68- 111)	61.33± 6.88 (49- 78)	13.85	0.0001**
Waist/Hip Ratio	0.91± 0.04 (0.81- 1)	0.87± 0.05 (0.71- 1.1)	3.95	0.0002**

Regarding clinical characteristics, there were significant differences between cases and controls except for age and height SDS that were statistically non-significant, as in table (2).

Table (3): Comparison of trace elements among cases and controls:

Mean± SD (Range)	Cases (N= 40)	Controls (N= 40)	t	P Value
Zinc (66- 144 µg/dl)	68.6± 10.81 (52- 90)	93.45± 8.61 (70- 108)	11.37	0.0001**
Copper (67- 147 µg/dl)	101.5± 19.83 (70- 151)	115.85± 14.72 (88- 146)	3.67	0.0004*
Iron (53- 119 µg/dl)	65.43± 21.16 (45- 119)	106.13± 13.94 (66- 120)	10.15	0.0001**
Magnesium (1.5- 2.3 mg/dl)	1.92± 0.32 (1.3- 2.3)	2.08± 0.18 (1.8- 2.3)	2.75	0.0073*

All trace elements were significantly lower among cases than controls except for copper which was significantly higher among cases than controls, as in table (3).

Table (4): Correlation between BMI SDS and clinical characteristics among studied cases:

Variable	r	P Value
Age (Years)	0.60	0.000**
Socioeconomic Score	-0.19	0.222
Height SDS	0.02	0.863
Triceps skin fold thickness (mm)	0.31	0.049*
Subscapular skin fold thickness (mm)	0.27	0.085
Waist Circumference (Cm)	0.11	0.47
Waist /Hip Ratio	0.09	0.57

SD: standard deviation, p value≤ 0.05: *statistically significant, p value>0.05: statistically insignificant, p value≤ 0.001 ** highly statistically significant

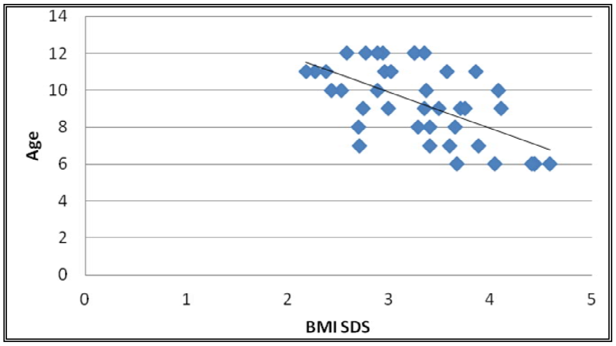

Figure (1): Correlation between BMI SDS and the age of studied cases

There were significant positive correlation between BMI SDS and each of age and triceps skin fold thickness, while others parameters didn't correlate with BMI SDS, as in table (4), figure (1).

Table (5): Logistic regression analysis (odds ratio) between BMI SDS and each of serum Zinc, copper, iron and magnesium among studied cases

	Odd Ratio	95% Ci	Z	p
Zinc Deficiency	108.77	3.217	3.21	0.0013*
Elevated Copper	657	34.18- 12626.13	4.30	0.0001**
Iron Deficiency	49.23	2.82- 859.26	2.67	0.0076*
Magnesium Deficiency	657	34.18- 12626.13	4.30	0.0001**

P value≤ 0.05: statistically significant, p value>0.05: statistically insignificant, p value≤ 0.001: highly statistically significant

Studying BMI SDS as risk factor for zinc, iron and magnesium deficiencies and elevated serum copper was done. A high BMI SDS was a significant risk factor for zinc deficiency and iron deficiency (p≤ 0.05), while it was highly statistically significant for magnesium deficiency and elevated serum copper level p≤ 0.001), as in table (5).

Discussion:

The current study results showed that among cases, 24 (60%) were males and 16 (40%) were females with age ranging between 6&12 years& mean 9.25± 2.07 (Mean± SD), their Height SDS had a mean+0.21± 0.95& BMI (kg/m2) was 29.6± 4.5 while BMI SDS was+ 3.32± 0.64. Triceps skin fold thickness (mm) (21.9± 3.64), Subscapular skin fold thickness (mm) (21.15± 3.64), Waist circumference (cm) (87.18± 9.59)& Waist/hip ratio (0.91± 0.04).

Our results agree with Dietz and Robinson[17] who found that BMI is a reliable and preferable measure of adiposity in children and adolescence. Also our results was in agreement with the study of Marreiro et al. (2002)[18] which was carried out with a group of 23 obese individuals, between 7- 14 yr of age (11 male and 12 female). The mean determined of the BMI was 30.1± 5.8 kg/m2 for the obese group which was slightly higher than current study results. According to the values determined for Triceps and subscapular skinfolds, all of the obese individuals were above the 85th percentile, showing that the body fat was above the expected average.

As regard Trace Element state in the studied group, the mean+ SD of iron, zinc, capper& magnesium were 65.43± 21.16 (µg/dl), 68.6± 10.81 (µg/dl), 101.5± 19.83 (µg/dl)& 1.92± 0.32 (mg/dl) respectively. This was at the lower limit of reference ranges as regard iron, zinc& magnesium (53- 119) µg/dl, (66- 144) µg/dl& (1.5- 2.3) mg/dl while it was at the higher level as regard capper (67- 147) µg/dl

Similar to current study results, Marreiro et al.[18] found in their results that almost half of the obese individuals (47.8%) showed plasma zinc concentrations lower than the reference values of (75- 110) µg/dL, 43.5% showed values within the range of normality, and 8.7% showed concentrations higher than the reference values.

Magnesium is a critical cofactor in numerous enzymatic reactions. Diabetic patients and obese subjects are often reported to have magnesium deficiency (Shechter et al.).[19] This was found in the current study and also found in results by Takaya et al.[20] as they reported that children with diabetes and obesity have [Mg2+]i deficiency.

Comparing cases and controls in the current study regarding clinical characteristics, there were significant differences between cases and controls except for age and height SDS that were statistically non-significant. The significance difference was found in Socioeconomic score (p=0.03*), BMI (kg/m2) (p=0.0001**), BMI SDS (p=0.0001**), Triceps skin fold thickness (mm) (p=0.0001**), Subscapular skin fold thickness (mm) (p=0.0001**), Waist circumference (cm) (p=0.0001**)& Waist/hip ratio (p=0.0002**).

Similar to the current results as regard clinical data, Salem et al.[21] reported highly significant difference between obese and control children as regards BMI, waist circumference (WC), hip circumference and waist to hip ratio in both males and females (P< 0.01).

These results were also similar to study by Marreiro et al.[18] as they found that obese group showed a higher mean for waist/hip ratio than the control group, with a statistically significant difference (p< 0.001). The mean value for the sum of the skinfolds of obese individual was also higher than that of the control group (p< 0.001). Also, These results are in concordance with another study by Chan et al.[22] who concluded that obese children had significantly higher values (p=0.01) than normal weight children regarding height, weight, waist cicumfrance hip circumfrance, waist hip ratio and abdominal fat thickness.

Pinhas-Hamiel et al.[23] stated that obesity is more prevalent in lower socioeconomic groups, which consume low-cost foods that are low in essential nutrients and rich in fats, sugars and preservatives. Also Monteiro et al.[24] estimating the prevalence of iron state in obese children in São Paulo, note prevalence of 35.6%- 46.9%, to girls and boys mainly from lower income groups. This was against the current study results where the obese children are of higher socioeconomic with significant difference when compared to control group, this can be explained as the fast food consumption is more common in high social class in Egypt nowadays.

Results of current study included that all trace elements (iron, zinc& magnesium) were significantly lower among cases than controls except for copper which was significantly higher among cases than controls. This can be explained as despite their excessive dietary and caloric intake, obese children and adolescents may be at risk of trace element disturbance because they tend to consume unbalanced meals, particularly rich in carbohydrates and fat.

Similar to current study results, Moayeri et al.[25] found that overall, the prevalence of iron deficiency increased as the subjects BMI rose from normal to overweight and to obese (2.5%, 5.3%, and 6.9%, respectively, P=0.001).

As regard zinc, Marreiro et al.[18] found significant difference between the obese& control (p< 0.05) as regard to the results of plasma zinc concentrations. The mean found for the index was 82.3± 17.8 µg/dL for the obese group and 91.4± 11.0 µg/dL for the control group. The results agreed with those of other authors that showed a reduced plasma zinc concentration in obese individuals (Chen et al.)[26]. Also Perrone et al.[27] found that a lower serum zinc content detected in obese than in control subjects.

Similar to our results, Takaya et al.[28], found that subjects with obesity had Magnesium which was significantly lower than in the normal control group. However in contrast to our results, Perrone et al.[27] data show no significant difference in serum copper levels between obese and normal subjects.

Studying BMI SDS as risk factor for zinc, iron and magnesium deficiencies and elevated serum copper was done. A high BMI SDS was a significant risk factor for zinc deficiency and iron deficiency ($p \leq 0.05$), while it was highly statistically significant for magnesium deficiency and elevated serum copper level $p \leq 0.001$).

This was in agreement with study of Yanoff et al.[29], where Serum iron was negatively correlated with BMI and fat mass in multivariate regression analyses that included sex, race, age and SES (P=0.0003 and P=0.0004, respectively).

In contrast, Dominique et al.[9] found that increasing BMI was not associated with plasma levels of Zn, nor Fe or Fe storage parameters; the degree of overweight was not associated with an increased risk of deficiency. Their results did not show any relationship between Fe status and obesity grade while a correlation was displayed between ferritin and metabolic risk factors; this correlation did not depend on inflammation; it suggests that alteration of Fe parameters is mainly a marker of the progression of disease to complications than of overweight itself. They concluded that Increasing BMI was associated with inflammation, but no difference was found for TE status.using multivariate regression analysis.

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الملخص

دراسة بعض العناصر النادرة وعلاقتها بالسمنة فى وسط عينة من الأطفال والمراهقين المصريين

أجريت هذه الدراسة لتحديد مستوى عناصر الزنك والنحاس والحديد والماغنسيوم فى مصل الدم ودراسة العلاقة بينهم وبين القياسات البشرية للأطفال والبالغين الذين يعانون من السمنة.

وتضمنت الدراسة على أربعين طفل وبالغ يعانون من السمنة وكانوا يترددون على عيادة السمنة بمستشفى الأطفال– جامعة عين شمس. وذلك خلال الفترة ما بين سبتمبر ٢٠١١ حتى أبريل ٢٠١٢. تمت مقارنة هؤلاء المرضى بنظائرهم طبيعين متطابقين فى العمر، الجنس ومرحلة البلوغ.

تم أخذ التاريخ المرضى كاملا مع التركيز على العمر والجنس والحالة الأجتماعية. وأيضا تم الفحص الأكينيكى خاصة القياسات البشرية (الوزن والطول ومؤشر كتلة الجسم). وتم قياس سمك الجلد ومحيط الخصر. وتم سحب عينات دم لتحليل نسبة وجود العناصر المدروسة (الزنك والنحاس والحديد والماغنسيوم).

وقد وجدت علاقة طردية ذات قيمة احصائية بين مؤشر كتلة الجسم أس دى أس وكلا من العمر وسمك الجلد المحيط بالعضلة ثلاثية الرؤس.

وبدراسة مؤشر كتلة الجسم اس دى اس، وجد انه كان ذو قيمة احصائية كعامل لوجود نقص فى الزينك والحديد والماغنسيوم وأيضا كعامل لوجود ارتفاع مستوى عنصر النحاس بدم المرضى الذين يعانون من السمنة.