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Fingernail selenium levels in relation to the risk of obesity in Chinese children

A cross-sectional study

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Abstract

Selenium (Se) has been suggested to be beneficial to obesity development. However, limited studies have evaluated the association between Se and childhood obesity and the findings are inconsistent.

The aim of this study was to examine the association of Se levels with obesity in children in a cross-sectional study.

A total of 62 obese (21 girls) and 65 normal-weight children (27 girls) aged 7 to 13 years were recruited in Shanghai, China. Obesity was defined as body mass index (BMI) ≥ its 95th age- and sex-specific percentile for children. Participant demographic data and parental information were obtained through a self-administered questionnaire. Se concentration in fingernail clippings was quantified using flame atomic absorption spectrophotometry.

The average age was 10.9 years (standard deviation = 1.0) and the mean BMI was 21.2 kg/m^2 (standard deviation = 5.0). Fingernail Se levels were relatively higher among normal-weight children as compared with obese participants, though the difference was not statistically significant (P = .79). Se levels were inversely associated with the risk of childhood obesity after adjustment for potential confounders. The multivariable-adjusted odds ratio (95% confidence interval) was 0.24 (0.07–0.84) comparing participants in the highest with those who in the lowest tertile of Se levels ($P_{linear\text{-}trend}$ = .03).

Our study supported an inverse association between fingernail Se levels and the risk of obesity in Chinese children. Data generated from the present study are useful for designing future prospective cohort studies and/or randomized clinical trials.

Abbreviations: BMI = body mass index, Ca = calcium, CIs = confidence intervals, Cr = Chromium, GPXs = glutathione peroxidases, Mg = magnesium, ORs = odds ratios, Se = selenium.

Keywords: childhood obesity, cross-sectional study, selenium

1. Introduction

Childhood obesity has become a major concern worldwide and been called "one of the most serious public health challenges in the 21st century.[1]" According to WHO report, 41 million children under the age of 5 and over 340 million children and adolescents aged 5 to 19 years were overweight or obese in 2016.[2] In China, the prevalence of childhood overweight/obesity increased from 11.7% to 25.2% during the period of 1991 to 2011.[3] The causes of the rising prevalence of childhood obesity remain unclear, though it is likely a multi-influenced phenotype related to genome, environment, and lifestyle.[4]

Obesity is characterized by increased oxidative stress together with chronic low-grade inflammation.[5–7] Laboratory studies suggest that Se plays a role in the pathophysiology of obesity due to its properties of antioxidant and anti-inflammation.[8] However, limited human studies have examined the association between Se and childhood obesity. An inverse association between Se and overweight or obesity was reported in 1 case–control[9] and 2 cross-sectional studies.[10,11] However, the findings were not supported by other 2 observational studies.[12,13]

The inconsistency in the literature may be explained, at least in part, by the use of serum or urine specimens to measure aggregated Se status. Serum and urinary Se reflect most recent exposures, usually a few days,[14] and fluctuated by recent dietary intake and/or supplementation.[15] In contrast, nail Se reflects a relatively long-term exposure that have occurred over the past 6 to 12 months, thus it has been recognized as a reliable marker of Se status.[14,16] Nail Se is especially a noninvasive and efficient method to assess Se status in children. However, no existing study has investigated the association between nail Se levels and childhood obesity.

Therefore, we aimed to examine the distribution of fingernail Se levels in Chinese children and to evaluate the association of Se levels with obesity in children.

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The authors declare that they have no competing interests.

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2. Materials and methods

2.1. Study population

A cross-sectional study was performed in Gaohang Town, Shanghai, China. After excluding those with a medical history of taking corticosteroids and antipsychotics, renal and/or endocrine disease, and born pre-term, 62 obese (21 girls) and 65 normal-weighted children (27 girls) were enrolled. Obesity was defined as body mass index (BMI) ≥95th age- and sex-specific percentile based on the Working Group of Obesity in China (WGOC) criteria for children.[17] Informed consent was obtained from the parents. This study was approved by the Ethics Committee of Ren Ji Hospital, School of Medicine, Shanghai Jiao Tong University.

2.2. Anthropometrical data

Trained medical staff conducted anthropometrical measurement. Weight was measured using an electrical scale (Tanita body composition analyzer TBF-410, Tokyo, Japan) with participants dressed in light underwear without shoes. Height was measured without shoes using a standardized wall-mounted height board (SG-210 Height Board Instrument; Zi Lang Instrument Co., Ltd., Nan Tong, China). BMI was calculated as weight in kilograms divided by squared height in meters.

2.3. Questionnaires

General information including participant's age and sex and parents' height, weight, and education levels ("middle school and below" *or* "undergraduate and above") were collected using a self-administered questionnaire. Birth weight was determined based on the birth certification. Parental overweight was defined as a BMI ≥24.0 kg/m^2.[18]

2.4. Measurements of selenium and other trace elements

Fingernail clippings were collected and stored in a sealed plastic bag in a dry and cool condition under room temperature until measurement. Samples were prepared and analyzed based on the following procedure: place samples in a beaker after weighting; add 6 mL nitric acid and 2 mL hydrogen peroxide solution to the breaker and leave it at room temperature overnight; heat the beaker to 180°C on an electronic oven until the samples are dissolved and the fluid turns clear; continue the heating process until the fluid volume reduces to 2 mL; add 5 mL hydrochloric acid to the beaker and continue heating until the fluid volume reduces to 2 mL; stop heating, transfer the fluid to a new volumetric flask, and let it cool naturally; drop deionized water into the volumetric flask until the volume reaches 25 mL; and the fluid is used for measuring Se, Chromium (Cr),[19] calcium (Ca),[20] and magnesium (Mg)[21] concentration by using lame atomic absorption spectrophotometry (ICP-AES optima 8000; PerkinElmer Company, Fremont).

2.5. Statistical analysis

The characteristics of study population were summarized using mean with standard deviations for continuous variables and proportions for categorical variables. Analysis of variance, Student *t* test, Chi-squared test, Kruskal–Wallis test, or Wilcoxon rank-sum test, as appropriate, was used to compare participants' characteristics across Se tertiles, or between obese and normal-weight groups.

Logistic regression model was used to examine the association between Se levels and the risk of childhood obesity. Multivariable-adjusted odds ratios (ORs) and the corresponding 95% confidence intervals (CIs) using the lowest tertile of Se levels as the referent were estimated in 3 sequential models. Model 1 reported unadjusted crude ORs (95% CIs). Model 2 was adjusted for age, sex, and birth weight. Model 3 was additionally adjusted for parental BMI (normal *or* overweight) and education level (neither, either, *or* both of the parents having undergraduate degree and above), levels of Cr (tertiles), and the ratio of Ca to Mg (tertiles). Tertiles of Se coded with 0, 1, and 2 were used to test for linear trend.

All statistical analyses were performed using Stata 13.0 (Stata Corp, College Station, TX). *P* values ≤.05 were considered statistically significant.

3. Results

Tables 1 and 2 present the characteristics of the study population by tertiles of Se levels and obesity status. Of 127 participants, 62.2% were boys. The average age was 10.9 years (standard deviation = 1.0). The mean BMI was 21.2 kg/m^2 (standard deviation = 5.0). The median concentration of fingernail Se was 0.5 ppm (interquartile range = 0.3–0.8). No significant differences were observed across Se tertiles, except for age and ratio of calcium/magnesium ($P < .001$) across Se tertiles (Fig. 1). Participants with higher Se levels were significantly younger and had higher calcium/magnesium ratio. Obese children were associated with greater birth weight and parental BMI (all $P < .01$).

Fingernail Se levels were relatively higher among normal-weight children as compared with obese participants, though the difference was not statistically significant ($P = .79$) (Fig. 2). Comparing the highest to the lowest tertile of Se levels, the odds of obesity was lower by 76% (OR = 0.24; 95% CI = 0.07–0.84; $P_{\text{linear-trend}} = .03$; Table 3) after adjustment for age, sex, birth weight, parental education levels, levels of Cr (tertiles), and the ratio of Ca to Mg (tertiles).

4. Discussion

Findings from the present study support the hypothesis that Se levels may be beneficial in the development of childhood obesity. Information generated from this cross-sectional study can be used for designing future prospective or intervention study on Se and obesity in children.

The results of the present study are generally consistent with findings from some, but not all previous studies. Azab et al[9] reported that serum Se concentration in obese children (mean age = 13.3 years) was significantly lower than age and sex-matched healthy controlsin Egypt. Blazewicz et al[10] also found that Polish obese children (mean age = 13.3 years) had significantly lower Se concentrations in serum and urine. Ortega et al[11] reported that Spanish children (mean age = 10.2 years) with excess of weight (BMI > 85th percentile) had significantly lower serum Se concentrations as compared with normal-weight children, and the correlation between serum Se and BMI was -0.39 ($P < .05$). However, other 2 observational studies did not support a significant inverse association between Se levels and the risk of childhood obesity.[12,13] Fan et al[13] assessed serum Se levels in a large sample of U.S. children and adolescents. They found that serum Se had a borderline positive association with the risk of overweight, but not obesity. When stratified data by age and sex, the association was only persisted in boys aged 13 to

Table 1

Characteristics of school students aged 7–13 years by tertiles of fingernail selenium levels: a cross-sectional study in Shanghai, China (n=127)*.

	Tertiles of selenium levels, ppm				
	<0.4	0.41–0.69	≥0.70	Total	*P*†
No. of participants	44	41	42	127	—
Age, y	11.5 (1.3)	10.5 (0.6)	10.6 (0.7)	10.9 (1.0)	<.001
Birth weight, g	3368 (470)	3409 (436)	3558 (443)	3445 (454)	.13
Height, cm	151.8 (10.9)	147.8 (10.0)	148.2 (7.6)	149.3 (9.7)	.11
Weight, kg	50.4 (16.6)	48.1 (17.6)	45.4 (12.6)	48.0 (15.6)	.33
BMI, kg/m^2	21.5 (5.0)	21.5 (5.1)	20.5 (4.8)	21.2 (5.0)	.61
Father's BMI, kg/m^2	24.6 (2.7)	24.5 (3.4)	25.6 (4.1)	24 (3.4)	.25
Mother's BMI, kg/m^2	22.8 (3.9)	22.9 (3.7)	21.7 (2.7)	22.5 (3.5)	.23
Proportions, %					
Boys	68.2	56.1	61.9	62.2	.52
Father's education					
Middle school and below	61.4	48.8	39.0	50.0	.12
Undergraduate and above	38.6	51.2	61.0	50.0	
Mother's education					
Middle school and below	63.6	42.5	43.9	50.4	.09
Undergraduate and above	36.4	57.5	56.1	49.6	
Parents with undergraduate degree and above					
Neither	52.3	40.0	29.3	40.8	.08
Either	20.5	12.5	24.4	19.2	
Both	27.3	47.5	46.3	40.0	

BMI=body mass index, SD=standard deviation, T=tertile.
* Data were means (SDs), or proportions (%).
† *P* values were obtained by analysis of variance, Chi-squared test, or Kruskal–Wallis test as appropriate.

19 years. Cayir et al[12] found a higher level of serum Se in obese children (mean age=11.9 years) in Turkey. However, that study found that serum Se level was positively correlated with PON1, an indicator of improved oxidative system with elevated values, which is still in concordance with the antioxidant capacity of Se.

Table 2

Characteristics of school students aged 7–13 years by obesity status: a cross-sectional study in Shanghai, China (n=127)*.

	Obesity status†		
	(−)	(+)	*P*‡
No. of participants	65	62	—
Age, y	10.9 (1.1)	10.9 (1.0)	.77
Birth weight, g	3340 (428)	3558 (458)	.007
Father's BMI, kg/m^2	24.0 (2.6)	25.9 (3.9)	.001
Mother's BMI, kg/m^2	21.5 (2.9)	23.5 (3.8)	<.001
Proportions, %			
Boys, %	58.5	66.1	.37
Father's education, %			
Middle school and below	44.6	55.7	.21
Undergraduate and above	55.4	44.3	
Mother's education, %			
Middle school and below	49.2	51.7	.79
Undergraduate and above	50.8	48.3	
Parents with undergraduate degree and above			
Neither	35.4	46.7	.37
Either	23.1	15.0	
Both	41.5	38.3	

BMI=body mass index, SD=standard deviation.
* Data were means (SDs), or proportions (%).
† Obesity was defined according to the age-, and sex- specific cutoff points for Chinese children.
‡ *P* values were obtained by Student *t* test, using Chi-squared test, or Wilcoxon rank-sum test as appropriate.

Obesity is suspected to be caused by the deleterious effects of oxidative stress due to the imbalance between oxidant and antioxidant systems.[22] Labortary studies suggest that Se exerts antioxidative effect directly or through its involvement in the synthesis of Se-dependant antioxidant and repair proteins.[23] For example, Se supplementation (provided as Brazil nut that is known for its Se content and high Se bioavailability) substantially improved the activity of glutathione peroxidases (GPXs) in morbidity obese women.[24,25] The antioxidant functions of Se are possibly mediated by the nucleophilic properties of Se center and some oxidizable and kinetic characters of Se-containing amino acids.[23,26] Furthermore, Se-containing amino acids could obviate redox-active metal ions.[23,26] A relative high level of Se is helpful to maintain antioxidant function, leading to clearance of biological oxidants.[23,26] Moreover, Se has been found to alleviate inflammatory signaling pathways, which is also involved in the pathophysiology of obesity, and thus may reduce the risk of childhood obesity.[27] Besides its anti-inflammatory and anti-oxidative capacities, Se affects peroxisome proliferator activated receptors, which regulate adipogenesis and are important parameters to consider when investigating obesity.[28]

Although this is a cross-sectional study, it is the first study that assessed fingernail Se concentrations in children. Serum Se was commonly used in previous studies, but its level may be increased at the early stage of obesity in response to oxidative stress and is affected largely by dietary and environmental factors[14] in addition to the relatively short exposure time frame. In contrast, Se measured in nails represents aggregated relatively long-term exposure. In addition, trace minerals are often interacted with each other. Studies suggested that chromium, calcium, and magnesium were associated with the development of obesity

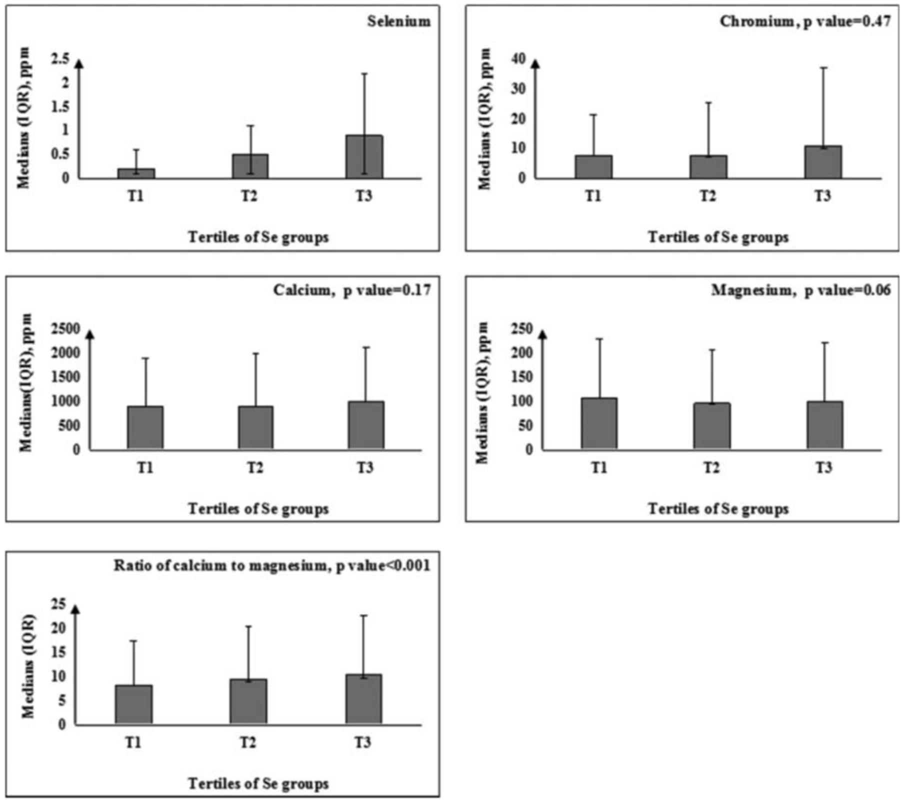

Figure 1. Fingernail trace elements concentration across fingernail selenium tertiles. *P* values were obtained by analysis of variance, using Chi-squared test, or Kruskal–Wallis test as appropriate. IQR = interquartile range.

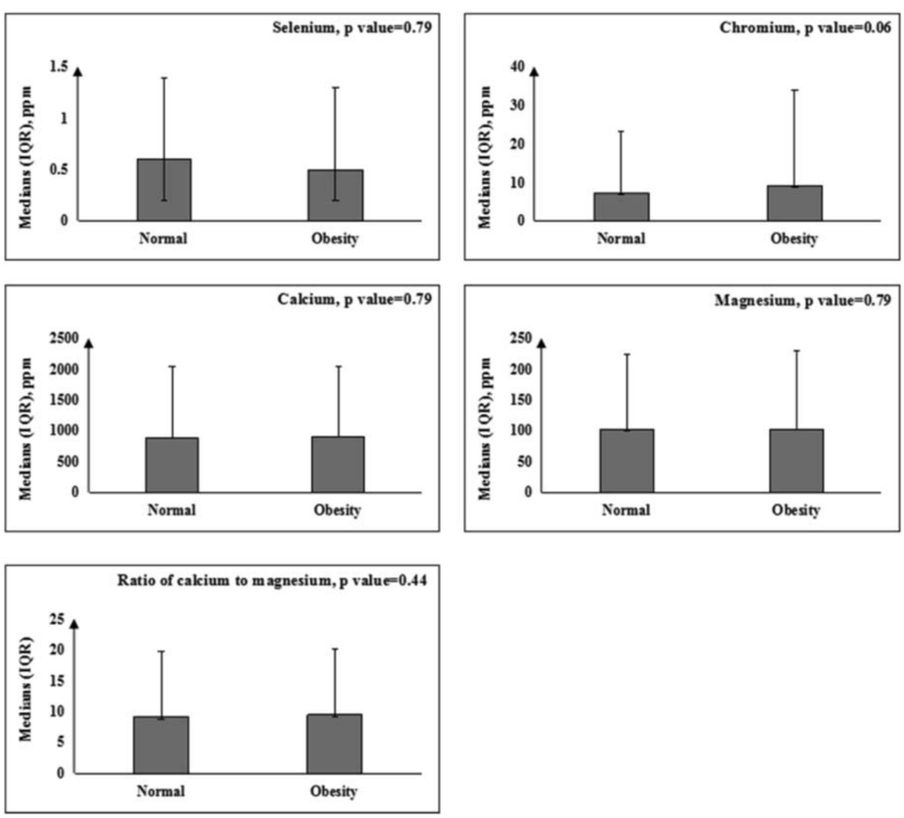

Figure 2. Fingernail trace elements concentration between normal-weight children and children with obesity. *P* values were obtained by analysis of variance, using Chi-squared test, or Kruskal–Wallis test as appropriate. IQR = interquartile range.

Table 3

Multivariable-adjusted ORs (95%CIs) of prevalent obesity by tertiles of fingernail selenium levels in school students aged 7–13: a cross-sectional study in Shanghai, China (n=127)[*].

	<0.4	0.41–0.69	≥0.70	*P* for trend[†]
No. of participants	44	41	42	—
No. of events	22	22	18	—
Model 1[‡]	1.00 (Referent)	1.16 (0.49–2.71)	0.75 (0.32–1.75)	.51
Model 2[§]	1.00 (Referent)	0.90 (0.34–2.39)	0.49 (0.18–1.33)	.15
Model 3[||]	1.00 (Referent)	0.57 (0.19–1.72)	0.24 (0.07–0.84)	.03

CI=confidence interval, OR=odds ratio, T=tertile.
[*] All models were constructed by using logistic regression model, and obesity was defined according to the age-, and gender- specific cutoff points for Chinese children.
[†] *P* for linear trend was examined by using tertiles of selenium coded with 0, 1, and 2.
[‡] Model I: unadjusted.
[§] Model II: adjusted for age, sex, and birth weight.
[||] Model III: further adjusted for parents' education (neither, either, or both with undergraduate degree and above), levels of chromium (tertiles), and the ratio of calcium to magnesium (tertiles).

because of their involvement in glucose and lipid metabolism.[8,20,29] In the analysis, we considered those minerals as potential confounders, which substantially reduced the potential confounding by those factors. Of note, because of the nature of cross-sectional study, data from the present study may only be used to generate hypothesis or design future prospective or intervention studies, which may provide solid evidence or establish causal relationship between Se and obesity. As obesity has been become a major health disorder, identifying any modifiable risk factor of obesity is clearly of great public health significance.

5. Conclusion

Data from this cross-sectional study support the hypothesis that Se levels are inversely associated with the risk of childhood obesity. Further studies are needed to provide solid scientific evidence and to establish causal inference.

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