Zinc level and obesity

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Background
Obesity is a chronic condition that is associated with disturbances in the metabolism of zinc. Therefore, the aim of this study was to investigate the relationship between serum zinc level and different clinical and biochemical parameters in obese individuals.

Patients and methods
Twenty-four individuals with BMI more than 30 kg/m^2 and 14 healthy controls (BMI < 24 kg/m^2) were assessed for BMI and waist circumference using anthropometric measurements. Colorimetric tests were carried out for the determination of zinc in serum.

Results
In this study, BMI and waist circumference were higher in the obese group than in the control group ($P < 0.05$). The mean serum zinc levels were 92 ± 31.1 and 101 ± 70 μg/dl in the obese group and control group ($P > 0.05$), respectively. There was a significant negative correlation between the serum zinc level and BMI, waist circumference and low-density lipoprotein ($P < 0.05$).

Conclusion
Plasma zinc concentration in obese individuals showed an inverse relationship with the waist circumference and BMI as well as serum low-density lipoprotein-cholesterol and correlated positively with high-density lipoprotein.

Keywords:
low-density lipoprotein, obesity, serum zinc

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Introduction

The essential trace element zinc (Zn) is important for several bodily functions such as vision, taste perception, cognition, cell reproduction, growth and immunity. It plays a vital role in metabolisms, particularly as a cofactor of many enzymes, required for natural metabolic processes [1]. Zinc has three major biological roles: Catalytic, structural and regulatory. It is a structural constituent in numerous proteins, including growth factors, cytokines, receptors, enzymes, and transcription factors belonging to cellular signalling pathways, and is essential for their biological activity [2]. Moreover, it is implicated as a cofactor in numerous cellular processes for an estimated 3000 human proteins including DNA and protein synthesis, enzyme activity and intracellular signalling [3]. The human genome bioinformatics study revealed that ~10% of all proteins may bind with zinc. The biological functions of these zinc-binding proteins are maintained through cellular zinc levels [3]. Therefore, homoeostatic mechanisms that modulate zinc absorption, distribution, cellular uptake and excretion are vital for maintaining cellular functions. Moreover, zinc's fundamental and diverse roles in many cellular processes require its delivery to the tissues and cells, and also its intracellular availability and intracellular distribution to be tightly controlled. These processes are governed by zinc transporters and channels and by zinc-sensing molecules, such as metallothioneins and metal-responsive element-binding transcription factor-1 [4]. Disturbances in zinc homoeostasis have been observed in many diseases, including diabetes mellitus [5], cancer [6], autoimmune disease [7] and cardiovascular disease [8]. Some studies have also shown that obese individuals have low concentrations of zinc in plasma, erythrocytes and serum, and that it is associated with alterations in the metabolism of the adipose tissue of these patients [9]. Zinc deficiency may also be associated with insulin resistance, hyperglycaemia and impaired glucose tolerance. The aim of this study was to define the relationship between the plasma zinc level and different clinical and laboratory parameters in obese Egyptian individuals.

Patients and methods

Study population

This study was conducted in the National Nutrition Institute (Cairo, Egypt). The study population consisted of 24 individuals with BMI more than 30 kg/m^2 selected from the outpatient clinic as well as 14 healthy individuals (BMI < 24 kg/m^2) as the control group. Both study groups were age-matched and sex-matched. The participants were eligible for the study if they were 20 years of age or older and not taking any vitamin or mineral supplementation. Exclusion criteria included factors that affect serum zinc levels, such as kidney disorders, diabetes, cancer, acute infections,

and smoking. Patients and controls included in the study underwent a standard procedure of detailed history taking and a complete physical examination. Blood pressure was recorded as a mean value of three different measurements in the sitting position using a sphygmomanometer. BMI was calculated using the following equation: BMI = weight (kg) divided by the square of the height (m). Those who voluntarily decided to participate in the study were asked to sign an informed consent.

Laboratory investigations

Sample collection

Peripheral blood samples were obtained after 12 h of fasting. Five millilitres of blood were collected in a plain vacuum tube, allowed to clot at room temperature, and the serum was separated by centrifugation. Fasting blood sugar, lipid profile [total cholesterol (TC), triglyceride (TG), low-density lipoprotein (LDL)] and high-density lipoprotein (HDL) were investigated. Zinc fluid monoreagent was used in the colorimetric test for the determination of zinc in serum. Zinc forms a red chelate complex with 2-(5-bromo-2-pyridylazo)-5-(*N*-propyl-*N*-sulfopropyl-amino)-phenol. The increase of absorbance was measured and was proportional to the concentration of total zinc in the sample. The values for lipid profile and zinc level were as follows:

(1) *Cholesterol*: Normal value, less than 200 mg/dl; borderline, 200–239 mg/dl; and high, 240 mg/dl or above.
(2) *TG*: Value less than 150 mg/dl was considered normal and 200–499 mg/dl was considered high; was considered borderline when the level falls within the above values.
(3) *LDL*: Value less than 100 mg/dl was considered optimal and up to 129 mg/dl was near-optimal. Borderline high LDL ranged from 130 to 159 mg/dl, whereas 160–189 mg/dl was considered high. Above that level was categorized as very high.
(4) *HDL*: For men levels above 40 mg/dl and for women levels above 50 mg/dl were considered normal [10].
(5) *Zinc*: For men 165–118 μg/dl and for women 59–98 μg/dl were considered normal [11].

Statistical analysis

IBM SPSS Statistics (version 21.0, 2012; IBM Corp., USA) was used for data analysis. Data were expressed as mean ± SD for quantitative parametric measurements in addition to median percentiles for quantitative nonparametric measurements, and both number and percentage for categorized data. The following tests were carried out: (i) comparison between two independent mean groups for parametric data using Student's *t*-test; (ii) Pearson's correlation test to study the possible association between both the variables among each group for parametric data. The *P* of error of 0.05 was considered significant, whereas that of 0.01 and 0.001were considered highly significant.

Results

The anthropometric data revealed a highly significant increase in weight, BMI and waist circumference in the obese group (99 ± 19, 38 ± 6.4 and 111 ± 16, respectively) compared with the control group (61 ± 7, 22.7 ± 1.4 and 80 ± 3, respectively) as expected; however, no significant difference was observed with respect to height. The mean systolic and diastolic blood pressure was normal in both groups; however, they were significantly higher in the obese group (127 ± 16 and 87 ± 11, respectively) compared with the control group (112 ± 9 and 72 ± 7, respectively) (Table 1).

The lipid profile showed no significant difference between both groups in TC; however, LDL was significantly high in the obese group (120.6 ± 26.4) compared with the control group (98 ± 18) and HDL was significantly low in the obese group (36.3 ± 7.1) compared with the control group (53 ± 9.0). The mean TG level was also significantly high in the obese group compared with the control group (108.2 ± 48.9 vs. 80 ± 31) and was within the normal range in both groups. Also serum zinc level was normal in both groups, although lower in the obese than in the control group, yet there was no statistical significant difference between them (Fig. 1).

Table 1 Comparison between control and obese group with respect to demographic, clinical and laboratory data

Parameters	Control group (*N* = 14)	Obese group (*N* = 24)	*P*
Age (years)	35.6 ± 4	38 ± 13	
Female sex (%)	50	50	
Anthropometric data			
Wight (kg)	61 ± 7	99 ± 19	0.000
Height (cm)	164 ± 8	161 ± 10	0.349
BMI (kg/m^2)	22.7 ± 1.4	38 ± 6.4	0.000
Waist circumference (cm)	80 ± 3	111 ± 16	0.000
Blood pressure			
Systolic blood pressure (mmHg)	112 ± 9	127 ± 16	0.001
Diastolic blood pressure (mmHg)	72 ± 7	87 ± 11	0.000
Laboratory data			
Total cholesterol (mg/dl)	167 ± 18	178.5 ± 25	0.120
LDL (mg/dl)	98 ± 18	120.6 ± 26.4	0.004
HDL (mg/dl)	53 ± 9	36.3 ± 7.1	0.000
TG (mg/dl)	80 ± 31	108.2 ± 48.9	0.038
Zn (μg/dl)	101 ± 70	92 ± 31.1	0.655

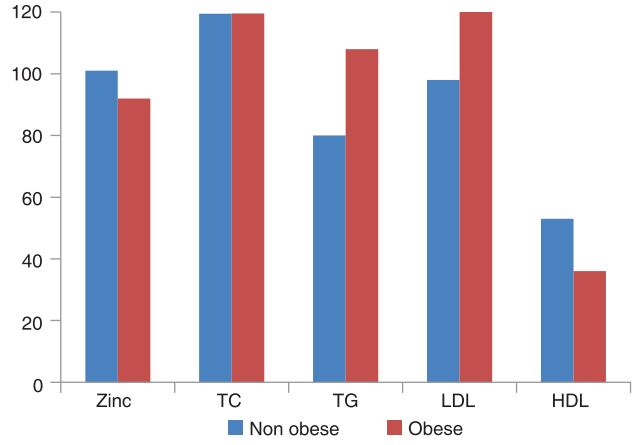
HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride; Zn, zinc.

Significant negative correlations were found between serum zinc level and BMI, waist circumference and LDL ($P < 0.05$); however, no significant correlations were found between zinc level and other clinical parameters such as age, weight, height, blood pressure and other biochemical parameters such as TC, TG and HDL (Table 2).

Discussion

Our study was performed in 24 obese individuals as well as 14 healthy controls to verify the serum zinc status in obese patients and its relationship with different clinical and laboratory parameters in those patients. The mean concentrations of zinc in the serum showed no statistically significant difference between the control and the obese groups ($P > 0.05$). Ennes Dourado Ferro *et al.* [12] also did not find any significant difference in plasma zinc concentration between the obese and the control groups. However, they found significant difference between both groups with respect to erythrocyte zinc level. Erythrocytes contain about 80% of zinc; however, it is only 16% in plasma. Also, plasma zinc has fast dynamics and is influenced by several pathophysiological factors in response to various conditions such as stress, infection, catabolism, hormones and food intake. This well explains our results of normal mean serum zinc level in both groups. Thus, zinc level in erythrocytes can be considered as a more sensitive parameter of zinc status than plasma or serum level. Zinc concentration in the erythrocytes of obese children and adolescents [13] and obese adult men [14] revealed significantly lower concentration than in the control group. Feitosa *et al.* [15] explain the lower concentrations of erythrocyte zinc in obese patients as the influence of inflammatory process on the metabolism of zinc as they found significant negative correlation between zinc and TNF-a. With respect to clinical parameters, the mean value of serum zinc showed significant negative correlations with BMI and waist circumference and no correlation with age or blood pressure. The results consistent with the multivariate regression analysis [12] demonstrated that the waist circumference and BMI had negative correlation with the concentration of zinc in erythrocytes. These data are associated with the fact that there is an accumulation of adipose tissue with an increase in the production of cortisol and adipocytokines, which in turn, results in chronic inflammation. The inflammation promotes the zinc accumulation in the liver and in adipocytes, which may have contributed to the negative correlation of serum zinc level with BMI and waist circumference in obese individuals. Significant negative correlations also were found between serum zinc and TG (LDL-cholesterol); whereas a significant positive correlation was found between serum zinc and HDL. Also, Al-Sabaawy [16] revealed a significant lower level of serum zinc in hyperlipidemic nonobese patients compared with the control group, as well as a significant negative correlation between serum zinc and TC, LDL and TG. Multiple studies have revealed that zinc supplementation had beneficial effects on lipid profiles in patients with diabetes or metabolic syndrome [17,18]. Zinc supplementation increase HDL-cholesterol and reduces TG in patients with type 2 diabetes [17]. However, the effect of zinc supplementation on lipid profile and other metabolic factors in obesity are more controversial among nondiabetic obese and nonobese individuals. Zinc supplementation at 30 mg daily for 8 weeks increased serum zinc by 15% and urinary zinc by 56%, but no significant difference was found with respect to TG and HDL-cholesterol after zinc supplementation [19]. Similarly, Beletate *et al.* [20] reported that zinc supplementation for 4 weeks did not have a beneficial effect on lipid levels in normal

Figure 1



Zinc and lipid profile of control (nonobese) and obese groups. HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol; TG, triglyceride.

Table 2 Correlation between serum zinc level and clinical and laboratory data in obese individuals

Variables	*R*	*P*
Age (years)	−0.143	0.515
Weight (kg)	−0.336	0.117
Height (cm)	0.105	0.635
BMI (kg/m^2)	−0.453	0.030
Waist circumference (cm)	−0.418	0.047
Systolic blood pressure (mmHg)	−0.196	0.371
Diastolic blood pressure (mmHg)	−0.052	0.813
Total cholesterol (mg/dl)	−0.362	0.090
LDL (mg/dl)	−0.465	0.025
HDL (mg/dl)	0.07	0.750
TG (mg/dl)	0.282	0.193

HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride.

glucose-tolerant obese women aged 25–45 years. However, in another study, after receiving 20 mg elemental zinc on a regular daily basis for 8 weeks, the mean fasting plasma glucose, insulin and HOMA-IR were decreased significantly with no change in BMI, waist circumference, LDL-cholesterol and TG. Further research on the effect of zinc supplementation on the lipid profile and the metabolic risks in obesity should be performed in a larger cohort with a longer follow-up period to determine the potential merits of zinc-based intervention in obese patients. Sarmento *et al*. [21] also revealed inverse association between zinc and coronary artery disease, and Afridi *et al*. [22] postulated that zinc deficiency may predispose to coronary artery disease in diabetes mellitus patients. Further study are also required to prove LDL as a link between increased cardiovascular risks with decreased zinc concentration in obese nondiabetic individuals.

Conclusion

Plasma zinc concentration in obese individuals presented an inverse relationship with the waist circumference and BMI as well as serum LDL-cholesterol and correlated positively with HDL.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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