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Effects of Zinc Supplementation on the Anthropometric Measurements, Lipid Profiles and Fasting Blood Glucose in the Healthy Obese Adults

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ABSTRACT

Purpose: The aim of this study was to assess the effects of zinc supplementation on anthropometric measures, improving lipid profile biomarkers, and fasting blood glucose level in obese people. ***Methods:*** This randomized, double- blind clinical trial was carried out on 60 obese participants in the 18-45 age range for one month. The participants were randomly divided into the intervention group, who received 30 mg/d zinc gluconate, and the placebo group who received 30mg/d starch. Anthropometric measurements (body mass index (BMI), weight and waist circumference) were recorded before and at the end of study. Lipid profile biomarkers and fasting blood glucose were determined using enzymatic procedure. Analysis of Covariance (ANCOVA) test was run to compare the post-treatment values of the two groups, and t-test was conducted to compare within group changes. ***Results:*** Serum zinc concentration was increased significantly in intervention group (p=0.024). BMI and body weight was significantly decreased (p=0.030 and p=0.020, respectively). Lipid profile biomarkers and fating blood glucose did not change significantly but triglyceride level was significantly decreased (p=0.006) in the intervention group. ***Conclusion:*** The obtained results indicate that zinc supplementation improves BMI, body weight, and triglyceride concentration without considerable effects on lipid profile and glucose level. Zinc can be suggested as a suitable supplementation therapy for obese people, but more studies are needed to verify the results.

Introduction

Obesity has become one of the major public-health concerns in the world[1] which is correlated with the incidence of many chronic diseases such as metabolic syndrome (MS), diabetes, cardiovascular diseases, certain cancers, respiratory disease, etc.[2-4] According to the World Health Organization (WHO) report, there are over 400 million obese and over 1.6 billion overweight adults in the world and it is estimated to be double by 2015. This concern is not restricted just to adults; at least 20 million children under the age of 5 were recognized as overweight in 2005.[5] The prevalence of obesity in Iran has been estimated to be 10.5% and 22.5% in men and women, respectively which indicates an obvious increase during a 14-year period.[6]

Obese people have high amounts of fat mass especially in adipose tissues. Plasma fatty acids are constantly influenced by adipose tissue fatty acids.[7] Plasma triacylglycerols are the major source of endogenous and exogenous fatty acids for the synthesis of complex lipids. The type of fatty acids in adipose tissue might exert a direct influence on serum lipids and the abnormality of serum lipids can affect the incidence of atherosclerosis, MS, and other chronic diseases. Therefore, adipose tissue region has an important role in the development of diseases. It has been suggested that intra-abdominal fat has a higher turnover rate than subcutaneous fat.[8] and it may have a greater influence on the plasma lipid profiles. Abdominal fat has been associated with insulin resistance, hyperlipidemia and hypertension, certain types of cancer and osteoporosis.[9] Recently, nutritional, hormonal, and biochemical status of obese patients are being attended by reserchers.[9-12] Overweight and obese individuals have lower blood level of vitamins and minerals compared to non-overweight and non-obese individuals.[13] zinc concentration in plasma, serum and erythrocytes of

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obese people is considered to be low.[14-15] Zinc, as an important micronutrient, plays a key role in macronutrient metabolism[16] as well as appetite control. In addition, zinc is involved in synthesis, storage, release, and action of insulin.[17,18] and its deficiency is associated with insulin resistance, impaired glucose tolerance and obesity.[19,20]

Weight loss is an effective approach in controlling obesity and it has been demonstrated that weight loss improves plasma concentration of glucose, insulin and lipids. Moreover, weight loss has a positive effect on increasing plasma zinc concentration.[21-23] The present study set out to investigate the effects of zinc supplementation on anthropometric measurements, lipid profiles and fasting blood glucose in healthy obese people.

Materials and Methods

This randomized, double- blind, placebo-controlled clinical trial was performed on 60 healthy obese participants. The research protocol was approved by regional Ethic Committee of Tabriz University in Medical Sciences. Clinical Trial Number was Irct ID: IRCT201112222017N5 with URL: www.irct.IR

Inclusion criteria were the age range of 18-45, nonsmoking, body mass index (BMI) between 30 and 40 (Kg/m^2), while exclusion criteria included pregnancy, breastfeeding and postmenopausal among women, as well as current clinical diseases specially gastrointestinal, liver and kidney, diabetes, and thyroid. Excluded from the study were also individuals who had defective immune systems, were using drugs that could interact with serum lipid profiles and weight loss, were consuming anti-coagulant drugs and beta blockers users, were taking mineral supplements such as zinc, Iron, calcium and vitamin A during the past 3 months, and finally those who were on a diet restriction. After explaning the nature of the study, a written informed consent was taken from the participants.

The eligible participants were randomly allocated to intervention-placebo groups based on random block procedure produced by Random Allocation Software (RAS).[24] Sample size was determined based on the information derived from the same study.[25] The confidence level was set at 95% and the formula $N= [(Z1-\alpha/2 + Z1-B)^2 (SD_1^2+SD_2^2)] /\Delta^2$ was used to calculate the 30 samples in each group. For one month, the Zinc group (n=30) had received a 30mg zinc gluconate tablet per day while the placebo group (n=30) had received 30mg placebo (starch) tablet per day. Tablets of the same color and shape were placed by a third person who labeled the bottles with 2 cods which remained unknown for the researchers until the end of the intervention. All the participants were asked not to change their usual dietary intakes during the study. To ensure that the participants would act in compliance with the prescriptions, they were weekly reached on phone and were required to return the tablet bottles at the end of the study so that the remainder of the tablets could be checked. Subsequent statistical analysis was carried out based on the data obtained from the participants who had consumed more than 90% of the tablets.

Blood samples were taken in a 12 hour fasting state at the beginning and the end of study and were further frozen in -70 ºC for biochemical analysis.

Demographic information was collected through questionnaires. Body weight was measured without shoes and light clothes by using a Seca scale (Seca, Hamburg, Germany). Height was also measured using a statiometer (Seca) without shoes. BMI was calculated as weight (in kilograms) divided by the square of height (in meters). Waist circumference (WC) was measured with a statiometer (Seca).

Serum zinc concentration was estimated by atomic absorption spectrometry (Chem Tech Analytical, CTA 2000, English).[26] Serum concentrations of triglyceride (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and fasting blood glucose (FBS) were determined using kit (Parsazmon, Tehran, Iran) and enzymatic method. Low-density lipoprotein cholesterol (LDL-C) was calculated according to the procedure of Friede-Wald formula.

Statistical Analysis

The data were analyzed by SPSS software (version 16:0, Shikagho.IL, USA). Quantitative data were stated as mean ± standard deviation (SD) and qualitative data were presented as frequency (percentage). Normality of variables distribution was evaluated using Kolmogorov-Smirnov test. Paired t-test was used to compare within group changes before and after the intervention. Analysis of Covariance (ANCOVA) test was also run to compare post treatment variables after adjusting for baseline values in both groups. In addition, chi-square test was used to examine the differences in qualitative variables in both groups. Statistical significance was defined as $p<0$.

Results

Demographic Characteristics

Demographic characteristics of the participants are presented in Table 1. In this randomized, double-blind, placebo-controlled clinical trial, proportion of males and females was similar in both groups (p=0.559).

Table 1. Demographic characteristics of participated obese people

Characteristics		Intervention group (mean ± SD)	Placebo group (mean ± SD)	P value
Age (year)		31±8	33±8	0.502
Sex [N (%)]	Male	7(23.3%)	9 (30%)	0.559
	Female	23(76.7%)	21 (70%)	

Anthropometric Measurements

Paired T-test analysis showed that there is a significant reduction in anthropometric parameters in the intervention group ($p<0.05$). The changes in

anthropometric parameters in the placebo group, however, were not significant (p>0.05). Regarding waist circumference, a significant reduction was also observed in the intervention group, but not in the placebo group (p<0.05).

Results obtained from the ANCOVA test (Table 2) indicate that there is significant differences in weight and BMI indexes between the intervention and the placebo groups after adjusting for baseline measurements (p<0.05). Nevertheless, reduction of waist circumference was not significant in the intervention group after adjusting for baseline values (p>0.05).

Table 2. Results of anthropometric measurements of zinc-supplemented obese people before and after intervention and between both groups.

Components	Intervention group		p^a	Placebo group		p^a	p^b
	before	after		before	after		
Weight (Kg)	90.4±15.4	88.7±15	0.014*	91.13±20.1	91.11 ±20	0.851	0.020*
Waist circumference (cm)	101.9±11.7	99.7±11.2	0.002*	100.2 ±11.8	99±11.2	0.058	0.319
BMI (kg/m^2)	35.4±4.3	34.7±3.9	0.015*	33.5±5.9	33.4±6.1	0.860	0.030*

*statistically significant, a: Paired *t*-test, b: ANCOVA test (between two groups with adjusting for baseline values)

Biochemical Markers

The participants' biochemical markers obtained at the onset of the study and at the end of it were further analyzed to compare the within-groups changes and the between-groups changes. The within-groups comparison of biochemical markers revealed no significant changes in serum FBS, TC, LDL-C and HDL-C levels after intervention (p>0.05), however, TG concentration represented significant reduction in the intervention group (p<0.05). Serum zinc concentration increased significantly in the intervention group at the end of study (p<0.05).

The between-groups comparison of biochemical markers at the end of the study indicated no significant change between groups in serum FBS, TC, LDL-C, TG and HDL-C levels. The increased level of serum zinc between groups was significant (p<0.05). Table 3 shows the results of biochemical markers.

Table 3. Results of biochemical markers of zinc-supplemented obese subjects before and after intervention and between two groups

Components	Intervention group (mean± SD)		p^a	Placebo group (mean± SD)		p^a	p^b
	before	after		before	after		
Fasting blood sugar (mg/dl)	96±9	94.9±13	0.535	86±3	90±4	0.210	0.103
Triglyceride (mg/dl)	146.4±6	131.4±5	0.006*	147±7	144±5	0.677	0.127
Total cholesterol (mg/dl)	185±30	182±34	0.472	153±39	156±35	0.648	0.489
Low density lipoprotein (mg/dl)	104±22	103±25	0.694	86±25	85±22	0.888	0.340
High density lipoprotein (mg/dl)	44±9	46±10	0.109	39±9	41±7	0.351	0.437
Serum zinc (µg/dl)	67±19	74.1±23	0.024*	40.8±19	45.8±17	0.054	0<001*

*statistically significant a: Paired t-test, b: ANCOVA test: between two groups with adjusting for baseline values

Discussion

Obesity is an important risk factor for metabolic abnormality and many chronic diseases.[4] In this study, the use of 30 mg/d zinc was higher than the recommended dose (DRIs 8-11 mg/day), and lower than the tolerable limit of highest intake (40 mg/day).[27]

There were no significant changes in serum FBS, HDL-C, TC and LDL-C concentration at the end of the study but significant decrease was observed in serum TG. According to a Meta-analysis investigation results, regarding the effect of zinc supplementation on lipid profiles were inconsistent.[28] Afkhami-Ardekani et al.,[29] demonstrated that supplementation of forty diabetic patients with 660 mg zinc sulfate for six weeks resulted in a remarkable reduction in TG, TC and LDL-C concentrations, a non-significant increase in serum HDL-C concentration and non-significant reduction in FBS at the end of the study. Samman et al.,[30] found that serum LDL-C, TC and TG concentration were unaffected by supplementation with up to 150 mg zinc per day. Hooper et al.,[31] assessed the effects of 440 mg/day zinc supplementation for five weeks and reported no significant changes in TC, TG and LDL-C concentration at the end of the study. However, TG concentration decreased in this study.

The present research findings were in line with of Roussel et al.,[32] and Fortes et al.[33] studies. Fortes et al.,[33] reported that 25 mg zinc sulphate for three months resulted in a decrease in plasma lipid peroxides. Mechanisms involved in improving lipid profiles and glucose concentration are not clearly identified yet. It has been stated that zinc can play an important role in enzymes involved in lipid and carbohydrate metabolism and similar action to insulin.[34-36] It has

been suggested that higher doses of zinc and longer periods of supplementation can be effective in remarkably reduction in TG, TC, and LDL-C concentration.[30] Low doses of zinc over short periods of intervention may be main reasons for non-significant changes in lipid profiles and blood glucose concentration.

In this study, serum zinc concentration increased notably after intervention. Similar to our study's results, Christos et al.,[37] observed that supplementation with 30 mg elemental zinc/day (in zinc acetate form) for 12 weeks and 60 mg elemental zinc/day (as zinc acetate) for 6 to 8 weeks resulted in an increase in plasma zinc concentration. Gomez et al.,[38] reported a significant rise in serum zinc concentration in 14 obese male subjects supplemented with 100 mg/day oral zinc sulfate ($p=0.001$). In contrast, in the study done by Marreiro and coworkers[11] plasma zinc concentration did not increase significantly at the end of study.

Regarding the anthropometric measurements, there was a significant reduction in weight, waist circumference and BMI indices after intervention. These results are supported by Song et al. and Hashemipour et al. Song et al.,[21] demonstrated that supplementation of 30 obese male S-D rats divided in four groups of 5-6 rats with drinking (no additive, 10 mg zinc plus 1mg Cyclo-(His-Pro) CHP. L-1, 10 mg zinc plus 3mg CHP.L-1 and 10 mg zinc plus 6mg CHP.L-1) for 15 days resulted in a significant reduction in weight especially in rats that were receiving 10 mg zinc plus 3mg CHP.L-1 ($p<0.01$). Likewise, Hashemipour et al., found that supplementation with 20 mg elemental zinc in of 60 obese children aged between 6-10 for 8 weeks resulted in significant reduction of BMI and weight without changes in waist circumference.[39]

The effective mechanisms of zinc supplementation on weight loss can be due to 1) the role of zinc in appetite regulation through changes in hypothalamic neurotransmitter metabolism by affecting the leptin system and its receptors, although zinc can induce synthesis of leptin and prevention of hyperplasia[11] 2) preventive role of zinc in the gene mutation which can increase the risk of obesity[40] 3) similarity of zinc to insulin action and improving insulin sensitivity and insulin resistance.[36,41]

Conclusion

The results of this study indicated that one month supplementation of zinc gluconate (30 mg/day) in obese male and female adults resulted in a remarkable reduction in weight and BMI indices as well as an increase in serum zinc concentration. However, serum lipid profiles and fasting blood glucose with the exception of TG did not change noticeably. To the best of our knowledge, this was the first study in the region that investigated the effect of zinc supplementation on obese adults in both gender and it can be considered as the strength of the study. Nevertheless, there was limitations such as short period of follow-up. It can be suggested that increasing the period of intervention and determining the safety and effectiveness of doses of zinc supplementation be considered in future studies.

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Conflict of Interest

The authors declare there is no Conflict of interest in the content of this study.

References

1. Malekzadeh R, Mohamadnejad M, Merat Sh, Pourshams A, Etemadi A. Obesity Pandemic: an Iranian perspective. *Arch Iranian Med* 2005;8(1):1–7.
2. Sola E, Jover A, Lopez-Ruiz A, Jarabo M, Vaya A, Morillas C, et al. Parameters of inflammation in morbid obesity: Lack of effect of moderate weight loss. *Obes Surg* 2009;19(5):571-6.
3. Ford ES. Prevalence of the metabolic syndrome defined by the international diabetes federation among adults in the U.S. *Diabetes Care* 2005;28(11):2745-9.
4. O'Kane JW, Teitz CC, Fontana SM, Lind BK. Prevalence of obesity in adult population of former college rowers. *J Am Board Fam Pract* 2002;15(6):451-6.
5. WHO. Obesity and overweight fact sheet [data base on the internet] UK: WHO Media centre; 2012; cited 2012 December; Available from: www.who.int/mediacentre/factsheets/fs311/en.
6. Ayatollahi SMT, Ghoreshizade Z. prevalence of obesity and overweight among adults in Iran. *Obesity Rev* 2010;10:335-7.
7. Lands WE. Long-term fat intake and biomarkers. *Am J Clin Nutr* 1995;61(3 Suppl):721S-5S.
8. Frayn KN. Visceral fat and insulin resistance--causative or correlative? *Br J Nutr* 2000;83 Suppl 1:S71-7.
9. Mataix J, Lopez-Frias M, Martinez-de-Victoria E, Lopez-Jurado M, Aranda P, Llopis J. Factors associated with obesity in an adult mediterranean population: Influence on plasma lipid profile. *J Am Coll Nutr* 2005;24(6):456-65.
10. Marreiro DN, Fisberg M, Cozzolino SM. Zinc nutritional status and its relationships with hyperinsulinemia in obese children and adolescents. *Biol Trace Elem Res* 2004;100(2):137-49.
11. Marreiro DN, Geloneze B, Tambascia MA, Lerario AC, Halpern A, Cozzolino SM. Effect of zinc supplementation on serum leptin levels and insulin resistance of obese women. *Biol Trace Elem Res* 2006;112(2):109-18.
12. Konukoglu D, Turhan MS, Ercan M, Serin O. Relationship between plasma leptin and zinc levels and the effect of insulin and oxidative stress on leptin levels in obese diabetic patients. *J Nutr Biochem* 2004;15(12):757-60.

13. Garcia OP, Long KZ, Rosado JL. Impact of micronutrient deficiencies on obesity. *Nutr Rev* 2009;67(10):559-72.
14. Richards BK, Steenhuis TS, Peverly JH, McBride MB, Perrone L, Gialanella G, et al. Zinc, copper, and iron in obese children and adolescents. *Nutr Res* 1998;18:183-9.
15. Chen MD, Lin PY, Sheu WH. Zinc status in plasma of obese individuals during glucose administration. *Biol Trace Elem Res* 1997;60(1-2):123-9.
16. Song Y, Wang J, Li XK, Cai L. Zinc and the diabetic heart. *Biometals* 2005;18(4):325-32.
17. Simon SF, Taylor CG. Dietary zinc supplementation attenuates hyperglycemia in db/db mice. *Exp Biol Med (Maywood)* 2001;226(1):43-51.
18. Chausmer AB. Zinc, insulin and diabetes. *J Am Coll Nutr* 1998;17(2):109-15.
19. Tallman DL, Taylor CG. Effects of dietary fat and zinc on adiposity, serum leptin and adipose fatty acid composition in c57bl/6j mice. *J Nutr Biochem* 2003;14(1):17-23.
20. Marreiro DN, Fisberg M, Cozzolino SM. Zinc nutritional status in obese children and adolescents. *Biol Trace Elem Res* 2002;86(2):107-22.
21. Song MK, Rosenthal MJ, Song AM, Uyemura K, Yang H, Ament ME, et al. Body weight reduction in rats by oral treatment with zinc plus cyclo-(his-pro). *Br J Pharmacol* 2009;158(2):442-50.
22. Jimenez J, Zuniga-Guajardo S, Zinman B, Angel A. Effects of weight loss in massive obesity on insulin and c-peptide dynamics: Sequential changes in insulin production, clearance, and sensitivity. *J Clin Endocrinol Metab* 1987;64(4):661-8.
23. Di Toro A, Marotta A, Todisco N, Ponticiello E, Collini R, Di Lascio R, et al. Unchanged iron and copper and increased zinc in the blood of obese children after two hypocaloric diets. *Biol Trace Elem Res* 1997;57(2):97-104.
24. Saghaei M. Random allocation software for parallel group randomized trials. *BMC Med Res Methodol* 2004;4(26):1-6
25. Dell RB, Holleran S, Ramakrishnan R. Sample size determination. *ILAR J* 2002;43(4):207-13.
26. Dabbaghmanesh MH, Kalantarhormozi MR, Soveid M, Sadeghalvad A, Ranjbar Omrani GR. Plasma zinc concentration in type 2 diabetic patients and control group in Shiraz city. *Iran J Diabetes Lipid Disorders* 2007;7(2):189-94.
27. Kathleen Mahan L, Escott-Stump S, Raymond JL, Krause MV. Krause's Food and the Nutrition Care Process. 13th ed. St. Louis: Elsevier Elsevier/Saunders; 2012.
28. Foster M, Petocz P, Samman S. Effects of zinc on plasma lipoprotein cholesterol concentrations in humans: A meta-analysis of randomised controlled trials. *Atherosclerosis* 2010;210(2):344-52
29. Afkhami Ardekani M, Karimi M, Mohammadi M, Nourani F. Effect of Zinc Sulfate Supplementation on Lipid and Glucose in Type 2 Diabetic Patients. *Pak J Nutr* 2008; 7(4): 550-3.
30. Hughes S, Samman S. The effect of zinc supplementation in humans on plasma lipids, antioxidant status and thrombogenesis. *J Am Coll Nutr* 2006;25(4):285-91.
31. Hooper PL, Visconti L, Garry PJ, Johnson GE. Zinc lowers high-density lipoprotein-cholesterol levels. *JAMA* 1980;244(17):1960-1.
32. Roussel AM, Kerkeni A, Zouari N, Mahjoub S, Matheau JM, Anderson RA. Antioxidant effects of zinc supplementation in tunisians with type 2 diabetes mellitus. *J Am Coll Nutr* 2003;22(4):316-21.
33. Fortes C, Agabiti N, Fano V, Pacifici R, Forastiere F, Virgili F, et al. Zinc supplementation and plasma lipid peroxides in an elderly population. *Eur J Clin Nutr* 1997;51(2):97-101.
34. Petering HG, Murthy L, O'Flaherty E. Influence of dietary copper and zinc on rat lipid metabolism. *J Agric Food Chem* 1977;25(5):1105-9.
35. Rogalska J, Brzoska MM, Roszczenko A, Moniuszko-Jakoniuk J. Enhanced zinc consumption prevents cadmium-induced alterations in lipid metabolism in male rats. *Chem Biol Interact* 2009;177(2):142-52.
36. Chen MD, Liou SJ, Lin PY, Yang VC, Alexander PS, Lin WH. Effects of zinc supplementation on the plasma glucose level and insulin activity in genetically obese (ob/ob) mice. *Biol Trace Elem Res* 1998;61(3):303-11.
37. Mantzoros CS, Prasad AS, Beck FW, Grabowski S, Kaplan J, Adair C, et al. Zinc May Regulate Serum Leptin Concentrations in Humans. *J Am Coll Nutr* 1998;17(3):270-5.
38. Gomez-Garcia A, Hernandez-Salazar E, Gonzalez-Ortiz M, Martinez-Abundis E. Effect of oral zinc administration on insulin sensitivity, leptin and androgens in obese males. *Rev Med Chil* 2006;134(3):279-84.
39. Kelishadi R, Hashemipour M, Adeli K, Tavakoli N, Movahedian-Attar A, Shapouri J, et al. Effect of zinc supplementation on markers of insulin resistance, oxidative stress, and inflammation among prepubescent children with metabolic syndrome. *Metab Syndr Relat Disord* 2010;8(6):505-10.
40. Prasad AS. Zinc in human health: Effect of zinc on immune cells. *Mol Med* 2008;14(5-6):353-7.
41. Haase H, Maret W. Protein Tyrosine Phosphatases as Targets of the combined insulinomimetric effects of zinc and oxidants. *Biometals* 2005;18(4):333-8.