ACTA FACULTATIS
MEDICAE NAISSENSIS

UDC: 616.379-008.64:612.12:546.47+546.23
DOI: 10.5937/afmnai42-52864

Original article

Association of Serum Zinc and Selenium Concentration with Insulin Resistance in Apparently Healthy Adults

Esraa Hammadi Fahad[1], Farqad Bader Hamdan[2], Qasem Sharhan Al-Mayah[3]

[1]*Mustansiriyah University, College of Pharmacy, Department of Pharmacology and Toxicology, Baghdad, Iraq*
[2]*Al-Nahrain University, Baghdad, College of Medicine, Department of Physiology, Baghdad, Iraq*
[3]*Al-Nahrain University, College of Medicine, Department of Medical Research Unit, Baghdad, Iraq*

SUMMARY

Introduction/Aim. Zinc is a trace element involved in insulin metabolism, including its production, storage, and release. Selenium is regarded as a vital micronutrient for humans. It participates in insulin signaling and control. Zinc and selenium may be possibly linked to insulin resistance; however, these relationships have not been well investigated. Therefore, we sought to examine the relationship between blood zinc and selenium levels and insulin resistance in apparently healthy individuals.
Methods. This study used a cross-sectional design including 203 apparently healthy people. Measurements were taken to determine zinc and selenium serum levels, fasting insulin, fasting blood glucose, and glycosylated hemoglobin. Insulin resistance was measured by utilizing the Homeostatic Model Assessment (HOMA–IR).
Results. The prevalence of insulin resistance, as determined by HOMA-IR, was 26.11%. Patients with insulin resistance had higher age (59.96 ± 12.28 years), body mass index (26.66 ± 3.16 kg/m^2), and waist-to-hip ratio (0.93 ± 0.05) compared to those with insulin sensitivity (54.19 ± 9.88 years, 25.92 ± 2.4 kg/m^2, 0.91 ± 0.05), with statistically significant differences (p-values—0.013, 0.013, 0.029, respectively). Serum zinc levels were elevated in insulin-sensitive individuals (87.12 ± 6.87 mcg/mL) compared to those who were insulin-resistant (84.05 ± 8.29 mcg/mL), with a p-value of 0.036. HbA1c concentration and fasting insulin levels were elevated in the insulin-resistant group (4.95 ± 0.49, 15.78 ± 1.59) compared to the insulin-sensitive group (4.79 ± 0.38, 10.1 ± 2.34), with p-values of 0.033 and 0.003, respectively.
Conclusion. In apparently healthy adults, there is an association between low serum zinc levels and insulin resistance. There is no association between selenium serum levels and insulin resistance.

Keywords: **insulin resistance, zinc, selenium**

Corresponding author:
Esraa Hammadi Fahad
e-mail: esraa.ham@uomustansiriyah.edu.iq

INTRODUCTION

The association between zinc content and insulin secretion and function was identified in 1930 as the zinc ion was found to stimulate insulin crystallization (1). Further research demonstrated that zinc is necessary for the processing and storing insulin in the pancreatic β-cell. Zinc (Zn) helps the pancreas produce and store insulin, which augments the body's absorption of glucose. Low plasma levels of zinc impair islet cell production and secretion of insulin (2). Pancreatic β-cells store and crystallize insulin in granules along with free cytosolic zinc. Under normal conditions, β-cells form a hexamer by combining six insulin monomers with two zinc ions in the core. The insulin-Zn crystal is stored and transferred across the cell membrane. According to a study in 2015 by Slepchenko et al., only the insulin monomer remains an active form of the hormone after the Zn-insulin complexes dissociate after being secreted (3). The increase in insulin secretion is correlated with the elevated extracellular concentration of free zinc (3).

Selenium (Se) is a vital mineral for the proper function of human organs. Selenium can be found in both organic and inorganic forms in nature. Selenate, selenite, selenide, and elemental selenium are examples of the inorganic forms of selenium. In contrast, the organic form is found in combination with amino acids and is referred to as selenomethionine (SeMet) and (selenocysteine) SeCys (4). Since selenium counteracts the effects of insulin through glutathione peroxidase (GPx-1) and selenoprotein p (SelP), elevated plasma selenium concentrations are linked to diabetes biomarkers (5). Pan-creatic β-cells are protected from oxidative stress by the action of enzymes like GPx, catalase, and superoxide dismutase, peroxiredoxins, thioredoxins, and thioredoxin reductases. Since the bioavailability of selenium is essential for the activity of thioredoxin reductases and GPx, selenium deficiency causes β-cell oxidative damage and decreased insulin secretion. However, too much selenium also causes dysregulation of insulin secretion, which raises insulin levels and results in the T2DM phenotype. These antioxidant enzymes, including selenoenzymes, generally interfere with vital redox signaling for cell differentiation and insulin secretion to influence these processes (6).

HOMA-IR (Homeostasis Model Assessment of Insulin Resistance) is a practical quantification method for assessing insulin resistance from an epidemiological or clinical perspective. Nevertheless, significant diversity exists in its threshold values. Furthermore, these threshold values vary based on ethnicity, clinical evaluation methodologies, and the metabolic state of the tested populations (7). The HOMA-IR thresholds for diagnosing insulin resistance may differ among racial groups (8). A recent study involving 1,327 non-diabetic, normotensive people in Tehran established this threshold at 1.8. Certain investigators have attempted to identify HOMA-IR cut-offs in individuals predisposed to insulin resistance or metabolic syndrome, although their results were inconsistent (9).

In our investigation, the HOMA-IR threshold was determined to be 3.1, aligning with prior studies on healthy Iraqi adults. Higher than this, individuals were classified as having insulin resistance (10, 11). The relationship between zinc, selenium, and insulin resistance in healthy individuals is intricate. Although research links zinc insufficiency to insulin resistance, selenium's effects are multifaceted, revealing positive and negative associations. The role of zinc and selenium in insulin resistance is still a matter of discussion. In this study, we try to explain the association of serum zinc and selenium with insulin resistance in apparently healthy adults.

SUBJECTS AND METHODS

The research included 203 apparently healthy Iraqi individuals of both genders who were identified as Arabs and were ≥ 40 years old. This cross-sectional study was conducted from May 2023 to February 2024. The study was conducted at Al Nahrain University/College of Medicine, Al-Farahidi University, and Mustansiriyah University, Baghdad, Iraq. It was approved by the Institutional Review Board (IRB) of the College of Medicine, Al-Nahrain University, under the reference number 20221027 on 01/02/2023. Prior to participating in the study, all participants provided their written informed consent.

Inclusion criteria

Subjects enrolled in the study were apparently healthy adults ≥ 40 years old, euglycemic, non-diabetic with HbA1C ≤ 6.5%.

Exclusion criteria

The presence of diabetes or other severe chronic disease such as heart and renal diseases, as well as the use of medications may influence IR or lipid metabolism (such as corticosteroids and lipid-lowering drugs), pregnancy, breastfeeding and women receiving oral contraceptive or hormone replacement therapy.

Sample collection: Participants were asked to fast for eight hours prior to samples' collection. The next morning, 5 ml of blood was taken from each participant. Blood samples were placed in a gel tube to collect serum. After that, the serum was recovered by centrifuging the sample for 15 minutes at 4000 rpm×g. The serum was collected and poured into many Eppendorf tubes for biochemical testing. Two milliliters of blood were obtained in two ethylene diamine tetra-acetic acid (EDTA) tubes for hematological tests.

Demographic factors: Demographic variables such as age, gender, smoking habits, place of residence, and family history of diabetes were obtained by direct interview. The participant's body weight (in kilograms) and height (in centimeters) were measured under the condition that they were wearing light clothes and without wearing shoes. The body mass index was determined using the following equation: weight (kg)/square height (m^2). Measurements were taken for waist circumference, hip circumference, and waist-to-hip ratio.

Biochemical tests: Using a commercially available kit, the hexokinase technique was used to assess glycosylated hemoglobin and fasting plasma glucose. Fasting insulin was determined by immunoradiometric assay. The calculation of insulin resistance was performed using the HOMA-IR method, as follows: HOMA-IR = (FBS (mg/dl) x fasting insulin (mU/L) / 405. In our investigation, the HOMA-IR cut-off value was established at 3.1, consistent with other research involving apparently healthy Iraqi adults. Higher than this, individuals were classified as having insulin resistance (10, 11).

Serum level of zinc: A colorimetric method with 5-bromo-PAPS was used to measure the serum zinc concentration. The assay principle involves the formation of a chelate complex between zinc and 2-(5-bromo 2-pyridylazo)-5(N-propyl-N- sulfopropyl-amino)-phenol. The rise in absorbance may be quantified and is directly proportional to the quantity of total zinc in the sample.

The normal range for males is 72.6-127 mg/dL, while in females it is 70.6-114 mg/dL.

Serum level of selenium: The serum level of selenium was measured by an atomic absorption spectrophotometer, which examined the wavelength of photons absorbed during the excitation of element atoms. The technique used to estimate the atomic absorption of elements is the graphite furnace method, in which the approximation reaches the limit of concentrations in parts per billion. The sample was placed in a graphite tube inside the electric furnace, evaporating until dry, burned, and converted to the atomic state. Here, the percentage of atoms that evaporated, decomposed, and became ready to absorb energy is more significant than in the case of direct flame. The results appeared directly on a screen linked to an atomic absorption spectrophotometer.

Statistical analyses: Statistical analyses were conducted using the SPSS software version 25.0 (SPSS, Chicago). The continuous data underwent a normality test using the Shapiro-Wilk test. Data that exhibited a normal distribution were reported as the mean and standard deviation and were analyzed using a Student's t-test. Data that did not follow a normal distribution were reported using the median and range, and were evaluated using the Mann-Whitney U test (for comparing two groups). Categorical variables were quantified using numerical values and percentages and then assessed using the Chi-square test. Participants were categorized into two groups based on whether they had insulin resistance or not according to HOMA-IR. In line with the previous population-based studies, the cutoff value of HOMA-IR was determined to be 3.1, beyond which subjects were considered to have IR (10, 11).

RESULTS

Demographic features of the study population

Table 1 displays the age, sex, weight, height, BMI, waist and hip circumferences, and the waist/hip ratio of the population under investigation.

Table 1. *Demographic data of the study population*

Parameter	Value
Age, years	
Mean ± SD	55.55 ± 10.75
Range	40-82
Sex	
Males	108 (53.2%)
Females	95 (46.8%)
Weight (Kg)	
Mean ± SD	72.01 ± 8.15
Range	47-89
Height, cm	
Mean ± SD	168.63 ± 9.71
Range	151-182
Waist circumference, cm	
Mean ± SD	89.42 ± 7.13
Range	70-103
Hip circumference, cm	
Mean ± SD	96.34 ± 7.91
Range	80-106
Body Mass Index, kg/cm^2	
Mean ± SD	26.09 ± 2.61
Range	20.34-34.6
Waist/Hip ratio	
Mean ± SD	0.92 ± 0.05
Range	0.77-1.02

Table 2. *Glycemic profile, insulin level, and HOMA-IR of the study population*

Parameter	Value
Fasting blood glucose, mg/dL	
Mean ± SD	88.49 ± 6.80
Range	71.4-109
Glycosylated hemoglobin, %	
Mean ± SD	4.83 ± 0.42
Range	4-5.9
Fasting insulin, μU/mL	
Mean ± SD	11.44 ± 3.26
Range	5.4-19.5
HOMA-IR	
Mean ± SD	2.5 ± 0.71
Range	1.17-4.02

The fasting blood glucose, HbA1c, and insulin levels and the HOMA-R of the study population are indicated in Table 2.

Table 3 shows serum zinc and selenium plasma levels for the studied population.

Table 3. *Trace elements of the study populations*

Parameter	Value
Zinc, mcg/mL	
Mean ± SD	86.11 ± 6.88
Range	71.5-101.5
Selenium, μg/L	
Mean ± SD	0.29 ± 0.15
Median	0.26
Range	0.06-0.74

Insulin status

The study population was divided into insulin-resistant or not based on HOMA IR. One hundred and fifty (73.89%) subjects were insulin sensitive, and the rest, 53 (26.11%) subjects, were insulin resistant (Figure 1).

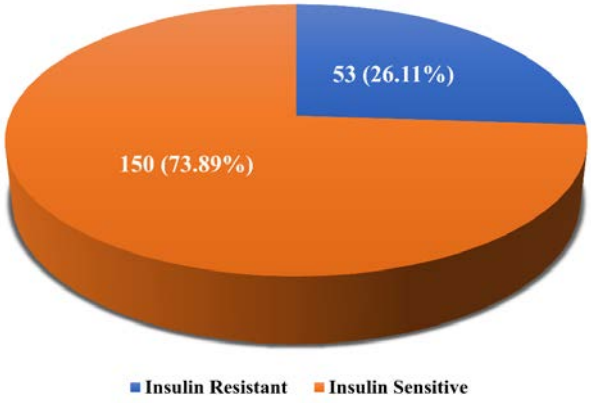

Figure 1. *Distribution of the study population into insulin-sensitive and insulin-resistant subjects*

Demographic data according to insulin status

Subjects of the insulin-resistant group were older and had higher BMIs than those of the insulin-sensitive group (p = 0.013, p = 0.013, respectively). Similarly, the WHR was higher in the insulin resistant group than the insulin-sensitive group (p = 0.029). Conversely, no significant difference was demonstrated in weight, height, waist, and hip circumferences. Likewise, no sex difference was noticed between the two subgroups, as shown in Table 4.

Insulin levels according to insulin resistance status

When subjects were divided into two groups, the HbA1c levels were 4.95 ± 0.49% versus 4.79 ± 0.38%, P = 0.033. The fasting insulin levels were 15.78 ± 1.59 μU/mL versus 10.1 ± 2.34 μU/mL (P = 0.003). FBG levels were 89.04±6.88 mg/dL versus 88.32 ± 6.78 mg/dL (P = NS). Thus, subjects with IR appeared to have higher levels of HbA1c insulin levels compared with those with insulin sensitivity but retained FBG levels, as shown in Table 5. For the p-value, the t-test was used.

Serum trace elements according to insulin status

Table 6 presents the level of trace elements in IR compared to insulin-sensitive subjects. Zinc serum level was 84.05 ± 8.29 mcg/mL versus 87.12 ± 6.87 mcg/mL (P = 0.036) respectively, whereas selenium level was 0.26 ± 0.11 ppm versus 0.30 ± 0.16 ppm (P = NS).

Table 4. *Demographic data of the study population according to insulin status*

Parameter	Insulin status		p-value
	Resistant (n = 53)	Sensitive (n = 150)	
Age, years			
Mean ± SD	59.96 ± 12.28	54.19 ± 9.88	0.013
Range	70-82	40-82	
Sex			
Males	31(58.5%)	77 (51.33%)	0.506^{NS}
Females	22 (41.5%)	73 (48.67%)	
Weight (kg)			
Mean ± SD	72.88 ± 7.56	71.75 ± 8.33	0.775 ^{NS}
Range	55-85	47-89	
Height, cm			
Mean ± SD	170.1 ± 5.82	168.17 ± 6.92	0.250 ^{NS}
Range	159-182	151-182	
Waist circumference, cm			
Mean ± SD	92.1 ± 6.28	88.59 ± 7.18	0.244 ^{NS}
Range	77-103	70-102	
Hip circumference, cm			
Mean ± SD	97.81 ± 4.17	95.88 ± 5.04	0.133 ^{NS}
Range	84-106	80-105	
Body mass index, kg/m^2			
Mean ± SD	26.66 ± 3.16	25.92 ± 2.4	0.013
Range	20.4-34.2	20.34-34.6	
Waist/Hip ratio			
Mean ± SD	0.93 ± 0.05	0.91 ± 0.05	0.029
Range	0.79-1.02	0.77-0.98	

NS = not significant. P-value for all parameters, we used t-test except for the p-value for sexes; we used the Chi-square test

Table 5. *Insulin resistance-related parameters of those with and without insulin resistance*

Parameter	Insulin status		p-value
	Resistant (n = 53)	Sensitive (n = 150)	
FBG, mg/dL			
Mean ± SD	89.04 ± 6.88	88.32 ± 6.78	0.305^{NS}
Range	77-109	71.4-106	
HbA1c level, %			
Mean ± SD	4.95 ± 0.49	4.79 ± 0.38	0.033
Range	4-5.9	4-5.7	
Fasting insulin, μU/mL			
Mean ± SD	15.78 ± 1.59	10.1 ± 2.34	0.003
Range	12.5-19.5	5.4-16.5	

FBG = fasting blood glucose; HbA1C = glycosylated hemoglobin; NS = not significant
For the p-value, the t-test was used

Table 6. *Serum trace elements according to insulin status*

Parameter	Insulin status		p-value
	Resistant (n=53)	Sensitive (n=150)	
Zinc, mcg/mL			
Mean ± SD	84.05±8.29	87.12±6.87	0.036
Range	71.5-101.5	74.1-101.4	
Selenium, ppm			
Mean ± SD	0.26±0.11	0.30±0.16	0.222[NS]
Range	0.06-0.74	0.06-0.74	

NS = not significant
For the p-value, the t-test was used

DISCUSSION

The present study showed that the serum zinc was lower in insulin-resistant subjects than in insulin-sensitive subjects. Many studies worldwide have confirmed this finding. Research conducted in Bangladesh found a correlation between the zinc content in the blood and insulin resistance in 142 individuals with normal blood sugar levels (12). Research conducted by Ahn et al. in Korea showed that there is a negative correlation between the concentration of zinc in the blood and insulin resistance in a large group of adults without diabetes (13).

A review study involving 56 articles found that zinc deficiency is associated with glucose intolerance and IR; however, the effectiveness of the intervention with the zinc supplementation is still inconclusive (14). In a separate study undertaken by Bjørklund et al., it was shown that zinc, selenium, and copper have a role in the development of diabetes (15). However, these trace elements are in excessive quantities and have harmful effects. Zinc seems to stimulate essential molecules involved in cellular signaling, which regulate glucose homeostasis. Zinc also modulates insulin receptors, extends the duration of insulin activity, and enhances favorable lipid profiles (15).

A recent experimental investigation explored the impact of zinc on insulin levels in male rats. The study shows that levels of zinc in the food influence the levels of insulin in the bloodstream and change the distribution of pancreatic β-cells responsible for producing insulin. Their findings indicate that variations in blood insulin levels, triggered by varying plasma concentrations of zinc, may lead to metabolic changes in insulin target organs, such as the liver and adipose tissue (16).

Multiple further investigations have shown that zinc plays a crucial role in the pathophysiology of glucose metabolism and affects insulin homeostasis (17). Previous research showed that persons with impaired glycemic control had considerably lower serum levels of zinc than healthy individuals (18). Furthermore, there is an evidence indicating that decreased levels of zinc are linked to a higher likelihood of acquiring type 2 diabetes (T2D) in the future (19).

Multiple publications indicate the processes by which zinc is implicated in insulin action. Zinc acts as a catalyst in promoting the process of phosphorylation of the beta component of the insulin receptor. The activity of phosphoinositide 3-kinases (PI3K) protein kinase B (PKP) mediates the insulin-like action on glucose transport (20). Zinc exerts its insulin-like effects by directly inhibiting endogenous glycogen synthase kinase-3beta (GSK-3β), a protein linked to insulin resistance (IR) and type 2 diabetes (21).

Another mechanism involves the interaction with oxidative stress, which has a role in developing and advancing insulin resistance (IR) and diabetes (22, 23). It is well established that pancreatic β cells are susceptible to damage from free radicals. Zinc, a cofactor of superoxide dismutase, reduces oxidative stress. Therefore, a zinc deficiency might worsen oxidative stress and contribute to the development of insulin resistance (24). Furthermore, zinc transporter 8 (ZnT8), situated on the surface of pancreatic β-cells, plays a crucial role in zinc's appropriate storage and functioning in insulin-secretory granules (25). The impairment of ZnT8 function or genetic mutations in the ZnT8 gene hinders the normal process of insulin crystallization. This results in increased degradation of insulin in the liver, decreasing the quan-

tity of insulin that reaches the target tissues. Consequently, this leads to the development of impaired glucose tolerance (26). The correlation between selenium and insulin resistance (IR) in animals and people is still unclear due to conflicting findings from prior research. Some studies indicate that an excessive buildup of selenium in the body is linked to type 2 diabetes (27), whereas other investigations do not uncover any significant connections (28). Research indicates that optimal levels of selenium are crucial for the production and effectiveness of insulin. However, an excessive amount of selenium in the body is linked to the development of insulin resistance (IR) and diabetes mellitus (DM) (29).

An extensive cross-sectional investigation on a representative sample of the U.S. population found a direct correlation between the levels of selenium in the blood and diabetes (30). The distinction in this research is that selenium was evaluated in plasma, which serves as a short-term indicator and is more responsive to immediate dietary fluctuations. Moreover, the study relied on a physician's self-reported diagnosis of diabetes, which might introduce bias and lead to an overestimation of the prevalence of diabetes. In contrast, a cross-sectional analysis of the health professionals' research revealed a negative correlation between toenail selenium levels and the incidence of diabetes among male health professionals (31). Zinc and selenium are both crucial for the metabolism of glucose and insulin. However, further studies are required to corroborate these results and clarify the underlying mechanisms.

CONCLUSION

The study indicates an association between apparently healthy adults' serum zinc levels and insulin resistance. There is no association between selenium concentration and insulin resistance. Additional longitudinal or experimental studies may be required to ascertain a causal relationship.

References

1. Maret W. Zinc in pancreatic islet biology, insulin sensitivity, and diabetes. Prev Nutr Food Sci 2017;22(1):1. https://doi.org/10.3746/pnf.2017.22.1.1

2. Rungby J. Zinc, zinc transporters and diabetes. Diabetologia 2010;53(8):1549-51. https://doi.org/10.1007/s00125-010-1793-x

3. Slepchenko KG, Daniels NA, Guo A, Li YV. Autocrine effect of Zn 2^{+} on the glucose-stimulated insulin secretion. Endocrine 2015;50:110-22. https://doi.org/10.1007/s12020-015-0568-z

4. Kieliszek M. Selenium-fascinating microelement, properties and sources in food. Molecules 2019;24(7):1298. https://doi.org/10.3390/molecules24071298

5. Wongdokmai R, Shantavasinkul PC, Chanprasertyothin S, et al. The involvement of selenium in type 2 diabetes development related to obesity and low grade inflammation. Diabetes, Diabetes Metab Syndr Obes 2021:1669-80. https://doi.org/10.2147/DMSO.S303146

6. Steinbrenner H, Duntas LH, Rayman MP. The role of selenium in type-2 diabetes mellitus and its metabolic comorbidities. Redox Biol 2022;50:102236. https://doi.org/10.1016/j.redox.2022.102236

7. Gayoso-Diz P, Otero-González A, Rodriguez-Alvarez MX, et al. Insulin resistance (HOMA-IR) cut-off values and the metabolic syndrome in a general adult population: effect of gender and age: EPIRCE cross-sectional study. BMC Endocr Disord 2013;13:47. https://doi.org/10.1186/1472-6823-13-47

8. Esteghamati A, Ashraf H, Khalilzadeh O, et al. Optimal cut-off of homeostasis model assessment of insulin resistance (HOMA-IR) for the diagnosis of metabolic syndrome: third national surveillance of risk factors of non-communicable diseases in Iran (SuRFNCD-2007). Nutr Metab 2010;7:26. https://doi.org/10.1186/1743-7075-7-26

9. Esteghamati A, Ashraf H, Esteghamati AR, et al. Optimal threshold of homeostasis model assessment for insulin resistance in an Iranian population: the implication of metabolic syndrome to detect insulin resistance. Diabetes Res Clin Pract 2009; 84(3): 279-87. https://doi.org/10.1016/j.diabres.2009.03.005

10. Ghani ZA, Qaddori H, Al-Mayah Q. Triglyceride/high-density lipoprotein ratio as a predictor for insulin resistance in a sample of healthy Iraqi adults. J Med Life 2023; 16(5): 668-74. https://doi.org/10.25122/jml-2022-0239

11. Khalid SH, Hashim ZH, Al-Mayah QS, Hisham AM. Predictive value of lipid profile in predicting the resistance to insulin in apparently healthy adults. Acta Pharm Sci 62(3). https://doi.org/10.23893/1307-2080.APS6243

12. Islam MR, Arslan I, Attia J, et al. Is serum zinc level associated with prediabetes and diabetes?: a cross-sectional study from Bangladesh. PLoS One 2013;8(4):e61776. https://doi.org/10.1371/journal.pone.0061776

13. Ahn BI, Kim MJ, Koo HS, et al. Serum zinc concentration is inversely associated with insulin resistance but not related with metabolic syndrome in nondiabetic Korean adults. Biol Trace Elem Res 2014;160:169-75. https://doi.org/10.1007/s12011-014-0045-1

14. Cruz KJC, de Oliveira ARS, Morais JBS, et al. Zinc and insulin resistance: biochemical and molecular aspects. Biol Trace Elem Res 2018;186:407-12. https://doi.org/10.1007/s12011-018-1308-z

15. Bjørklund G, Dadar M, Pivina L, et al. The role of zinc and copper in insulin resistance and diabetes mellitus. Curr Med Chem 2020;27(39):6643-57. https://doi.org/10.2174/0929867326666190902122155

16. Nakamura A, Kido T, Seki Y, Suka M. Zinc deficiency affects insulin secretion and alters insulin-regulated metabolic signaling in rats. J Trace Elem Med Biol 2024;83:127375.

https://doi.org/10.1016/j.jtemb.2023.127375

17. Fukunaka A, Fujitani Y. Role of zinc homeostasis in the pathogenesis of diabetes and obesity. Int J Mol Sci 2018;19(2):476. https://doi.org/10.3390/ijms19020476

18. Fernández-Cao JC, Warthon-Medina M, Moran VH, et al. Dietary zinc intake and whole blood zinc concentration in subjects with type 2 diabetes versus healthy subjects: A systematic review, meta-analysis and meta-regression. J Trace Elem Med Biol 2018;49:241-51. https://doi.org/10.1016/j.jtemb.2018.02.008

19. Luo YY, Zhao J, Han XY, et al. Relationship between serum zinc level and microvascular complications in patients with type 2 diabetes. Chin Med J 2015;128(24):3276-82. https://doi.org/10.4103/0366-6999.171357

20. Tang Xh, Shay NF. Zinc has an insulin-like effect on glucose transport mediated by phosphoinositol-3-kinase and Akt in 3T3-L1 fibroblasts and adipocytes. J Nutr 2001;131(5):1414-20 https://doi.org/10.1093/jn/131.5.1414

21. Ilouz R, Kaidanovich O, Gurwitz D, Eldar-Finkelman H. Inhibition of glycogen synthase kinase-3β by bivalent zinc ions: insight into the insulin-mimetic action of zinc. Biochem Biophys Res Commun 2002;295(1):102-6. https://doi.org/10.1016/S0006-291X(02)00636-8

22. Wiernsperger NF. Oxidative stress as a therapeutic target in diabetes: revisiting the controversy. Diabetes Metab J ;2003;29(6):579-85. https://doi.org/10.1016/S1262-3636(07)70072-1

23. Lann D, LeRoith D. Insulin resistance as the underlying cause for the metabolic syndrome. Med Clin North Am 2007;91(6):1063-77. https://doi.org/10.1016/j.mcna.2007.06.012

24. Levine AS, McClain CJ, Handwerger BS, et al. Tissue zinc status of genetically diabetic and streptozotocin-induced diabetic mice. Am J Clin Nutr 1983;37(3):382-6. https://doi.org/10.1093/ajcn/37.3.382

25. Goktepe E, Baltaci SB, Unal O, et al. The relationship between beta cell activation and SLC30A8/ZnT8 levels of the endocrine pancreas and maternal zinc deficiency in rats. J Trace Elem Med Biol 2023;79:127217. https://doi.org/10.1016/j.jtemb.2023.127217

26. Samuel VT, Petersen KF, Shulman GI. Lipid-induced insulin resistance: unravelling the mechanism. Lancet 2010;375(9733):2267-77. https://doi.org/10.1016/S0140-6736(10)60408-4

27. Moon S, Chung HS, Yu JM, et al. Association between serum selenium level and the prevalence of diabetes mellitus in US population. J Trace Elem Med Biol 2019;52:83-8. https://doi.org/10.1016/j.jtemb.2018.12.005

28. Cardoso BR, Braat S, Graham RM. Selenium status is associated with insulin resistance markers in adults: findings from the 2013 to 2018 National Health and Nutrition Examination Survey (NHANES). Front Nutr 2021;8:696024. https://doi.org/10.3389/fnut.2021.696024

29. Fontenelle LC, Feitosa MM, Morais JBS, et al. The role of selenium in insulin resistance. Braz. J. Pharm. Sci 2018;54:e00139. https://doi.org/10.1590/s2175-97902018000100139

30. Bleys J, Navas-Acien A, Guallar E. Serum selenium and diabetes in U.S. adults. Diabetes Care 2007;30(4):829-34. https://doi.org/10.2337/dc06-1726

31. Rajpathak S, Rimm E, Morris JS, Hu F. Toenail selenium and cardiovascular disease in men with diabetes. J Am Coll Nutr 2005;24(4):250-6. https://doi.org/10.1080/07315724.2005.10719472

Article info
Received: August 20, 2024
Revision 1: November 25, 2024
Revision 2: January 6, 2025
Accepted: February 13, 2025
Online first: March 5, 2025

Povezanost koncentracija cinka i selena u serumu sa insulinskom rezistencijom kod naizgled zdravih odraslih osoba

Esraa Hammadi Fahad[1], Farqad Bader Hamdan[2], Qasem Sharhan Al-Mayah[3]

[1]*Univerzitet Mustansiriyah, Fakultet za farmaciju, Departman za farmakologiju i toksikologoiju, Bagdad, Irak*
[2]*Univerzitet Al-Nahrain, Medicinski fakultet, Departman za fiziologiju, Bagdad, Irak*
[3]*Univerzitet Al-Nahrain, Medicinski fakultet, Departman za medicinska istraživanja, Bagdad, Irak*

SAŽETAK

Uvod/Cilj. Cink je element koji je u tragovima uključen u metabolizam insulina, uključujući proizvodnju, skladištenje i oslobađanje insulina. Selen se smatra vitalnim mikronutrijentom kod ljudi i učestvuje u signalizaciji i kontroli insulina. Cink i selen mogu biti povezani sa insulinskom rezistencijom. Međutim, ovi odnosi još nisu dobro istraženi. Iz tog razloga, nastojali smo da ispitamo odnos između nivoa cinka i selena u krvi i insulinske rezistencije kod naizgled zdravih osoba.
Metode. U ovoj studiji primenjen je poprečni presek, a u istraživanje su uključene 203 naizgled zdrave osobe. Merenja su izvršena da bi se odredili nivoi cinka i selena u serumu, insulin natašte, glukoza u krvi natašte i glikolizirani hemoglobin. Insulinska rezistencija merena je korišćenjem procene homeostatskog modela (engl. *homeostasis model assessment for insulin resistance* – HOMA-IR).
Rezultati. Prevalencija insulinske rezistencije, kako je utvrđeno modelom HOMA-IR, iznosila je 26,11%. Bolesnici sa insulinskom rezistencijom bili su stariji (59,96 godina ± 12,28 godina), imali su viši indeks telesne mase (26,66 kg/m² ± 3,16 kg/m²), kao i povećanu vrednost odnosa struka i kuka (0,93 ± 0,05), nego ispitanici osetljivi na insulin (54,19 godina ± 9,88 godina, 25,92 kg/m² ± 2,4 kg/m², 0,91 ± 0,05), sa statistički značajnim razlikama (p vrednosti: 0,013, 0,013, 0,029, redom). Nivoi cinka u serumu bili su povišeni kod osoba osetljivih na insulin (87,12 mcg/mL ± 6,87 mcg/mL) u poređenju sa osobama koje su bile otporne na insulin (84,05 mcg/mL ± 8,29 mcg/mL), sa p vrednošću od 0,036. Koncentracija HbA1c, kao i nivoi insulina natašte, bili su povišeni u grupi ispitanika rezistentnih na insulin (4,95 ± 0,49, 15,78 ± 1,59) u poređenju sa grupom ispitanika osetljivih na insulin (4,79 ± 0,38, 10,1 ± 2,34), sa p vrednostima od 0,033 i 0,003, redom.
Zaključak. Kod naizgled zdravih odraslih osoba utvrđena je povezanost između niskog nivoa cinka u serumu i insulinske rezistencije. Ne postoji povezanost između nivoa seruma selena i insulinske rezistencije.

Ključne reči: **insulinska rezistencija, cink, selen**