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Correlation Between Dietary Zinc Intakes and Its Serum Levels with Depression Scales in Young Female Students

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Abstract It has been suggested that mood disorders and depressive status may be accompanied by lowered zinc status in the body, and adequate consumption of zinc increases a general perceived well-being. The main objective of this study was to assess the correlation between serum zinc concentrations and dietary zinc intakes with depression scores in university female students. In the first phase, Beck's depression questionnaire was applied in a random sampling of 308 selected 20–25-year-old female students (one third of total students in Ahvaz Jondi-Shapour University of Medical Sciences Golestan dormitories) to assess the major depressive disorder (MDD) scales. Then, in the second phase, 23 students who identified as having moderate and severe depression were selected as the case group, and 23 healthy age matched were chosen as the controls. Each of them completed a 12-item semiquantitative food frequency questionnaire containing the main food sources of zinc in the usual dietary patterns and also a 24-h food recall questionnaire to assure the daily zinc intakes. Daily zinc intakes were obtained by multiplying each portion size by its zinc content using food tables. A 5-ml blood sample was taken for further serum zinc status using flame atomic absorption spectrophotometry technique. Pearson's r was used to show the correlation between quantitative variables. Both daily zinc intake and serum zinc concentrations of MDD group were about two thirds of healthy index ($p<0.01$). Depressed individuals used to eat lower servings of red meats and chicken as the main food sources of zinc in students' usual diets ($p<0.001$). Consumption of other foods as the sources of zinc was not significantly different in two groups. A linear significant correlation between

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dietary zinc intakes and its serum levels was seen in samples (r=0.62; p<0.001) and MDD students (r=0.55; p<0.001). There was a linear inverse correlation between Beck questionnaire scores and serum zinc concentrations in all of the investigated students (r=-0.65; p<0.001) and MDD girls (r=−0.71; p<0.001). Beck questionnaire scores and diatary zinc intakes were also inversly correlated (r=−0.58; p<0.001). However, no statistical correlation was seen between these two variables in MDD cases. In depressed female students, dietary zinc intake is correlated to its serum concentrations; however, the serum zinc levels are inversely correlated to depression scales. Consumption of the main dietary sources of zinc such as red meats and chicken should be encouraged in young depressed girls.

Keywords Zinc · Nutrition · Depression · Female students

Introduction

Depression is a psychiatric disorder with high morbidity and mortality. It is estimated that depression is the cause of 50–70% suicides [1]. The World Health Organization predicts that depression will be the second most important cause of human disability—adjusted life years by the year 2020 [2].

During the last several years, many articles have been presented indicating important role of zinc in the psychopathology and therapy of depression. Zinc is a trace element, essential for living organisms.

More than 300 enzymes require zinc for their activities. Zinc plays an important role in the DNA replication, transcriptions, and protein synthesis, influencing cell division and differentiation [3]. Dietary zinc deprivation retards growth of human and animal organisms [4]. The highest amount of zinc is present in the brain, especially in the hippocampus and cerebral cortex [3, 5]. Zinc deprivation influences brain zinc homeostasis and leads to alteration in behavior, learning, mental function, and susceptibility to epileptic convulsions [4].

Zinc, as an antagonist of the glutamate/*N*-methyl-D-aspartate receptor, exhibits antidepressant-like activity in rodent tests/models of depression. Similar to antidepressants, zinc induces brain-derived neurotrophic factor (BDNF) gene expression and increases level of synaptic pool of zinc in the hippocampus. Clinical observations demonstrated serum hypozincemia in depression, which was normalized by effective antidepressant treatment [6].

Recent results show that chronic treatment with antidepressants and electroconvulsive shock induces an increasing in zinc concentrations in the rat brain. Calculation of the hippocampus/brain region zinc concentration ratio within groups treated with antidepressants (such as citalopram or imipramine) demonstrated a significantly higher value after treatment with both drugs [7].

On the other hand, women of childbearing age are at high risk for major depressive disorder (MDD). The lifetime risk for MDD in community samples has varied from 10% to 25% for women, with peak prevalence between 25 and 44 years old [8].

In Iran, studies conducted by the Ministry of Health at national level have concluded that prevalence of zinc deficiency in females living in southwest of Iran (including city of Ahvaz) is about 20% based on serum zinc levels [9].

MDD is a leading cause of disease-related disability among women worldwide [8].

During this century, MDD is occurring earlier in the life span in successive generations; therefore, an increasing number of women will become ill during their childbearing years.

MDD is underrecognized and undertreated in clinical settings [10]. If depression is appropriately diagnosed, the high cost and side effects of antidepressants remain important

treatment barriers for many women [11, 12]. Although, not all depressed women respond to drug treatment, the additional therapies would be needed [13].

Given the public health importance of MDD and the ubiquitous problem of poor diet quality, and also historic prevalence of zinc deficiency in some subsamples of Iranians [14], our objective was to evaluate the current status of serum levels and dietary intake of zinc in a sample of depressed young girls and to address implications for women of childbearing age.

Methods

Subjects In the fall and winter 2006, as the first setp of study, a 21-question Beck's questionnaire [15] was applied to assess the MDD scales in a sample of 308 female students in the range of 20–25 years old. Scores below 9, 10–18, 19–29, and 30–63 were regarded as normal, mild, moderate, and severe depression, respectively.

They were one third of total girls living in Ahvaz Jondi-Shapour University, Golestan dormitory complex. Jondishapour University is one of the eight main class-A National Iranian Medical Universities which is located in city of Ahvaz, Khuzestan provience, north of the Persian Gulf.

In the second phase, 23 students were selected and defined as having moderate to severe depression (scores higher than 19) as the MDD group and 23 age-matched student with no history of any mood deprivations assigned as controls.

Dietary Assessment For evaluating both qualitative and quantitative dietary patterns, all 46 samples completed a 12-item semiquantitative food frequency quetionnaire containing the main dietary sources of zinc in food groups consumed according to the students' daily and weekly patterns. However, four food items including shrimp, river fishes, shelfishes, and nuts (except soy nut and peanut) were not reported in the students' usual dietary patterns so they were excluded in analysis. They also completed a 24-h food recall questionnaire to assure the amount of daily zinc intake. After multiplyng zinc contents in each food item by its portion size, daily zinc intakes were reported as milligrams per day using Nutritrack 3® software, USA. The database of this software was used for evaluating zinc contents of each food items. All data were recorded through direct interviews carried out by three trained senior nutrition students. All subjets followed their daily meals provided by the university self-service as a weekly constant meal program.

Serum Zinc Status Each of 46 individuals in both groups gave 5-ml blood sample for further laborotary measurements. Serum zinc concentrations of samples were measured by fivefold diluting them, aspirating into the atomic absorption flame, and comparing the their signals with the those from aqueous calibrators, which was prepared in the diluted glycerol (5 ml/dL). Instrument was Chemtech, model CTA 3000, made in England, by setting wavelength for reaout absoption 213.9 nm and slit width 0.7 nm. Serum zinc levels lower 70 μg/dL was regarded as deficiency [16].

Statistics Kolmogrov–Smirnov test was applied to show normal distribution of variables. Independent *t* test was conducted to compare variables means between groups. Pearson's *r* was used to illustrate linear correlation between continious quantitative variables using SPSS® software version 13. To compare consumption of the food categories between groups, chi-square test was applied. *p* value less than 0.05 was regarded as significant.

Medical Ethics All students gave their written consents, and no name was disclosed in the results. Medical Ethics Committee of Jondi-Shapour Univerity of Medical Sciences approved the protocol of study.

Results

Table 1 shows no significant diference between mean age of two groups. Both daily zinc intake and serum zinc concentrations of MDD group were about two thirds of healthy samples ($p<0.001$). Evaluation of dietary patterns (Table 2) showed that affected individuals used to consume lower servings of red meats and chicken as the main food sources of zinc in students' usual diets ($p<0.001$) However, there was no significant diference in consumption of other dietary zinc sources between study groups (eight items were answered as the main dietary usual zinc sources on both daily and weekly basis; Table 2).

Figures 1 and 2 indicate a linear regression between dietary zinc intakes and serum zinc levels in all samples ($r=0.62$; $p<0.001$) and MDD students ($r=0.55$; $p<0.001$), respectively. Figures 3 and 4 show a linear negative regression between Beck questionnaire scores and serum zinc concentrations in all subjects ($r=-0.65$; $p<0.001$) and MDD girls ($r=-0.71$; $p<0.001$), respectively.

There was also an inverse correlation between Beck questionnaire scores and diatary zinc intakes (milligram per day) in all subjects ($r=-0.58$; $p<0.001$; Fig. 5). However, no statistical correlation was seen between these two variables in MDD subjects.

Discussion

Zinc has the second highest concentration of all transition metals after iron in the brain [17]. Most zinc is localized within synaptic vesicles of specific neurons, where it is thought to modulate synaptic transmission and may itself act as a neurotransmitter [3, 17]. Clinical manifestations of zinc deficiency include behavioral disturbances such as anorexia dysphoria, impaired learning and cognitive function, some neurological disorders (e.g., epilepsy, Alzheimer's disease), and depression [17–22].

In the present study, it was shown that both serum zinc levels and dietary zinc intakes in depressed girls were lower (about two thirds) compared with their healthy counterparts (Table 1). Furthermore, we found that 23 percent of depressed—but no one of healthy subjects—had serum zinc concentrations below 70 μg/dL (data not shown) which is indicated as the cutoff point of zinc deficiency [20].

Table 1 Basic Characteristics of Study Groups

Criteria	Healthy ($n=23$)	Depressed ($n=23$)	p value
Age (year; mean±SD)	20.2±0.9	20.7±1.6	0.9
Dietary zinc intake (mg/dL; mean±SD)	2.93±0.9	1.97±0.5	<0.001
Serum zinc concentration (mg/dL; mean±SD)	111.6±21.9	79.6±30.7	<0.001
Beck scores (mean±SD)	2±1.2	47.2±17.3	<0.001

SD standard deviation

Table 2 Consumption of the Main Dietary Sources of Zinc in Students' Usual Diets

Food items	Servings[a]	Healthy *n* (%)	Depressed *n* (%)	*p* value
Red meats (beef)	3–4 times/week	14 (60.8)	2 (8.7)	<0.001
Chicken	3–4 times/week	15 (65.2)	2 (8.7)	<0.001
Liver	2–3 times/month	23 (100)	20 (87.6)	0.7
Fish	2–3 times/month	23 (100)	22 (95.6)	0.8
Eggs	3–4 times/week	21 (91.3)	20 (87.6)	0.7
Legumes	3–4 times/week	23 (100)	23 (100)	0.9
Soy nuts	3–4 times/week	16 (69.5)	15 (65.2)	0.7
Peanut	2–3 times/month	20 (87.5)	18 (78.3)	0.6

The zinc content of each item in software database is varied due to different varieties, and in most items, we chose an average amount

[a] Servings denote the portion sizes in each food item

Both Hansen et al. and McLoughlin have reported that blood zinc concentrations are lower in individuals with MDD compared with control ones [20, 21]. Maes and colleagues studied serum zinc in 48 unipolar MDD patients and 32 control individuals and found that zinc concentrations were correlated with severity of depression [23].

As the main cause of different dietary zinc intakes between groups, the intake of red meat and chicken was shown to be more than seven times higher than in controls. However, it is worthy to note that all girls in two groups had considerably low daily zinc intake which had been indicated more than four decades ago in Fars province, southwest of Iran [14]. No similar results regarding dietary zinc intakes and consumption of its food sources in depressed girls were found in the literature.

Marcellini et al. in their study on zinc status and psychological and nutritional assessment in old people recruited in five European countries (ZINCAGE project) showed that all psychological variables (Mini Mental State Examination, the Geriatric Depression Scale, and the Perceived Stress Scale) were related to plasma zinc values and nutritional assessment. In particular, a relationship between marginal zinc deficiency and impaired

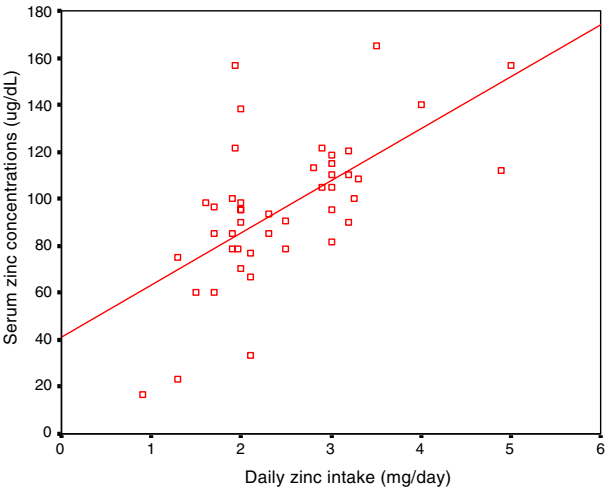

Fig. 1 Correlation between dietary zinc intakes (milligram per day) and its serum concentrations (microgram per deciliter) in all subjects studied (r=0.62; p<0.001)

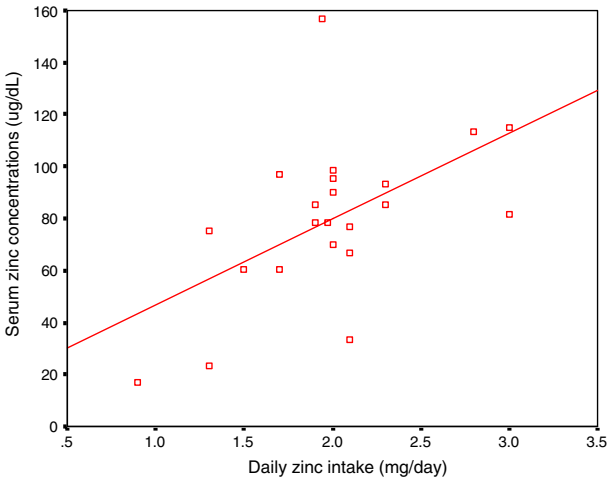

Fig. 2 Correlation between dietary zinc intakes (milligram per day) and its serum concentrations (microgram per deciliter) in MDD subjects (r=0.55; p<0.001)

psychological dimensions occurred in Greece than in compare with other European countries due to low intake and less variety of rich of zinc foods. They concluded that this phenomenon was independent by the age, suggesting that a correct zinc intake from a wide range of foods may be useful to maintain a satisfactory plasma zinc levels as well as psychological status in elderly with subsequent achievement of healthy aging [24].

For further assessment of the correlation between serum zinc concentrations and its dietary intake, it was found that a linear correlation exists between these variables in all students and also in depressed subjects (Figs. 1 and 2).

In the present study, it has been documented that there is a statistical negative correlation between Beck's depression scores and serum levels and in all students and depressed girls. However, the correlation was stronger in the latter group (r=−0.65 vs. r=−0.71).

Notably, to illustrate the correlation between dietary zinc intake and its serum levels and also their correlations with depression scores, it is necessary to conduct researches with more number of samples in larger scales.

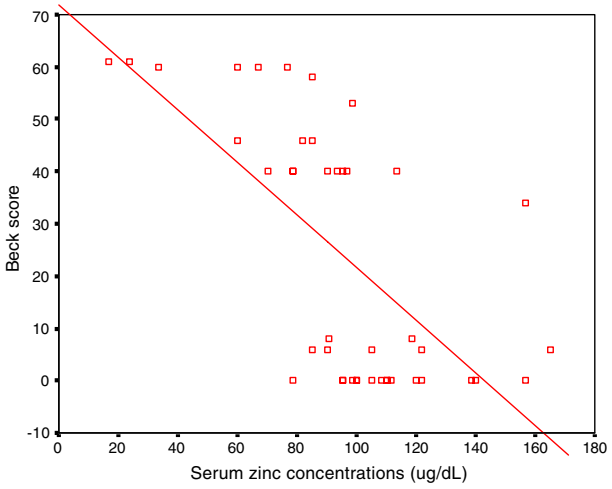

Fig. 3 Correlation between Beck scores and serum zinc concentrations (microgram per deciliter) in all subjects studied (r=−0.65; p<0.001)

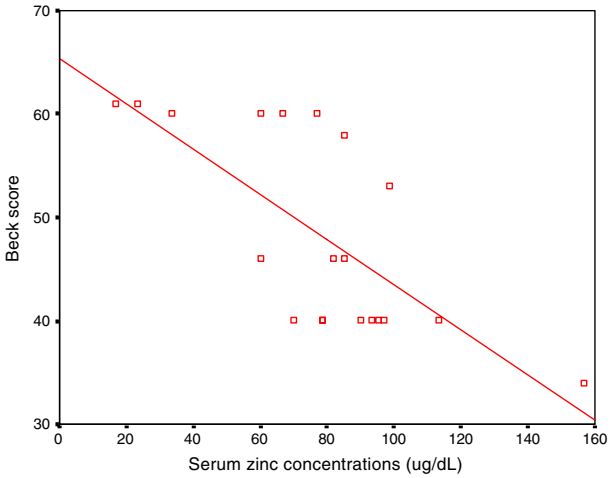

Fig. 4 Correlation between Beck scores and serum zinc concentrations (microgram per deciliter) in MDD subjects (r=−0.71; p<0.001)

Zinc supplementation in depressed people is one of the critical suggestions remained to be more clarified. Previously, Nowak and his colleagues [25] had shown that their study on unipolar depressed subjects is the first demonstration of the benefit of zinc supplementation in antidepressant therapy, and in a newer review, Levenson has introduced zinc as a new antidepressant [26]. In another study, Sowa-Kućma et al. evaluated the antidepressant activity of zinc in a chronic mild stress (CMS) model of depression and the effect of zinc treatment on BDNF protein and the messenger RNA level. In CMS, zinc hydroaspartate (10 mg/kg) exhibited a rapid (after 1 week of treatment) antidepressant-like effect [27].

Although more researches are needed to clarify the role of nutrition in the pathophysiology of MDD among young women, clearing the potential for dietary modification to improve mental health is compelled. Moreover, assessment of antioxidants, selenium, and iron status along with zinc is suggested because these nutrients have received less attention in the literature but hold substantial promise in modulating mood [28]. Confounders and effect modifiers of the nutrition–MDD relation, including socioeconomic

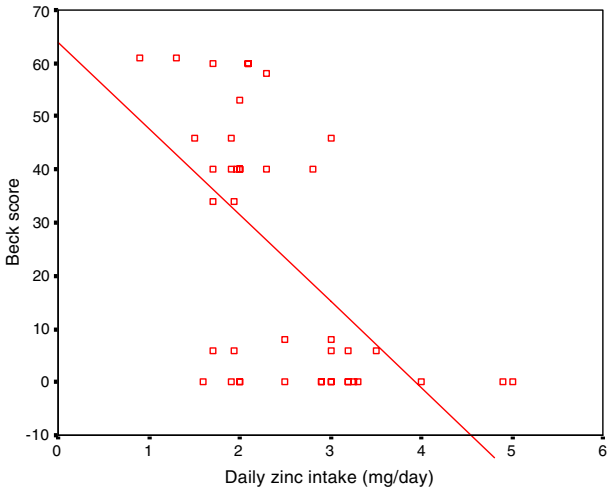

Fig. 5 Correlation between Beck scores and diatary zinc intakes (milligram per day) in all subjects studied (r=−0.58; p<0.001)

status, race/ethnicity, parity, body mass index, access to health care, physical activity, and dietary supplement use, should be measured and addressed in the analysis.

Nutrition interventions are relatively inexpensive, easy to administer, and generally acceptable to patients. Indeed, nutritional modification may benefit psychiatric conditions and countless aspects of human well-being, as well as have the potential for tremendous public health/nutrition impact.

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