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Zinc, copper, magnesium and glycated haemoglobin levels in obese individual in Nnewi, Anambra State, Nigeria

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Obesity is a major risk factor for a plethora of severe diseases associated with micronutrient metabolism. Zinc, copper and magnesium serve variety of catalytic, structural and regulatory functions in the body. Their bioavailability may be disturbed in obesity. It is important to understand the status of these elements in obesity to appreciate their roles in the complications of obesity. Eighty-six obese individuals and fifty control subjects were studied. Ethical Clearance and informed consent were obtained prior to sample collection. 5ml of fasting venous sample were collected and 3ml dispensed into plain bottle while the remaining 2ml were dispensed into lithium heparin container for glycated haemoglobin (HbA1c) estimation. The clotted sample was spun and the serum harvested for the assay of the trace elements. HbA1c was estimated using the method of Karunamnayake and Chandrasekharan. Method of Mann and Yoe was used to estimate magnesium while copper and zinc were assayed using AAS. Mean level of zinc of controls was higher than those of obese individuals, ($p = 0.017$). Mean level in Class 111 obesity was yet lower than in Class 1 but not in Class 11 obesity ($p = 0.05$). Copper showed steady non-significant decrease in value with increase in BMI. Magnesium decreased among groups ($p = 0.043$) with increase in BMI. Similarly HbA1c concentration increased steadily with increase in BMI ($p = 0.019$). Deficiencies of zinc, copper, magnesium have been observed in obese individuals suggesting the need to measure trace elements concentrations to forestall the development of deficiency states and related health complications.

Keywords: Copper, zinc, magnesium, glycated haemoglobin, obesity

INTRODUCTION

Obesity is defined as a medical condition in which excess of body fat has accumulated to the extent that it may have an adverse effect on health, leading to reduced life expectancy and/or increased health problems (WHO, 2000). It is a risk factor for type 2 diabetes, hypertension, dyslipidaemia, dysglycaemia, insulin resistance and coronary artery disease (Abidoye et al., 2003; Soodini and Hamd, 2004). The body mass index is the usual anthropometric index for the assessment of obesity and has been found to have a high correlation with body fat (Calle and Kaaks, 2004; Siminnialayi et al., 2008). Obesity may also be associated with abnormal micronutrient metabolism,(Dermerdash, 2015).

The trace elements, zinc, copper and magnesium serve a wide range of catalytic, structural and regulatory functions in the body. These elements interact with macromolecules such as enzymes, pre-hormones, pre-secretory granules and biological membranes, (Rockwood and Bakowska, 2010)

The bioavailability of these trace elements may be disturbed in obesity since they are involved in the production of or in the protection against inflammation and

Table 1. Showing the mean (±SD) values of copper (Cu), magnesium (Mg), zinc(Zn) and glycated haemoglobin (GHb) of control and obese subjects.

	No	Cu	Mg	ZN	GHb
Control	**50**	**108.00(30.40)**	**0.88(0.07)**	**114.22(29.16)**	**7.21(0.50)**
Obese Class 1	55	101.97(23.59)	0.86(0.12) [a]	92.56(15.60) [a]	7.75(1.59)
Obese Class 11	22	101.82(21.97)	0.85(0.18) [a]	89.37(20.11)[a]	7.81(0.87) [b]
Obese Class 111	9	100.92(28.99)	0.77(0.09) [a,b,c]	85.29(18.77)[a,b]	7.82(2.09) [a,b,c]
F-value		1.226	2.073	5.478	4.696
p-value		0.123	0.043**	0.017**	0.019**

** Mean difference is significant at 0.05.
a = p<0.05 compared with control
b = p<0.05 compared with Obese Class 1
c = p<0.05 compared with Obese Class 11

peroxidation which are key factors in the development of the metabolic complications of obesity, hypertension, dyslipidaemia and insulin resistance/diabetes. Glycated haemoglobin reflects the plasma glucose concentration in the preceding 3 to 4 months of its estimation. The link between obesity glycemic status and trace elements may not be quite clear from the literatures. It is important to understand the status of these elements in obesity to help in the appreciation of their roles in the complications of obesity.

MATERIALS AND METHODS

This is a case-control study carried out in Nnewi North Local Government Area of Anambra State of Nigeria between March and July, 2016. 86 obese otherwise apparently healthy individuals (BMI ≥30) were recruited along with 50 apparently healthy non-obese individuals who served as control. Sample calculation was done using the formula of Naing et al. (2006).Their ages ranged from 30 to 52 years. The obese individuals were further grouped into Class 1 (50); Class 11 (42); Class 111 (39) according to BMI of 30 – 34.9; 35 – 39.9 and ≥ 40 kg/m^2 respectively (Seidell and Flegal, 1997). Fasting blood glucose was done to exclude individuals with unreported diabetes and blood pressure was measured to eliminate cases of hypertension.

Ethical clearance was obtained from the Ethic Committee of Faculty of Health Sciences, Nnamdi Azikiwe University and informed written consent was obtained prior to sample collection. The Institutional Ethical Clearance acknowledge number was FHST/EC/0116/2016.

Five milliliters of fasting venous sample were collected using standard procedure (Dacie and Lewis, 1975) and 3 ml dispensed into plain bottle while the remaining 2 ml were dispensed into lithium heparin container for glycated haemoglobin estimation. The clotted sample was spun at 5000 rpm for 5 minutes and the serum harvested for the assay of the trace elements.

Glycated haemoglobin was estimated using the colorimetric method of Karunamnayake and Chandrasekharan (1985). The method described by Mann and Yoe (1957) was used to estimate magnesium while copper and zinc were assayed using Atomic Absorption Spectrophotometer. The relationship between BMI and concentration of elements was detected by linear correlation and a p ≤ 0.05 was considered statistically significant. Statistical analyses were done by 't' for test and control and one-way ANOVA for comparing data of the different classes of obesity using SPSS version 20.

RESULTS

The mean level of serum zinc of the control was higher than those of the obese individuals, (p = 0.017). Zinc mean level in Class 111 obesity was lower than in Class 1 but not Class 11 obesity (p = 0.05). Serum copper showed no significant differences either with the control or class of obesity among the participants instead there was a steady decrease in values with increase in BMI. Serum magnesium differed among the groups (p = 0.043) decreasing steadily with increase in BMI. In Class 111 obesity serum magnesium was significantly lower than in the other classes, (p = 0.05). Conversely glycated haemoglobin concentration increased steadily with increase in BMI (p = 0.019) and highest values were recorded in obesity Class 111, (Table 1).

Serum concentration of the trace elements decreased with increase in BMI but only those of zinc and magnesium are significant (p = 0.017; 0. 029). Glycated haemoglobin increased with BMI also p = 0.019.

DISCUSSIONS

There were decreases in the mean values of zinc, copper magnesium and increase in glycated haemoglobin with increase in BMI. However, the change in the mean value of magnesium was not statistically significant.

Obesity has been identified as a medical diagnosis worth great attention. Obesity may be associated with abnormal metabolism, respiratory deficiencies and worse still not easy to diagnose micronutrient deficiencies. Obesity is often accompanied by an increased risk of sudden death, post surgery and complications, the process of administering anethesia intraoperatively. In the case of non-fatal health problems, the quality of life is impaired because of associated conditions, including sleep apnoea, respiratory problems, infertility etc,(Soodini and Hamd, 2004; Calle and Kaaks, 2004). Its prevalence is said to be increasing globally, Abelson and Kennedy 2004) making it a world-wide public health challenge.

In obese individuals, antioxidant defenses are said to be lower than in normal weight counterpart, (Isabella et al., 2013). Resulting oxidative stress leads to insulin resistance within the adipose tissue as well as within the peripheral tissues and it is one of the hallmark of obesity and accounts for many of its comorbidities, (Hurrle and Hsu, 2017). The physiological production of reactive oxygen species, (ROS), is regulated by defense systems consisting of antioxidant enzymes, small molecules and proteins which hold the transition metals in an inactive state for the formation of ROS. Some trace elements such as copper, zinc are essential for the activity of antioxidant enzymes, (Leung, 1998). These elements play regulatory, immunologic and anti-oxidant roles in their interaction with molecules.

Zinc was observed to be lower in the obese than the control and the reduction increases with the increase in BMI. It is an important element in DNA synthesis, gene expression and activity of various enzymes and maintenance of normal growth. It plays a critical role in integrity of the immune system and wound healing. It is also found to enhance synthesis, storage and release of insulin. Zinc deficiency has been reported in obese subjects, (Chen et al., 1997; Marreiro et al., 2002).Some studies have suggested that it may be due to its accumulation in the adipose tissues or due to increased production of adipokines, and leptins. The increased expression of adipokines and leptins results in the accumulation of trace elements – zinc and copper- in the hepatocytes and adipose tissue hence their decreased serum concentration. Zinc concentration has been observed to be directly associated with serum leptin concentration, an adipokine associated with satiety, (Baltaci and _Mogulkoc, 2017). Decreased serum zinc concentration in obese subjects may dispose to insulin resistance, glucose intolerance, diabetes mellitus and coronary artery disease, (Kazi et al., 2008).

In this study, there is a non-significant but obvious decrease in serum copper with increase in BMI. However, copper levels were reported to be significantly higher in obese patients compared to normal body weight controls by some authors. Some authors reported a negative correlation between serum copper and high-density lipoprotein (HDL)-cholesterol, (Hayour-Mobarhan, 2005). It has been reported that factors like geographical location, climate, occupation, dietary habits can influence the plasma levels of these elements, (Skalny and Skalnaya, 1999; Günther, 2010). This may account for the discrepancy between our results here as regards copper and reported cases.

Low and high levels of magnesium have been documented in ill patients, (Whang and Ryder, 1990) as a result of which, magnesium has occasionally been called the "forgotten cation." (Konrad (2008); Martin et al., 2009).Magnesium is essential for absorption and utilization of nutrients; carbohydrates, fats and proteins. It is a critical cofactor for hundreds of enzymes especially those involved in glucose metabolism and a direct antagonist of intracellular calcium. Moreover, it is associated with insulin sensitivity. As hypomagnesaemia results in reduced insulin sensitivity, reduced β-cells proliferation and thus affecting insulin production. The exact mechanism of hypomagnesaemia in obese patients is unclear but may be related to eating habits; as increased intake of carbonated soft drinks, which are rich in phosphorous and thereby interfere with magnesium absorption, or increased intake of caffeine results in increased magnesium excretion. Another mechanism may be increased intake of dairy products with high Ca++ content and or fat content thus interfere with its absorption, (Agus, 1999)

The elevation in the mean values of HbA1c with increase in BMI is due to the worsening insulin resistance occasioned by visceral fat accumulation and decrease in the concentration of the trace elements that have roles in insulin metabolism.

Conclusion

There is a decrease in the plasma concentrations of zinc, copper and magnesium and increase in glycated haemoglobin in obesity and overweight. There is also evidence of insulin resistance which can predispose to the development of metabolic syndrome. Obese individuals may need supplemental intake of these elements to stay healthy.

Author Disclosure Statement

The authors declared no competing financial interests exist.

Authors' contributions

ISIO, EVN and OJE designed the study and ISIO drafted the manuscript. BNE, OCC, participated in the sample collection and analysis; ONJ and UC reviewed the manuscript. All authors read and approved the final version of the manuscript.

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