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Original Article:

A Comparative Study of Plasma Trace Elements (Copper, Iron and Zinc) Status in Anaemic and Non-anaemic Pregnant Women in Abakaliki, Nigeria

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Abstract: For a comparative study of plasma copper, iron and zinc between anaemic and non-anaemic pregnant women, data for anaemic (n = 223) and non-anaemic (n = 126) pregnant women drawn from a cohort of 351 pregnant Nigerians recruited at gestational age of ≤ 25 weeks for the study of impacts of trace element status on pregnancy outcomes were analysed. With the exception of plasma copper which was significantly ($p < 0.05$) higher in anaemic women in comparison to the non-anaemic women (10.11 ± 10.15 vs. 8.68 ± 7.92 µmol/l), plasma iron and zinc were lower ($p > 0.05$) in the former. While plasma copper, iron and zinc concentration were not correlated with maternal haemoglobin concentration, plasma zinc significantly correlated negatively ($r = -0.141$, $p < 0.05$) with plasma copper. It is thus concluded that anaemia in pregnant women in this population may partly be due to a combination of trace element deficiencies and their interactions with each other. While interventions should go beyond improving intakes, more research is desired to clearly define these interactions.

Key Words: Anaemia; Pregnancy; Copper; Iron; Zinc; Abakaliki; Nigeria

Introduction:

Anaemia has been recognised as one of the leading health challenges of the developing countries with alarming prevalence in Asia and sub-Saharan Africa (1-3) and a leading cause of pregnancy related complications, not only for the mother, but also for their foetus.(4-6) In developing countries, maternal anaemia during pregnancy is a product of many factors, such as maternal malaria, intestinal parasitic infection, recurrent infection, reduced dietary intakes, and micronutrient deficiencies just to name but few.(7) Data relating haemoglobin concentrations and plasma micronutrients levels, particularly trace elements have been conflicting and inconclusive. For instance, zinc and copper deficiencies have been associated with anaemia or iron deficiency with adverse effects on foetus and pregnant women during pregnancy.(8) Also zinc status to some extent has been found to account for haematological abnormalities in middle-aged and pregnant Japanese women.(9,10) However, while Abdelrahim et al.(11) reported that haemoglobin levels significantly correlated positively with zinc and copper levels, Ma and colleagues (8) documented an inverse correlation between copper and haemoglobin, especially among anaemic pregnant women.(8) Additionally, Bushra et al (12) reported that maternal age, parity, gestational age, ferritin, zinc and copper were not predictors for anaemia. Elemental interactions among trace elements such as copper, zinc, iron and magnesium has also been suggested to contribute to variations in the plasma levels of these trace elements (13) and contribute to anaemia. Regrettably however, most supplemental programmes in developing countries mainly focus on iron supplementation.(14) In the present study the plasma levels of copper, iron and zinc were evaluated in anaemic and non-anaemic pregnant women in a bid to ascertain the impact of maternal anaemia on these trace elements. The possible interactions between these trace elements were also assessed.

Materials and Methods:

The study was carried out among pregnant women attending antenatal clinic of the Department of Obstetrics and Gynaecology of the Federal Medical Centre, Abakaliki, one of the referral tertiary health institutions in the South Eastern part of Nigeria. The protocol for this study was approved by the Ethics and Research Committee of the Federal Medical Centre, Abakaliki. Three hundred and fifty-one (351) women, aged 15-40 years (Gestational age ≤ 25 weeks), who gave their consent to participate in the study, were recruited between July 2007 and September 2008. Subjects' selection and detailed methodology has been previously described.(15) Plasma copper and zinc were determined by Atomic Absorption Spectrophotometer (Bulk Scientific, model AVG 210), haemoglobin concentration was determined by Cyanmethaemoglobin method and total white blood cell counts (TWBC) were determined as in a standard haematology textbook.(16) Data for anaemic (n = 223) and non-anaemic (n = 126) pregnant women were analysed using Statistical Package for Social Sciences (SPSS version 7.5).

Data Analysis: Data were analysed for proportions, mean and standard deviation while comparison between subjects and controls were analysed using Student's t-test with statistical significance set at $p < 0.05$.

Results:

Table 1 shows maternal characteristics. Both the anaemic and non-anaemic pregnant women were of comparable age, body mass index and gestational age. However, while anaemic subjects had significantly ($p < 0.05$) higher parity and total white blood cell count than their non-anaemic counterparts, the latter had statistically significant ($p < 0.05$) higher haemoglobin concentration and attended more Antenatal Clinic.

Table 1: Comparison of Maternal Characteristics between Anaemic and Non-anaemic Pregnant Women[1]

Parameters	Non-anaemic (n=126)	Anaemic (n=223)	p-values
Age (yrs)	27.75 ± 4.56	26.67 ± 4.81	0.075
BMI (Kg/m^2)	28.19 ± 4.54	26.79 ± 4.06	0.290
Gestational age (wks)	21.83 ± 3.29	21.75 ± 3.00	0.160
Parity (n)	1.17 ± 1.36	1.55 ± 1.5	0.004*
Number of ANC attendance	7.51 ± 2.82	6.71 ± 2.29	0.002*
HBC (g/dl)	11.54 ± 0.51	9.46 ± 0.87	0.000*
TWBC (x 10^9/l)	5.15 ± 1.21	5.88 ± 1.50	0.001*

BMI: Body Mass Index; **ANC:** Antenatal Clinic; **TWBC:** Total White Blood Cell.
[1] Values are expressed as mean ± standard deviation
* p-values statistically significant ($p < 0.05$).

From Table 2, although there appeared to be higher prevalence of trace element deficiencies in anaemic women when compared to non-anaemic women, the differences were not statistically significant ($p > 0.05$).

Table 2: Comparison of Prevalence of Trace Element Deficiencies between Anaemic and Non-anaemic Pregnant Women[1]

Parameters	Non-anaemic (n = 126)	Anaemic (n = 223)	p-values
Copper	69 (54.8)	134 (60.10)	0.332
Iron	79 (62.7)	143 (64.1)	0.790
Zinc	50 (39.7)	110 (49.3)	0.082
Copper & Iron	46 (36.5)	82 (36.8)	0.961
Copper & Zinc	23 (18.3)	60 (26.9)	0.068
Iron and Zinc	33 (26.2)	65 (29.1)	0.620
Copper, Iron and Zinc	16 (12.7)	33 (14.8)	0.588

[1] Percentages in parenthesis

Except for plasma copper which was significantly ($p < 0.05$) higher in anaemic women in comparison to the non-anaemic women (10.11 ± 10.15 vs. 8.68 ± 7.92 µmol/l), plasma iron and zinc were lower ($p > 0.05$) in the anaemic women, although the values were within the reference ranges (Table 3). Pearson correlation analysis showed that plasma copper, iron and zinc concentration were not correlated with maternal haemoglobin concentration. However, plasma zinc significantly correlated negatively ($r = -0.141$, $p < 0.05$) with plasma copper.

Table 3: Comparison of Plasma Trace Elements (Copper, Iron and Zinc) Levels between Anaemic and Non-anaemic Pregnant Women[1]

Parameters	Non-anaemic (n = 126)	Anaemic (n = 223)	p-values
Copper (µmol/l)	8.68 ± 7.92	10.11 ± 10.15	0.004*
Iron (µmol/l)	10.36 ± 7.65	10.18 ± 7.72	0.567
Zinc (µmol/l)	9.74 ± 8.59	8.81 ± 9.48	0.941

[1] Values are expressed as mean ± standard deviation
* p-values statistically significant ($p < 0.05$).

Discussion:

Data from the present study show that deficiencies of copper, iron and zinc were prevalent and appeared to be higher ($p > 0.05$) in anaemic than non-anaemic women, with lower plasma levels of the elements in the former, except for copper which was significantly ($p < 0.05$) higher. Also, although a significant inverse relationship ($r = -0.141$, $p = 0.008$) was found between plasma copper and zinc, plasma levels of copper, iron and zinc were not related to maternal anaemia. The higher prevalence (although not significant) of copper, iron and zinc deficiencies in anaemic pregnant women when compared to their non-anaemic counterparts in the present study highlight the importance of these elements in erythropoiesis. Again, the lower plasma levels of iron and zinc in anaemic pregnant women when compared to their non-anaemic counterparts in the present study are in corroboration with earlier studies (8), thus reaffirming the roles of these elements in haemoglobin synthesis. Widespread prevalence of micronutrient deficiencies have been associated with several factor, including low dietary intake, low bioavailabity as in the case of copper, iron and zinc, poor utilisation due to environmental factors such as poor hygiene that lead to increased infections and infestations, adverse nutrient-nutrient interactions (17) and genetic causes. (18) High prevalence of copper, iron and zinc deficiencies has been previously reported in this population.(19) It could therefore be inferred that deficiencies of these elements probably may have contributed in part to anaemia of pregnancy in this population. Significantly higher plasma copper in anaemic pregnant women in the present study however contrasts lower serum copper reported by Bushra et al(12) among anaemic pregnant women in Central Sudan. Although the reason for increased plasma copper concentration in the presence of lower plasma iron and zinc in anaemic women is obscure, inter-element interactions have been documented among divalent cations, leading to changes in plasma concentrations of the elements.(13) Interactions between trace elements are evidenced by the inverse correlation between plasma copper and zinc in the present study. Interactions between trace elements have long been recognised.(20,21) For instance, an intriguing interactions appear to exist between copper, zinc and iron in absorption and utilisation. On one hand, supplementation of iron has been reported to affect bioavailability of zinc and copper in iron deficiency anaemia by inter-element competition in the bowel, while on the other hand, bioavailability of copper and iron are affected by zinc supplementation which is reflected in their blood levels.(17) The secondary effects of iron deficiency on copper metabolism have been confirmed in several studies. For instance, it has been established that iron deficiency results in increased copper levels in the liver(22,23), while severe copper deficiency causes changes in iron metabolism, leading to anaemia and accumulation of iron in the liver.(24) Also intraluminal and intracellular interactions have been suggested to occur between iron and zinc.(25,26) Three possible mechanisms have been proposed for iron-zinc interactions.(27) These include: (1). Displacement of one another on the molecule responsible for their uptake from the lumen into the enterocytes.(2) Competition between the two elements for pathways through the mucosal cell into the systemic circulation or (3) Interactions between the two elements with a third substance to form an insoluble complex that may impair the absorption of both. The lack of correlation between plasma trace elements and maternal haemoglobin recorded in this study is in corroboration with the findings of Bushra et al (12), but contrasts the significant positive correlation between haemoglobin and zinc levels reported among adolescent schoolgirls in Eastern Sudan.(11) The difference in the two finding may be partly attributed to patients' selection. While the present study was done on pregnant women, theirs was on non-pregnant adolescent schoolgirls. The present findings of significantly higher parity

in anaemic pregnant women also contrast earlier report of lack of effect of parity on maternal anaemia among pregnant women in Central Sudan.(12) However, it has been shown that multiparous women are more prone to nutritional deficiencies and by extension to anaemia as a result of maternal depletion syndrome.(28) Evidence suggests that anaemia in pregnant women in this population may not only be due to trace elements deficiencies, but also as a result elemental interactions. Thus, in addition to improving dietary intakes, further studies are needed to clarify these interactive forces.

References:

1. Mason JB, Lotfi M, Dalmiya N, Sethuraman K, Deitchler M, Geibel S, Gillenwater K, Gilman A, Mason K, Mock N. The micronutrient report: current progress in the control of vitamin A, iodine and iron deficiencies. Ottawa Micronutrient Initiative/International Development Research Center. 2001(Available at: http://www.micronutrient.org/frame_HTML/resource_text/publications/mn_report.pdf. (Accessed on 20/10/2007).
2. Janghorban R, Ziaei S, Faghihzade S. Evaluation of serum copper level in pregnant women with high haemoglobin. *Iran J Med Sci* 2006;31(3):170-172.
3. World Health Organisation. The prevalence of anaemia in women: a tabulation of available information. WHO. Geneva. 1992
4. Allen LH. Anaemia and iron deficiency: effects on pregnancy outcome. *American Journal of Clinical Nutrition* 2000;71(Suppl.):1280S-1284S.
5. Scanlon KS, Yip R, Schieve LA, Cogswell ME. High and low *cience haemoglobin* during pregnancy: differential risks for preterm birth and small for gestational age. *Obstetrics and Gynaecology* 2000;96(5 pt1):741-748.
6. World Health Organisation. (2002). Turning the tide of malnutrition, responding to the challenge of the 21st century, WHO, Geneva.
7. Verhoeff FH, Brabin BJ, Chimsuku L, Kazembe P, Broadhead R. An analysis of the determinant s of anaemia in pregnant women in rural Malawi-a basis for action. *Annals of Tropical Medicine and Parasitology* 1999;93:119-133.
8. Ma AG, Chen XC, Xu RX, Zheng MC, Wang Y, Li JS. Comparison of serum levels of iron, zinc and copper in anaemic and non-anaemic pregnant women in China. *Asia Pacific J Clin Nutr* 2004;13(4):348-352.
9. Nishiyama S, Irisa K, Matsubasa T, Higashi A, Matsuda I. Zinc status relates to haematological deficits in middle-aged women. *Journal of the American College of Nutrition* 1998;7(3):291-295.
10. Nishiyama S, Kiwaki K, Miyazaki Y, Hasuda T. *Journal of the American College of Nutrition* 1999;18(3):261-267.
11. Abdelrahim II, Mahgoub HM, Mohamed AA, Ali NI, Elbashir MI, Adam I. Anaemia, folate, zinc and copper deficiencies among adolescent schoolgirls in Eastern Sudan. *Biol Trace Elem Res* 2009 Dec;132(1-3):60-66.
12. Bushra M, Elhssan EM, Ali NI, Osman E, Bakheit KH, Adam II. Anaemia, zinc and copper deficiencies among pregnant women in Central Sudan. *Biol Trace Elem Res* 2010 Dec;137(3):255-61. Epub 2009 Dec 29.
13. Kathleen M. Sylvia ES. Food, nutrition and diet therapy, 11th ed. Saunders, USA, 2004. pp101-109.
14. Stephannsson O, Dickman PW, Johanson A, Cnattingiuss S. Maternal haemoglobin concentration during pregnancy and risk of stillbirth. *Journal of American Medical Association* 2000;284(20):2611-2617.
15. Ugwuja EI, Akubugwo EI, Ibiam UA, Obidoa O. Impact of Maternal Copper and Zinc Status on Pregnancy Outcomes in a Population of Pregnant Nigerians. *Pakistan Journal of Nutrition*. 2010;9(7):678-682.
16. Dacie JV, Lewis SM. Practical Haematology, 8th Ed. Churchill livingstone, Edinburg 1994. Pp 49-59.
17. Sandstorm B. Micronutrient interactions: effects on absorption and bioavailability. *British Journal of Nutrition* 2001;85 (2): S181-185.
18. Seshadri S. Nutritional anaemia in South Asia: In Malnutrition in South Asia-A regional Profile 1997;75:124.
19. Ugwuja EI, Akubugwo EI, Ibiam UA, Obidoa O, Ugwu NC. Plasma Copper and Zinc among Pregnant Women in Abakaliki, Southeastern Nigeria. *The Internet Journal of Nutrition and Wellness* 2010;10(1).
20. Danzeisen R, McArdle HJ. Identification & location of a placenta copper oxidase in a human choriocarcinoma cell line. *J Physiol London* 2000;523:172-175.
21. Fox PL. The copper-iron chronicles: the story of an intimate relationship. *Biometals* 2003;16:9-40.
22. Evans JL, Abraham PA. Anaemia, iron storage and ceruloplasmin in copper nutrition in the growing rat. *Journal of Nutrition* 1973;103:196-201.
23. Owen Jr., CA. Effects of iron on copper metabolism and copper on iron metabolism in rat. *American Journal of Physiology* 1973;224:514-518.
24. Auclair S, Feillet-Coudray C, Coudray C, Schneider S, Muchenthaler MU, Mazur A. Mild copper deficiency alters gene expression of proteins involved in iron metabolism. *Blood Cell and Molecular Disease* 2006;36:15-20.
25. Rossander-Hulten L, Brune M, Sanstrom B, Lonnerdal B, Hallberg L. Competitive inhibition of iron absorption by manganese and zinc in humans. *American Journal of Clinical Nutrition* 1991;54:152-156.
26. Solomons NW, Pineda O, Viteri F, Sandstead HH. Studies of the bioavailability of zinc in humans: mechanism of the intestinal interaction of nonheme iron and zinc. *Journal of Nutrition* 1983;113:337-349.
27. King JC. Determinants of maternal zinc status during pregnancy. *American Journal of Clinical Nutrition* 2000;71(Supp l):1334S-1343S.
28. King JC. The risk of maternal nutritional depletion and poor outcomes increases in early or closely spaced pregnancies. *Journal of Nutrition* 2003;133:1732S-1736S. Available at http://jn.nutrition.org/content/133/5/1732S.-full