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Plasma Antioxidant Vitamins Are Not Related to Body Mass Index but Socio-demographic Factors among Apparently Healthy Nigerians Resident in Abakaliki, Ebonyi State

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ABSTRACT

Introduction: Existing literature suggests that oxidative stress may be an important underlying denominator for obesity development and its co-morbidities. The beneficial role of antioxidants in the prevention of oxidative stress and development of diseases is well known. The present study explored the associations between antioxidant vitamins and body mass index (BMI) with other health-related factors in apparently healthy Nigerians. **Methods:** In this cross-sectional study, 443 apparently healthy adults aged 18-83 years (mean 38.4±13.7 years) were recruited. A structured questionnaire was used to collect the socio-demographic data of the participants while weight (kg) and height (m) were determined using standard procedures. Participants were categorised as underweight (n=18), normal weight (n=259), overweight (n=124) and obese (n=42) in accordance with WHO BMI classification. Blood samples were collected for determination of antioxidant vitamins A, C and E using HPLC. **Results:** The prevalence of obesity in our study population was 9.5%. Obesity and overweight were found to be more prevalent among the artisans and individuals with secondary education. Vitamins A, C and E levels were not significantly different ($p>0.05$) among the BMI groups. **Conclusion:** Our results demonstrate a non-significant relationship between plasma antioxidant vitamins and BMI in apparently healthy Nigerians in Abakaliki. However, our study suggests that secondary education and the middle age group (31-40 years) may be associated with overweight and obesity.

Keywords: Antioxidant vitamins, body mass index, obesity, overweight, socio-demographic factors, underweight

INTRODUCTION

Overweight and obesity are emerging global epidemics affecting both adults and children, and is associated with significant morbidity and mortality (Crowley, 2008). Obesity rates have doubled worldwide

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since 1980, and obesity-related diseases are regarded as the fifth leading risk factor for global deaths (Garland, 2014). More than 10% of the world's adult population is obese, as determined by body mass index (BMI) ≥ 30kg/m^2 (Wali, Thomas & Sutherland, 2014). While it is suggested that up to 20% of the population in Western countries are obese with 50% classified as overweight (Crowley, 2008), the prevalence of obesity in the US is 34%, and this is projected to increase to 42% by 2030 (Wali *et al.,* 2014). In Canada, obesity rates have risen steadily during the last decades, and in 2011, 25.3% of the Canadian population identified themselves as obese (Gotay *et al.*, 2012). This disorder is one of Nigeria's major health problems with a current prevalence range of 4.2% to 49% across the geographical regions (Okafor *et al.,* 2014a), and the rising potential for obesity has been observed among the urban adults and preschool children (Adebayo *et al.,* 2014).

Obesity, expressed as high BMI, is a phenotypic expression of human adiposity (Heymsfield *et al.,* 2009), and is widely used in clinical measurement for public health-related purposes. It is a metabolic expression of a chronic imbalance between energy intake and energy expenditure. It is particularly associated with increased adiposity, body weight and multiple health problems that range from osteoarthritis and sleep apnoea, to cardio-metabolic perturbations (Crowley, 2008). These conditions may result in type 2 diabetes, hyperlipidemia, hypertension and an overall increase in cardiovascular risk with decreased quality of life and life expectancy (Crowley, 2008). According to the US statistics, more than 80% of individuals with type 2 diabetes are obese or overweight (NDI, 2005). Obesity is increasingly being recognised as a risk factor for certain cancers, including breast, colon, prostate, endometrial and cervical cancers (WHO, 2000; Crowley, 2008).

Although studies point to the mechanism of leptin resistance for increased weight gain (Townsend, Lorenzi & Widmaier, 2008; Houseknecht & Baile, 1998), increased intake of processed food, reduction of complex carbohydrate content, poor physical activity, sedentary lifestyle, improved socio-economic status, and the infiltration of a 'western diet laden with saturated fats and refined sugars' contribute to the explosive increase in obesity prevalence in many countries (Monteiro, Conde & Popkin, 2007; Ijezie *et al*, 2013; Mahan & Escott-Stump, 1996). No system in the human body is spared by obesity and the body burden of adiposity changes various metabolic pathways to generate injury-inducing reactive oxygen species (ROS) (Razquin *et al.*, 2009; Savini *et al.*, 2013). The association of socio-demographic and behavioural factors with weight gain is an important source of ROS (Wolfe *et al.*, 1997).

Numerous studies have found elevated oxidative stress biomarkers in obesity (Razquin *et al,* 2009) and suggest that ROS-mediating oxidative stress may be the linking mechanism underlying the development of co-morbidities in obesity (Vincent & Taylor, 2006). Disequilibrium between generated free radicals and bio-available antioxidants leads to oxidative stress, a denominator implicated in diverse pathologic states including diabetes mellitus, hypertension, cancer and cardiovascular diseases. The obesity-induced ROS damages DNA, carbohydrates, and proteins, promotes lipid oxidation, and stimulates inflammatory cascades and compromises cell function (Vincent & Taylor, 2006). Evidence suggests an inverse relationship between plasma antioxidant vitamin carotenoids and vitamin E, and cardiovascular diseases (Reitman *et al*, 2002). Some studies have shown that there is enhanced oxidative stress and low concentrations of plasma antioxidant vitamins in obese boys (Desci, Molnar & Koletzko 1997), obese girls and in adult patients with obesity (Reitman *et al*, 2002). Although a limited number of studies have assessed a link between socio-demographic factos, BMI and plasma antioxidant levels, recent reports suggest a beneficial role for a change in dietary pattern in the reduction of body weight and an increase in antioxidant capacity (Razquin *et al*, 2009; Jarvinen *et al*, 1994). In this regard, the current suggestion is that the beneficial role may be related to inhibition of oxidative stress and/or increased free radical scavenging capacity. However, a study conducted by Ijezie *et al* (2013) in Nigeria revealed that high income among the adults and tertiary education level were associated with the rising prevalence of obesity.

The emerging link between oxidative stress and obesity suggest that antioxidant vitamin level may be involved in obesity development and its co-morbidities. We therefore aimed to assess the associations that may exist between plasma antioxidant vitamins, socio-demographic factors and BMI in apparently healthy Nigerian.

METHODS

Ethical approval

The Ethics and Research Committee of the Federal Teaching Hospital, Abakaliki approved the study protocol. The study was conducted in accordance with the Declaration of Helsinki (World Medical Association Declaration of Helsinki, 2000). Participation in the study was voluntary and written informed consent was obtained from each participant.

Study population

The study area and recruitment of participants had previously been described (Ugwuja *et al.,* 2015). Briefly, 443 apparently healthy Nigerians who were permanent residents in Ebonyi State in South-east Nigeria, were investigated. Pregnant women and those with chronic diseases such as hypertension, diabetes, malignancies and other underlying illnesses were excluded from the study. Those who refused to give consent were equally excluded. None of the participants were taking vitamins or food supplements, nor was anyone on weight-adjustment diet at the time of this study.

Socio-demographic and anthropometric data

A set of structured questionnaires was used to obtain socio-demographic data of the participants, including age, education level and occupation. Thereafter, a standiometer (RGZ 160 by Pyrochy Medical, UK) was used to measure the height (cm) while the body weight (kg) was measured using a Seca scale with precision set at 0.1kg, and the BMI (weight divided by the square of the height in metres) was calculated for each participant. The WHO BMI classification (WHO, 1995) was used to categorise the participants into underweight (BMI< 18.5 Kg/m^2; n=18), normal weight (BMI: 18.5-24.9Kg/m^2, n=259); overweight (BMI: 25-29.9kg/m^2, n=124) and obesity (BMI: ≥30kg/m^2, n=42).

Blood collection and analyses

Seven millilitres (7.0 ml) of fasting venous blood samples were collected at recruitment, during 08.00 -10.00 hours, and were dispensed into heparinised bottles. The blood samples were conveyed in an ice pack to the Chemical Pathology Laboratory of Ebonyi State University, Abakaliki for separation. Plasma was separated and kept at -20^{o}C until analysed. Antioxidant vitamins, and vitamins A, C and E were determined by High Performance Liquid Chromatography.

Statistical analysis

SPSS 20.0 for windows (SPSS Japan, Tokyo, Japan) was used for statistical analysis. The differences between groups were compared using one-way analysis of variance (ANOVA). Data were expressed as average ± standard deviation. The statistical significance was set at p value ≤ 0.05.

RESULTS

A total of 443 participants (119 males and 324 non-pregnant females) took part in the study. All participants were adults (age range 18-83 years) with mean age of 38.4±13.7 years. The distribution of subjects' BMI according to age, occupation and education level are presented in Table 1.

The prevalence of overweight and obesity was 28.0% and 9.5%, respectively. Underweight was found to be higher in the elderly in comparison to younger age groups. However, underweight was not observed in the age group 31-40 years. For overweight, age groups < 30 years and 31-40 years had the highest prevalence in comparison to older age groups. Similarly, significantly higher percentages of obese individuals were found in the same age groups.

Significantly higher (p<0.05) prevalence of overweight and obesity were observed in individuals whose occupations were farming and artisan, respectively, in comparison to housewives/retirees and civil servants. Meanwhile, house -wives/ retirees had the least prevalence of overweight (7.3%) and obesity (9.5%), respectively (Table 1).

Educational level was found to have significant impacts on the BMI. Individuals without formal education and/or with primary education had the highest prevalence of underweight and least prevalence of obesity. However, overweight and obesity were found to be more prevalent among individuals with secondary education while the least prevalence of overweight and obesity was recorded in individuals with tertiary education (Table 1).

Table 2 shows the comparison of antioxidant vitamins among the BMI groups. The antioxidant vitamins (vitamins A, C and E) were non-significantly higher (p>0.05) in overweight and obese groups than in normal weight group.

Table 1. Distribution of subjects' BMI according to age groups, occupation and education level[a]

	Body Mass Index Category			
	Underweight	*Normal*	*Overweight*	*Obese*
Age group				
<30	5 (27.8)[a]	98(37.8)[a]	37 (29.8)[a]	11 (26.2)[a]
31-40	0 (0.0)[b]	66 (25.5)[b]	41 (33.1)[a]	20 (47.6)[b]
41-50	2 (11.1)[c]	46 (17.8)[c]	19 (15.3)[b]	5 (11.9)[c]
>50	11 (61.1)[d]	49(18.9)[c]	27 (21.8)[b]	6 (14.3)[c]
Total	18 (4.1)	259 (58.5)	124 (28.0)	42 (9.5)
Occupation				
Hw/R	2 (11.1[a])	22 (8.5)[a]	9 (7.3)[a]	4 (9.5)[a]
C/S	3 (16.7)[a]	53 (20.5)[b]	14 (11.3)[a]	8 (19.1)[b]
Artisan	3 (16.7)[a]	64 (24.7)[b]	41 (33.1)[b]	20 (47.6)[c]
Farming	10 (55.6)[b]	120(46.3)[c]	60 (48.4)[c]	10 (23.8)[b]
Total	18 (4.1)	259 (58.5)	124 (28.0)	42 (9.5)
Educational level				
None	8 (44.4)[a]	47 (18.2)[a]	26 (21.0)[a]	4 (9.5)[a]
Primary	6 (33.3)[b]	102 (39.4)[b]	41 (33.1)[b]	10 (23.8)[b]
Secondary	3 (16.7)[c]	84 (32.4)[b]	47 (37.9)[b]	24 (57.2)[c]
Tertiary	1 (5.6)[d]	26 (10.0)[c]	10 (8.0)[c]	4 (9.5)[a]
Total	18 (4.1)	259 (58.5)	124 (28.0)	42 (9.5)

[a] percentage in parenthesis. Values with different superscripts along the row were statistically significant (p<0.05). Hw/R: House wife/Retiree, C/S: Civil servant

Table 2. Comparison of antioxidant vitamins among the body mass index groups

Parameters	*Body Mass Index (BMI)*			
	Underweight (n=18)	*Normal weight (n=259)*	*Overweight (n=124)*	*Obese (n=42)*
BMI (Kg/m2)	17.3±0.7	22.2 ±1.7	29.1±1.4	33.5±3.7
Vitamin A (mg/dl)	66.1±11.7	66.4±18.2	68.7±14.7	69.1±21.2
Vitamin E (mg/dl)	1.51±0.27	1.54±0.45	1.57±0.36	1.59±0.49
Vitamin C (mg/dl)	0.84±0.15	0.85±0.24	0.88±0.19	0.88±0.28

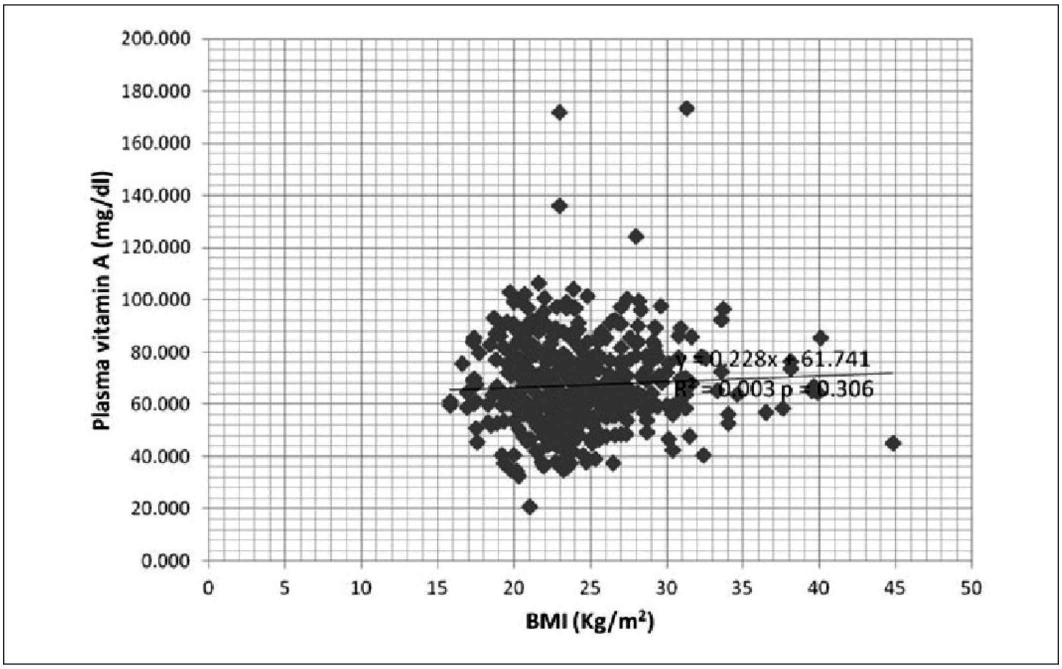

Figure 1. Scatter plots of plasma vitamin A against BMI (Kg/m2)

Figures 1-3 shows the scatter plots of plasma antioxidant vitamins against body mass index. There was no significant relationship between BMI and plasma levels of the vitamins.

DISCUSSION

The emergence of nutrition transition and change in socio-demographic status, indicated by dietary changes, increased education, high incomes and increasing ageing population, have contributed to increased diet-related chronic degenerative diseases (Crowley, 2008). Chronic disease risk factors, including obesity, are the adverse health effects of high calorie food intake with sedentary lifestyle and physical inactivity, leading to excess weight gain and development of obesity.

The prevalence of overweight and obesity in this study was 28.0% and 9.5%, respectively. It is lower than the prevalence rates of overweight and obesity of 32.7% and 22.2% in an urban community in

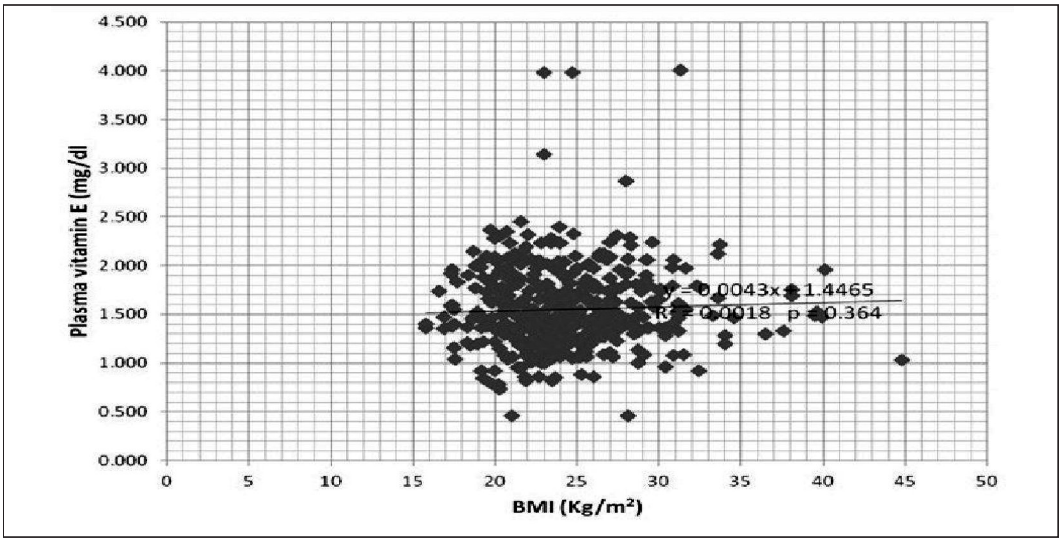

Figure 2. Scatter plots of plasma vitamin E against BMI (Kg/m2)

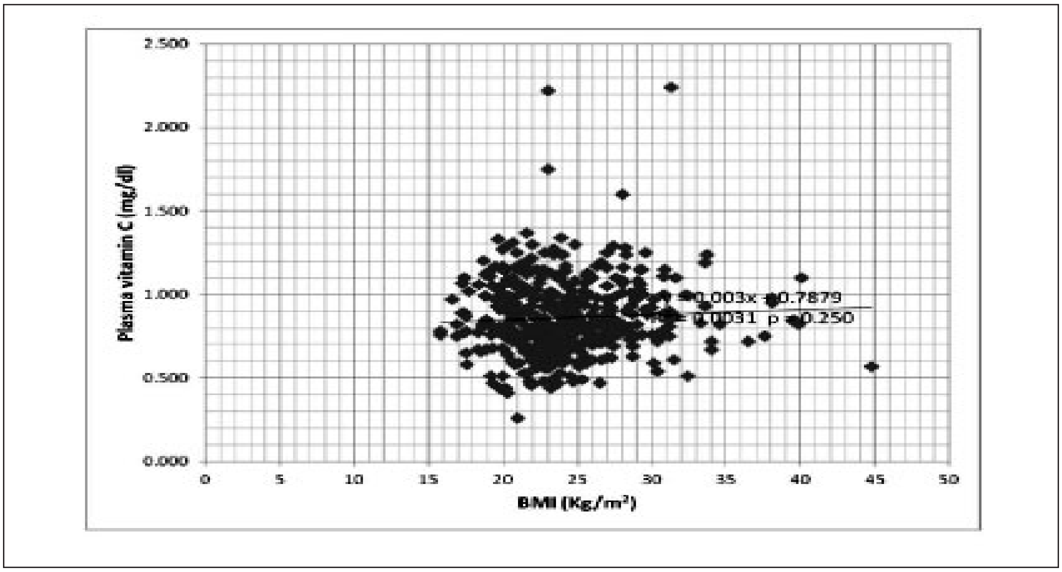

Figure 3. Scatter plots of plasma vitamin C against BMI (Kg/m2)

South-western Nigeria (Amira *et al.*, 2011), 35.1% and 9.8% in North-central Nigeria (Desalu *et al.*, 2008), and 31% and 17% in a pooled population from five geo-political zones of Nigeria (Okafor et al, 2014a). However, earlier studies have reported lower prevalence of 6% for obesity in the Nigerian population (Adebayo *et al.*, 2014; Iloh *et al.*, 2011). This suggests a progressive increase in the burden of obesity and associated health problems and potential for enormous health cost increases in the future. Age is one of the factors significantly associated with the development of overweight and obesity (Okafor et al., 2014b; Iloh *et al.,* 2011).

In agreement with the study of Adienbo, Hart & Oyeyami (2012), our study found a significantly higher number of overweight or obese participants below or equal to 40 years of age, than older adults. By implication, younger Nigerians, at least below 40 years, as shown in the current study, are progressing to the BMI of obesity. Previous studies have presented findings on the prevalence of overweight and obesity among the middle-aged (>45years) and the elderly (Adebayo *et al.,* 2014; Iloh *et al.,* 2011). Conceivably, the current trend of intense urbanisation process, increased infiltration of a 'western lifestyle' and fast foods with high fats in Nigeria have led to increased vulnerability to consumption of sweetened beverages, soft drinks, more snacks and a sedentary lifestyle in recent years among young adults (Monteiro *et al.,* 2007). The significantly higher prevalence of overweight observed in farmers and obesity in artisans in comparison to other occupational groups contradicts previous findings that associated physically demanding jobs with decreased risk for obesity (Chau *et al.*, 2012; Bonauto, Lu & Fan, 2014). The literature generally suggests that individuals involved in occupations with a high level of physical activity should have a lower rate of obesity; however, the current finding did not support this suggestion. The current finding could partly be attributed to the socio-economic status which had been associated with obesity. According to research studies, obesity and socio-economic status are inversely associated; individuals with low socio-economic status are more likely to be obese (Sarlio-Lähteenkorva Lissau & Lahelma, 2006). Farming and artisan are occupations with greater physical tasks (Bureau of Labour Statistics, 2006).

Furthermore, moderate to intense levels of regular physical activity increase the caloric intake needed to compensate for the energy expenditure (Melzer *et al,* 2005). Additionally, overweight and obesity have been shown to be inversely associated with level of education both in men and women, although gender differences may result in inconsistency of the findings of prior studies (Hermann *et al*, 2011; Maddah *et al,* 2003). Consistent with previous reports (Hermann *et al*, 2011; McLaren, 2007), in the present study, low or secondary education was significantly associated with overweight and obesity. The explanation for this association could be that less education predisposes to behavioural characteristics, such as poorer diet and unhealthy eating habits that increase the risk of obesity. Knowledge of the educated individuals on the effect of obesity on health may affect the choice of foods.

Evidence implicates inflammation and oxidative stress in overweight and obese individuals and this has gained attention of late. Studies have shown that BMI is associated with oxidative stress in adults, adolescents, and children (Imboden, 2014). Findings from systematic investigations indicate that co-morbidities associated with obesity such as DM, CVD, hypertension and hypercholesterolemia could be attributed to or a result of oxidative stress (Imboden, 2014). In this study, vitamins A, C and E levels appeared to be non-significantly higher in overweight and obese individuals than the normal weight ($p>0.05$), with none of the vitamins having a significant relationship with BMI. In previous studies, oxidative stress was shown to be associated with low plasma concentrations of antioxidants in patients with severe obesity (Reitman *et al.,* 2002). Savini *et al*. (2013) state that, although the exact sequence of their relationship may be difficult to ascertain, oxidative stress and inflammation may be connected to obesity. The literature suggests that the metabolic burden of obesity may decrease antioxidant status, therefore suggesting an important role for antioxidant intervention (Ghadiri-Anari Nazemian & Vahedian-Ardakani, 2014). The cause for the mild increases in antioxidant vitamins in both overweight and obese categories, although insignificant in this study, is unclear. The increases may not be attributed to supplementation as the study eliminated Nigerian adults on vitamin supplements. However, Choi *et al.* (2013) had reported a negative association between vitamin C intake and abdominal obesity in women.

CONCLUSION

Overweight and obesity are prevalent among young Nigerian adults and those in the middle age group (31- 40 years) and individuals with secondary education. Plasma levels of antioxidant vitamins (A, C, and E) were not associated significantly with BMI in the subjects. Further studies are needed to evaluate antioxidant enzymes, such as superoxide dismutase (SOD), catalase (CAT) and other health-related factors such as metabolic syndrome. The strength of the study lies in the analysis of blood samples for antioxidant vitamins, but the shortcomings include being a cross-sectional study and without records of dietary intake to provide for more relationship data with blood antioxidants.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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