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Relationship between Obesity and Fasting Blood Glucose among Secondary School Adolescents in Ado-Ekiti, South West Nigeria

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Abstract: **There has been documented increase in type 2 diabetes mellitus and obesity in children over the past two decades globally. In Nigeria, there is paucity of data on the measure of obesity and fasting blood glucose profile of adolescents, although there are impression of increasing adiposity compared to years past. This was a cross sectional study involving 628 adolescents from three different secondary schools in Ado Ekiti over four month duration. With parental consent, volunteers completed a questionnaire, had their weight, height, waist and hip circumferences and fasting blood glucose measured and documented. 346 male and 282 female adolescents whose ages ranged from 10 to 19 years were studied. 180 (28.7%) and 4 (0.6%) had FBG in pre-diabetic and diabetic range respectively while the rest had normal FBG. 552 (87.9%) had normal BMI percentile, 42 (6.7%) were overweight, 5 (0.8%) were obese and 29 (4.6%) were underweight. Only female gender, early adolescence (age group 10-14 years), and family history of obesity have statistically significant influence on FBG levels (*p* value = <0.001, <0.001 and 0.045 respectively). There was linear relationship between FBG and BMI percentile and also between FBG and WHR though not predictive (r^2 =0.005 and 0.018 respectively). This study showed that there was linear correlation between the BMI, WHR and FBG among secondary school adolescents in Ado-Ekiti.**

Keywords: **Body mass index, fasting blood glucose, adolescents, Nigeria.**

1. INTRODUCTION

There is rising incidence of non-communicable diseases like diabetes, hypertension and coronary heart diseases globally.[1-3] Obesity in adolescents has been found to be associated with increased risk of impaired glucose tolerance, insulin resistance, and type 2 diabetes (T2DM).[4] Overweight adolescents are also at risk of developing one or more risk factors for cardiovascular disease, such as hypertension and high cholesterol as well as other chronic medical conditions such as premature puberty/ adrenarche, hypovitaminosis D, and osteopenia/ osteoporosis, which need to be attended to early.[5-8] A study among obese children and adolescents showed that 70% of them had at least one risk factor for cardiovascular disease while 39% had two or more risk factors.[5] Previous studies among adolescents have also demonstrated significant relationship between fasting blood glucose (FBG), body mass index (BMI) and waist circumference (WC) of overweight-obese female adolescents.[1,2] Obesity in children and adolescents is increasing globally with attendant consequences on health and mortality.[1,3,5,6] Studies among Moroccan adolescents showed that there was a significant relationship between fasting blood glucose and both body mass index and waist circumference in overweight-obese girls.[2] There is paucity of data on body mass index (BMI), waist circumference (WC) and fasting blood glucose (FBG) profile of adolescents in Nigeria and, for that matter, in most parts of Africa. Ado-Ekiti is a rapidly developing city in Nigeria with very dynamic changes in the life style of the populace. Baseline data is needed to assess the impact of increased civilization on a previously semi-urban community.

The fundamental cause of obesity is a chronic imbalance between the amount of energy intake as food and energy expended by the body in daily activities.[9] Much researches continue to better the understanding of the pathogenesis of obesity, the contribution of genetics and also the contribution of environment factors promoting obesity. Leptin, a peptide hormone discovered in 1994, is involved in a complex circuit of hormones and neurotransmitters to control appetite.[9,10] Absence of leptin, because of rare genetic defects, causes failure of coupling between energy intake and energy expenditure, resulting in obesity. In some reports the pathology of obesity has been cleverly described as the enlarged fat cells while the pathophysiology is the increased secretion of those factors associated with these enlarged fat cells.[9]

Beck-Nielsen and Groop[11] proposed a three-stage model for the development of T2DM. Stage 1 includes fasting hyperinsulinemia with normal or slightly increased blood glucose, especially mild fasting hyperglycemia. Stage 2 is characterized by prediabetic glucose intolerance with insulin resistance, and Stage 3 is development of classical symptomatic or non-symptomatic T2DM with more persistent hyperglycemia present. Many of the macrovascular changes associated with diabetes and related to cardiovascular disease (CVD) begin in stages 1 and 2, well before overt diagnosis.[12] Thus, if overweight children are identified early, lifestyle changes and other measures potentially may be put in place to prevent the development or progression of prediabetes or full T2DM. Many programs around the world are being proposed under this reasonable assumption but hard scientific proof of this concept has remained difficult to produce when surveying the current medical literature or listening to obesity experts. The multicenter TODAY study[13] sadly failed to document demonstrable improvement despite intensive financial efforts vis-à-vis psychosocial, education and medicinal interventions! Obese individuals also often have metabolic problems termed Metabolic Syndrome (MS) deemed a precursor to future dysglycemia and/or frank diabetes. The overall prevalence of MS among 12- to 19-yr-olds in the United States was found to be 4.2% .[14] Other problems obese individuals are prone to include: hyperandrogenism/ premature adrenarche, precocious puberty, sleep apnea/ obesity-related hypoventilation, asymptomatic hypertension, nonalcoholic fatty liver disease (steatosis), gall bladder disease, orthopaedic problems (Blount's disease, slipped capital femoral epiphysis), osteopenia and osteoporosis, skin changes (acanthosisnigrican), pseudotumorcerebri as well as low self-esteem.[10,15]

2. MATERIALS AND METHODS

The present study was a cross sectional study involving apparently healthy secondary school adolescents from three different secondary schools in Ado-Ekiti, Ekiti State, Nigeria. Ethical clearance and permission to enter the schools was obtained from the Research and Ethical Committee of the Ekiti State University Teaching Hospital, Ado-Ekiti and the State's Ministry of Education respectively. Students aged 10-19 years who gave assent and whose parent/ guardian gave written consent were recruited. Prospective study subjects reported at 7.30am at an agreed upon study room within the school premises made available by the school authorities. Subjects fasted overnight with their agreed-upon last meal being 9pm the previous night of the day for the study. A structured questionnaire was administered to obtain socio-demographic data and information relevant to the study. Weight, height, waist circumference (WC) and hip circumference was measured using standard procedures. Body weight was measured to the nearest 0.1 kg using a portable weighing scale with minimal clothing and no shoes; belts and other accessories were removed and pockets emptied. Height was measured to the nearest 0.1 cm using a portable stadiometer with the subjects standing erect, barefoot, heels together and looking straight ahead in the Frankfurt plane. The lower edge of the eye socket was in the same horizontal plane as the external auditory meatus, with the heels and back against the height rule.[16] Waist circumference was measured to the nearest 0.1 cm in standing position at the midpoint between the lowest rib and the iliac crest and at the end of normal expiration, using a flexible measuring tape. Hip circumference was measured to the nearest 0.1 cm using a flexible measuring tape to measure the widest diameter around the hip and having the greater trochanter as landmark. BMI was calculated as weight in kilogram divided by the square of height in meter (kg/m^2). Using these measurements and BMI-for-age percentiles charts by the US Centers for Disease Control and Prevention (CDC), the weight status of each subject was categorized as follows: obese (≥ 95^{th} percentile); overweight (85^{th} to < 95^{th} percentile); normal weight (5^{th} to < 85^{th} percentile); underweight (< 5^{th} percentile).[17]

Blood Sampling: capillary blood sample for fasting blood glucose was measured using Accu-Chek Active® glucometer; after the thumb or index finger has been cleaned with wet (water) cotton wool. The finger site was then dried and finger-prick done with new sterile needle for each subject. The test result was discussed with participants and counseled appropriately. Each participant was given an apple fruit to break their fast after the study. Fasting blood glucose (FBG) was classified according to the recommendation of American Diabetes Association[18] and it states that FBG ≥ 7.0 mmol/L (126 mg/dL) is provisional diagnosis of diabetes; FBG 5.6-6.9 mmol/L (100-125 mg/dL) is impaired fasting glucose and FBG < 5.6 mmol/L (100 mg/dL) is normal fasting glucose. Data was entered and analyzed using SPSS 16.0 for Windows

(SPSS Inc, Chicago, USA). Test for association with chi square (χ^2) was done and *P* values less than 0.05 was regarded as significant. Pearson correlation of BMI, WHR and FBG of the subjects was assessed.

3. RESULTS

There were 3,525 adolescents in the three secondary schools out of which 628 adolescents who satisfied the inclusion criteria were studied: 346 males and 282 females giving a male to female ratio of 1.2: 1. The mean age of participants was 14.2 ± 1.7 years. FBG was normal in 444 (70.7%) of the studied adolescents; four (0.6%) had FBG in diabetic range while 180 (28.7%) had impaired fasting blood glucose (FBG). There were 77 (41.8%) males and 107 (58.2%) females in the 184 (29.3%) adolescents with high FBG (180 in pre-diabetic and 4 in diabetic range) among the studied 628 adolescents giving a male to female ratio of 0.7:1. The proportion of males with high FBG of the overall studied male population of 346 was 77 (22.3%) while the proportion of females with high FBG of the overall female population of 282 was 107 (37.9%). This difference was statistically significant (χ^2 = 18.462, df = 1, p = 0.000)

The BMI percentile of 552 (87.9%) of the subjects was within normal limits, 42 (6.7%) were overweight, 5 (0.8%) were obese and 29 (4.6%) were underweight using WHO definition. The proportion, 39 (13.8%), of the studied 282 female adolescent who were overweight/ obese was significantly higher than 8 (2.3%) of 346 male participants; this difference was statistically significant (χ^2 = 29.767, df =1, p = <0.001). Greater proportion, 31 (66%), of the overweight/ obese adolescents were in the 10-14 years age group while the remaining 16 (34%) were in the 15-19 years age group. Also, all the four (100%) adolescents who had diabetic FBG range were in the same 10-14 year age group.Only female gender, early adolescence (age group 10-14 years), and family history of obesity have statistically significant influence on FBG levels (*p* value = <0.001, <0.001 and 0.045 respectively).

Figure 1shows the pattern of WHR of the secondary school adolescents in Ado-Ekiti. The mean for their WHR was 0.82 ± 0.05, the median was 0.82 and it ranged from 0.6 to 1.0. Figure 2 is the box plot of the WHR for age group 10-14 years and 15-19 years; it shows that the median WHR for younger adolescents is higher than the older adolescents, though both are evenly distributed. The mean WHR for age group 10-14 years was 0.83 ± 0.049 and 0.80 ± 0.046 for age group 15-19 years. Figures 3 and 4 show how the fasting blood glucose and body mass indices of secondary school adolescents in Ado-Ekiti changes with age respectively. The BMI for age chart showed two peaks which occurred at 12 and 17 years of age. There was an increase from 10 to 12 years, a slight decline at 13 years, and then a steady increase till 17 years after which it declined steadily. The FBG chart-for-age also showed two distinct peaks which occurred at 12 and 17 years though there appear to be a little rise at age 14 years.126 (25.7%) of 491 adolescents whose WHR was less than 0.9 had high FBG, while 58 (42.3%) of 137 adolescents whose WHR was ≥ 0.9 had high FBG. This was statistically significant (χ^2 = 14.367, df =1, p = 0.000)

There was linear relationship between FBG and BMI percentile and also between FBG and WHR, though not predictive (r^2 = 0.005 and 0.018 respectively)

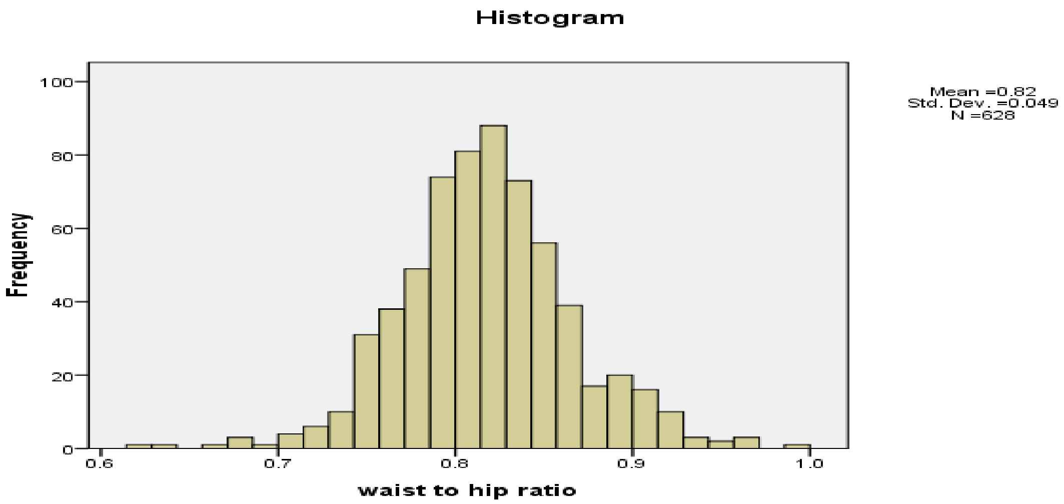

Figure 1: Pattern of waist to hip ratio the secondary school adolescents in Ado-Ekiti

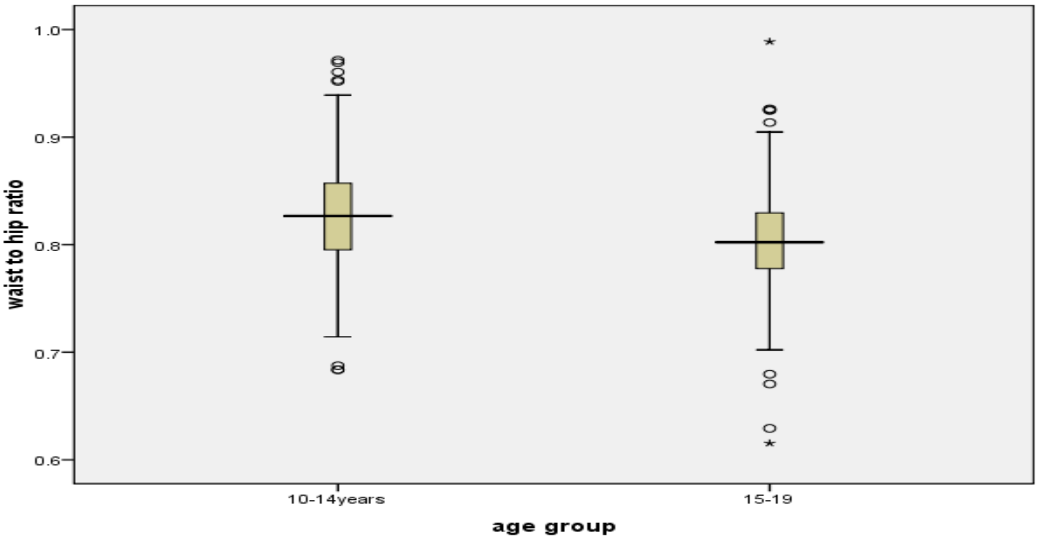

Figure 2: Box plot of waist to hip ratio for younger and older adolescents

Figure 3: Profile of fasting blood glucose [mg/dL] according to age [years] of adolescents in Ado-Ekiti

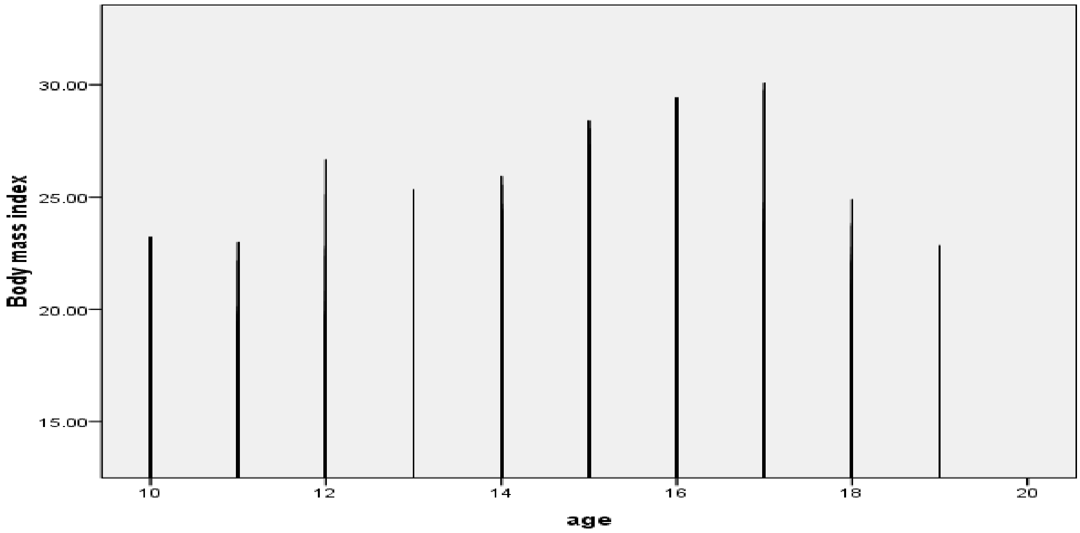

Figure 4: Profile of body mass index [kg/m^2] according to age [years] of adolescents in Ado-Ekiti

4. DISCUSSION

There are variations in the prevalence of overweight and obesity based on the gender of the adolescents: this study showed that female adolescents (13.8%) were more overweight/ obese compared to males (2.3%) and this was statistically significant (P= <0.001). This agrees with findings in most other studies within and outside Nigeria[2,7,8,19-23]but there are a few studies reporting a higher prevalence among male[22,24] Earlier puberty and early growth spurts in females versus males is normal and to be expected but this may be a confounding factor and contribute to this difference since there is increased accumulation of relative adipose tissue in females during puberty followed by a reduction in adipose tissue accumulation after puberty.[21,23] This could partly explain the two peaks observed in the BMI of the adolescents at 12 and 17 years of age in this study which roughly correspond to the time for early and late phase of puberty respectively in the mixed population of male and female adolescents.[21, 23] Male adolescents are generally more physically active than girls and are more likely to get involved in sporting activities like football and running within and outside school, thus helping them to balance calorie intake and expenditure. This may partly explain lower prevalence of overweight/ obesity among the male adolescents. The prevalence of overweight and obesity among secondary school adolescents in our study in Ado-Ekiti, though low compared to findings from other communities/ countries, is higher than "ideal" so a recommendation to medical, public health, government and school authorities should take heed of this information. There is established evidence that non communicable diseases are associated with overweight and obesity[4-6,25] and measures must be put in place to prevent it in every adolescent.[9]

Increased secretion of growth hormone, adrenocortical and gonadal hormones during puberty usually causes increase in insulin resistance and this could explain the peaks in FBG of adolescents at 12 and 17 years which roughly correspond to early and late phase of puberty in both genders combined.[26] It was also demonstrated in this index study that early adolescence (age group 10-14 years), female sex and family history of obesity have statistically significant association with impaired fasting blood glucose and this finding agrees with findings from previous studies.[26,27] The FBG profile of the adolescents plotted against their ages showed two distinct peaks which occurred at 12 and 17 years (Figure 11); this is similar to the peaks in their BMI which occurred at the same ages of 12 and 17 years. This finding is in concordance with findings among adolescents in Beijing area of China[27] whose FBG peaked at 12-13 years and at 17 years of age. Moreover, the mean FBG in the male and female adolescents in index study (93.4 ± 10.8; 97.6 ± 10.5 mg/dl respectively) is slightly higher than those of Moroccan[2] male and female adolescent of similar age (92 ± 14.0; 89 ± 10.0 mg/dl respectively). This difference may be due to different method used for analysis of FBG; Mehdadet al.[2] in the Moroccan study used hexokinase method to determine FBG while index study assessed capillary FBG with Accu-Chek Active® glucometer. Also, the Moroccan study[2] had a fewer and disproportionate study population (44 males; 123 female) compared to the index study of 346 male and 282 female adolescents.

Overall, there was statistical linear relationship between body mass index and fasting blood glucose and between waist-to-hip ratio and fasting blood glucose of secondary school adolescents in Ado-Ekiti. This finding is in consonance with findings in previous studies.[2,26] There is therefore the need to regularly monitor measures of obesity and FBG in adolescent with a view to early detection and management of prediabetic phase. Also physical activities should be encouraged in all schools with healthy diet within and outside schools.

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Conflict of interest:

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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