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Overweight and Obesity and their Relationship with Glucose Dysregulation in the Nigerian Youth

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Abstract

Fasting plasma glucose is a risk factor for diabetes and cardiovascular disease in obese children. This study aimed to evaluate the association between WC, BMI and WHtR and blood glucose in children.

Methods: This was part of a cross-sectional study in 2,995 students 9-19 years (1,187 boys and 1,808 girls) using a multistage cluster sampling design. 442 (Girls 313, Boys 129) with risk factors for glucose dysregulation were selected for fasting blood glucose measurement. Weight, height, Waist circumference (WC) were measured and body mass index (BMI) and waist to height ratio (WHtR) calculated. Data were analyzed to get the mean; SD. Logistic regression analysis was computed to examine the relationship between impaired fasting glucose (IFG) and its associations.

Results: IFG was found in 72 (23.0%) mean fasting blood glucose 107+ 6.3 mmo/l and 5 (1.6%) had diabetes, mean blood glucose 144.6 + 16.8 mmol/l among the girls, while 52 (40.3%) and 2 (1.6%) of the boys had IFG and diabetes, mean fasting glucose 107 + 5.9 and 129.3 + 0.4 mmol/l respectively. There was progressive increase in the blood glucose levels among the boys and girls from age 12 to >15 years. Those with increased WC had the highest fasting blood glucose and increased WC had 2.2 times greater odds of IFG regardless of sex, OR 2.200 95% CI 1.189-4.068.

Conclusion: Waist circumference appears to be the best anthropometric index for IFG. A measure of fasting blood glucose in overweight/obese children could identify those for targeted preventive measures in Nigeria.

Keywords: Youth; Waist Circumference; Obesity; Impaired Fasting Glucose

List of abbreviations: BMI: Body Mass Index; WHtR: Waist-Height Ratio; WC: Waist Circumference; SD: Standard Deviation; IFG: Impaired Fasting Glucose; FPG: Fasting Plasma Glucose; FBG: Fasting Blood Glucose; HDL: High Density Lipid; IGT: Impaired Glucose Tolerance

Introduction

Obesity is associated with a less favorable cardiovascular risk factor status in children and adolescents and evidence has shown that excess of adipose tissue is associated with subclinical inflammation, insulin resistance and atherosclerosis [1,2].

Worldwide, with changing food habits and increased sedentary lifestyles, the prevalence of overweight and obesity in school-age children has increased at alarming rate [3,4] and in Nigeria, reports from different regions of the country showed a prevalence ranging from 1% to 18% [5-7]. This suggests that millions of children are now vulnerable to pathologies previously only seen in adults which include type 2 diabetes, hypertension and dyslipidaemia and cardiovascular disease [8]. Nichols et al in a large group of adults, has observed a 6% increased risk of developing diabetes with each 0.06mmol/l increase in FPG [9].

Studies have demonstrated that impaired fasting glucose (IFG) is associated with a threefold increase in the risk of developing type 2 diabetes thus acts as a good marker of the acute insulin response and the glucose disposition index [9,10]. Reports have also suggested that high normal FBG levels constitute an independent risk factor for diabetes and a risk marker for cardiovascular disease [11]. Thus, before fasting glucose reaches the diagnostic range for IFG, impairment in the regulation of glucose homeostasis might already exist. In obese youths classified as having normal glucose tolerance (NGT) but with 2-hour glucose levels in the higher range, reduced B-cell function relative to insulin sensitivity has already developed, increasing the future risk of impaired glucose tolerance [12].

It is important therefore to determine whether a child who is obese has a higher odd of presenting with risk factors known to lead to cardio-metabolic disease for targeted screening and subsequent lifestyle interventions. This study aimed to evaluate the association between WC, BMI and WHtR and blood glucose levels, and to ascertain which of the three simple anthropometric indices is the best predictor of IFG in adolescent Nigerians.

Materials and Methods

This study was part of a cross-sectional study conducted in 2,995 students aged 9-19 years (1,187 boys and 1,808 girls) in 20 secondary schools in the Federal Capital Territory Abuja, Nigeria. The Federal Capital Territory has citizens from every part of Nigeria; the three major ethnic groups (Yoruba, Ibo, Hausa) and the minorities are all resident there, with their children in schools.

Sampling Technique

A multistage cluster sampling design was used. Sample was stratified according to school types (government and private) the schools randomly selected from the list obtained from the School's Board and the Ministry of Education. In the second stage, inside each school, students were randomly selected from each class (Junior Secondary 1-3, Senior Secondary 1-3). Subjects represented socio-economic and urban/rural groups. The third stage of sampling involved 442 students (Girls 313, Boys 129) with risk factors for glucose dysregulation, had their fasting blood glucose measured.

Anthropometric Measurements

All measurements were performed by well-trained health professionals: Weight was measured in minimal clothing and recorded to the nearest 0.1kg on calibrated scales and height in bare feet to the nearest millimeter. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2) [13]. Waist circumference (WC) was measured at the point of noticeable waist narrowing to the nearest millimeter and waist-to-height ratio (WHtR) calculated as waist circumference (in cm) divided by height (in cm) [14].

Statistical Methods

SAS software (SAS Institute, Cary, North Carolina, USA) version 9.4 was used for database management and analyses. The data was not normally distributed so a non-parametric analysis was done. A total of 2,995 students 9-19 years (1,187 boys and 1,808 girls) enrolled in the study but 442 students (Girls 313, Boys 129) with risk factors for glucose dysregulation, were selected for fasting blood glucose measurement and subjected to analysis.

Mean + Standard Deviation (SD) were calculated for continuous variables (weight, height, BMI, WC and WHtR) while categorical variables were given as percentages. Mann-Whitney and Kruskal-Wallis tests were used for comparing continuous variables between males and females. Logistic regression analysis was computed to examine the relationship between IFG and its associations. A value of $P < 0.05$ was considered as significant.

Abnormal waist circumference (WC) was based on the International Diabetes Federation (IDF) 2007 consensus cutoff ≥ 90th percentile [15], WHtR ≥0.5 was used to detect abdominal obesity [16], while overweight and Obesity using BMI were defined according to WHO growth reference for school-aged children and adolescents [17]. Impaired Fasting Glucose (IFG), was defined according to ADA criteria: fasting plasma glucose level of 100-125 mg/dL [18].

Approval for the study was obtained from the Federal Capital Territory Education Secretariat, Secondary Education Board and the Federal Ministry of Education. Written and oral consent was obtained from the school authorities, students and their parents.

Results

Table 1: presents the mean, standard deviation, minimum and maximum for age, anthropometric data and fasting blood glucose for students by sex. The mean BMI and WHtR were statistically significantly higher in girls than in boys, while the boys were taller and had significantly higher fasting blood glucose. It is worthy of note that we had a maximum waist circumference of 118cm for girls and 117cm for boys.

Characteristic	Girls						P-value	Boys					
	n (%)	Mean	SD	Min	Med	Max		n (%)	Mean	SD	Min	Med	Max
Age (years)	313 (70.8)	14.1	2.2	9.0	14.0	19.0	0.4113	129 (29.2)	14.0	2.3	10.0	14.0	19
WC (cm)		79.27	9.54	56.00	79.00	118.00	0.3518		80.06	11.63	56.00	79.00	117.00
BMI (kg/m²)		27.42	4.24	16.60	26.90	45.00	0.0070*		26.33	4.98	15.00	26.30	48.50
Body height (m)		1.60	0.08	1.40	1.59	1.82	<0.0001*		1.65	0.11	1.40	1.67	1.86
Body weight (kg)		69.05	12.76	40.00	68.00	117.00	0.0938		70.62	16.77	30.00	70.00	126.0
WHtR		0.497	0.059	0.361	0.494	0.720	0.0207*		0.487	0.069	0.363	0.485	0.765
FBS (mg/dL)		94.70	11.95	58.00	93.00	173.00	0.0001*		97.62	12.10	50.00	98.00	129.60

P-value is MWW test for comparing means between sexes; *significant differences between males and females. N= Number SD=Standard Deviation, Med = Median, Min=Minimum Max= Maximum BMI=Body Mass Index WC=Waist Circumference WHtR= Waist Height Ratio

Table 1: Baseline characteristics of the subjects by sex

Table 2: shows the prevalence of overweight, obesity using waist circumference (WC), waist height ratio (WHtR) and body mass index (BMI) by age and sex. Among the girls, using WC and WHtR, 26.5% and 46.0%, and the boys, 18.6% and 40.3% had abdominal obesity respectively. Using BMI, the girls had 33.9% and 56.2% overweight and obesity, while the boys had 24.0% and 55.8% overweight and obesity respectively.

	N	WC		WHtR		BMI		
		Normal	Obese	Normal	Obese	Normal	Overweight	Obese
N (%)								
Girls (years)								
All Girls	313	230 (73.5)	83 (26.5)	169 (54.0)	144 (46.0)	31 (9.9)	106 (33.9)	176 (56.2)
≤12	82	34 (10.9)	48 (15.3)	30 (9.6)	52 (16.6)	4 (1.3)	3 (1.0)	75 (24.0)
13 -15	146	116 (37.1)	30 (9.6)	83 (26.5)	63 (20.1)	12 (3.8)	52 (16.6)	82 (26.2)
>15	85	80 (25.6)	5 (1.6)	56 (17.9)	29 (9.3)	15 (4.8)	51 (16.3)	19 (6.1)
Boys (years)								
All Boys	129	105 (81.4)	24 (18.6)	77 (59.7)	52 (40.3)	26 (20.2)	31 (24.0)	72 (55.8)
≤12	40	26 (20.2)	14 (10.9)	12 (9.3)	28 (21.7)	4 (3.1)	4 (3.1)	32 (24.8)
13 -15	53	46 (35.7)	7 (5.4)	34 (26.4)	19 (14.7)	10 (7.8)	10 (7.8)	33 (25.6)
>15	36	33 (25.6)	3 (2.3)	31 (24.0)	5 (3.9)	12 (9.3)	17 (13.2)	7 (5.4)

N= Number %= Percentage WC= Waist Circumference WHtR= Waist Height Ratio BMI= Body Mass Index ≤= less or equal to >= greater than

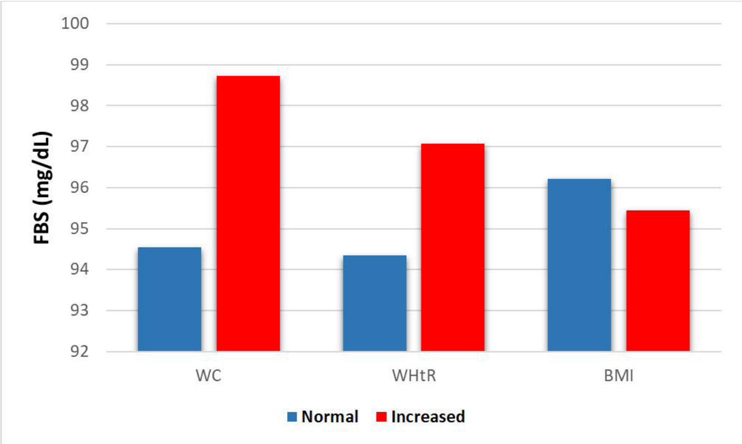
Table 2: Anthropometric Indices of the Subjects categorized by age and Sex

Table 3: Blood glucose dysregulation according to age and sex among the students. Impaired fasting glucose (IFG), was found in 72 (23.0%) with a mean blood glucose of 107+ 6.3 mmo/l and 5 (1.6%) had diabetes with a mean blood glucose 144.6 + 16.8 mmol/l among the girls, while 52 (40.3%) and 2 (1.6%) of the boys had IFG and diabetes with mean glucose values of 107 + 5.9 and 129.3 + 0.4 mmol/l respectively. It is also noted that there is a progressive increase in the blood glucose values among the boys and girls from 12 to >15 years.

	Normal < 100mg/dL		IFG 100-125mg/dL		Diabetic ≥ 126mg/dL	
	N (%)	Mean±SD	N (%)	Mean±SD	N (%)	Mean±SD
Girls (years)						
All Girls	236 (75.4)	89.7±6.5	72 (23.0)	107.7±6.3	5 (1.6)	144.6±16.8
≤12	50 (16.0)	90.0±5.9	30 (9.6)	106.5±5.7	2 (0.6)	156.0±24.0
13 -15	114 (36.4)	89.7±6.9	29 (9.3)	107.8±6.3	3 (1.0)	137.0±7.8
>15	72 (23.0)	89.3±6.4	13 (4.2)	110.5±7.3	NA	NA
Boys (years)						
All Boys	75 (58.1)	90.1±8.9	52 (40.3)	107.3±5.9	2 (1.6)	129.3±0.4
≤12	26 (20.2)	89.2±12.3	14 (10.9)	106.4±4.6	NA	NA
13 -15	26 (20.2)	90.5±6.6	26 (20.2)	106.6±5.4	1 (0.8)	129.6
>15	23 (17.8)	90.5±6.6	12 (9.3)	109.8±7.7	1 (0.8)	129.0

	Normal < 100mg/dL		IFG 100-125mg/dL		Diabetic ≥ 126mg/dL	
	N (%)	Mean±SD	N (%)	Mean±SD	N (%)	Mean±SD
Both sexes (years)						
All	311 (70.4)	89.8±7.2	124 (28.1)	107.5±6.1	7 (1.6)	140.2±15.6
≤12	76 (17.2)	89.8±8.6	44 (10.0)	106.5±5.3	2 (0.5)	156.0±24.0
13 -15	140 (31.7)	89.9±6.8	55 (12.4)	107.2±5.9	4 (0.9)	135.2±7.4
>15	95 (21.5)	89.6±6.4	25 (5.7)	110.1±7.4	1 (0.2)	129.0

N= Number, IFG= Impaired Fasting Glucose, > greater than < less than, ≥greater than or equal to, ≤ less than or equal to, SD= Standard Deviation,
Table 3: Glucose Dysregulation among the Subjects According to Age and Sex



FBS= Fasting Blood Sugar WC= Waist Circumference WHtR= Waist Height Ratio BMI= Body Mass Index
Figure 1: Mean Fasting blood glucose of the Subjects according to Anthropometric Indices

Figure 1: Mean blood glucose categorization according to waist circumference, waist height ratio and body mass index of the students. On the whole, the students with abnormal WC had the highest fasting blood glucose, followed by WHtR and lastly BMI.

Table 4: Logistic regression model of associations of impaired fasting glucose (IFG). In a multivariate analysis, the female sex had a reduced association with IFG, (OR 0.423, 95% CI 0.269-0.664). Increased WC had 2.2 times greater odds of having IFG regardless of sex OR 2.200 95% CI 1.189-4.068.

Risk Factor	Multivariate Analysis		
	Parameter Estimate	Adjusted Odds Ratio	95% Confidence Interval
Sex			
Boys		1	
Girls	-0.8613	0.423	0.269 - 0.664
WC			
Normal weight		1	
Obese central weight	0.7884	2.200	1.189 - 4.068

Table 4: Logistic regression model of associations of Impaired Fasting Glucose in the Subjects

Discussion

Studies have shown that there is substantial tracking of body weight and obesity from adolescence into adulthood [19]. Garnet et al reported that 78.9% of children who were overweight or obese on the basis of BMI at 8 years, were still overweight and obese at 15 years and 69.2% of children who had increased central adiposity at 8 years continued to be so at 15 years [20].

Our result showed that the mean waist circumference among the girls and boys were similar 79.3 + 9.5 and 80.1 + cm, with a maximum WC of 118cm in girls and 117cm in the boys. However, the mean BMI and WHtR were significantly higher in the girls than in the boys. Studies have demonstrated a close relationship between increased excess of adipose tissue in the abdominal region and increased risk of cardiovascular disease [21,22] and that WC is the best simple anthropometric index of abdominal visceral adipose tissue and may also be the best index for predicting cardiovascular disease [23,24].

Waist height ratio (WHtR) is also being increasingly used to detect the risk of diseases related to central fatness in children. The rational being that for a given height, there is an acceptable degree of fat stored on the upper body [25,26]. In Nigeria, reference values for waist circumference and waist height ratios have been suggested to detect abdominal adiposity in youths 10-18 years of age [27].

Some other studies have shown that both absolute total fat and adipose tissue distribution are closely associated with cardio-metabolic risks [28,29]. Al-Daghri et al. in their study however found BMI to be superior among all obesity indices in terms of relationship with adipokines and cardiometabolic risk factors [30].

Reports have documented that before fasting glucose reaches the diagnostic range for impaired fasting glucose (IFG), impairments in the regulation of glucose homeostasis might already exist [31,32]. In this study, 124 (28.1%) of the students were found to have pre-diabetes, while 7 (1.6%) were newly diagnosed with diabetes. 72 (23%) of the girls and 52 (40.3%) of the boys had IFG. It was also noted that there was a progressive increase in fasting blood glucose values from age 12 to 15 years among the girls 106.5 + 5.7 to 110.5 + 7.3 and boys 106.4 + 4.6 to 109.8 + 7.7mmol/l respectively. Waliul lslam et al. in a longitudinal study of 42 obese children aged 7-15 years, found significant increases in fasting plasma glucose, insulin, uric acid and systolic blood pressure and a significant decrease in HDL as compared to the non-obese children [33].

Looking at the obesity indices in relation to blood glucose values in this study, the mean FBG was highest in the children with increased WC, followed by WHtR and lastly BMI in a decreasing order; 98.7 + 14.1, 97.1 + 13.0 and 95.5 + 11.9 mmol/l respectively, even though the values were still within the conventional normal ranges.

Multivariate analysis showed that the children with increased WC are 2.2 times more likely to have IFG regardless of sex than those with normal WC, OR 2.200 95% CI 1.189-4.068. WC has been said to be the best simple anthropometric index of abdominal visceral adipose tissue and may also be the best index for predicting cardiovascular disease [23,24].

The Bogalusa Heart Study showed that children and adolescents with large waist circumference were more likely to have elevated cardiovascular risk factors than those with normal a smaller waist circumference. Also, that fasting glucose levels were positively related to the level of obesity and adults who developed IGT or type 2 diabetes had higher glucose levels from childhood [34].

O'Malley et al in his work on obese youths, stratified the children into quartiles of fasting plasma glucose. They noted that quartile four with the highest normal fasting plasma glucose had the greater degree of obesity [8].

Claudio et al in Italy has demonstrated that fasting blood glucose could be considered a screening tool to narrow clinical indication to OGTT in obese white children and adolescents [35]. O' Malley et al. in their work have suggested that in children who are in the metabolically stressful state of obesity, glucose dysregulation appears to occur earlier than adverse cardiovascular profile. Thus, a critical window of opportunity for effective treatment before the onset of cardiovascular damage might be available to clinicians in children with high normal fasting plasma glucose [8].

Conclusion

In conclusion, our findings highlight the fact that overweight and obese children, with fasting blood glucose concentration within the seemingly normal range or with IFG are not normal with respect to glucose metabolism and the risk of developing diabetes and cardiovascular disease in future. Waist circumference appears to be the best anthropometric index for IFG in this study. Early diagnosis of IFG could be very helpful; thus, a simple measure of fasting blood glucose in this category of children could assist clinicians in identifying those for targeted preventive measures in the Nigerian setting.

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Conflict of Interest

The authors declare that there is no conflict of interest associated with this manuscript.

References

1. Park MH, Falconer C, Viner RM, Kinra S (2012) The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. Obes Rev 13: 985-1000.

2. Lloyd LJ, Langly-Evans SC, McMullen S (2012) Childhood obesity and risk of the adult metabolic syndrome: a systematic review. Int J Obes (Lond) 36: 1-11.

3. Chinn S, Rona RJ (2001) Prevalence and trends in overweight and obesity in three cross sectional studies of British Children, 1974-94. BMJ 322: 24-6.

4. World Health Organization (WHO) (2016) Obesity and Overweight Fact Sheet. World Health Organization, Geneva, Switzerland.

5. Senbanjo IO, Njokanma OF, Oshikoya KA (2009) Waist circumference values of Nigerian children and adolescents. Ann Nutr Metab 54: 145-50.

6. Abah SO, Aigbiremolen AO, Duru CB, Awunor NS, Asogun AD, et al. (2012) Prevalence of overweight and obesity among students in private and public secondary schools in a peri- urban Nigerian town. J Biol Agric and Healthcare 2: 11.

7. Toriola AL, Ajayi-Vincent OB, Oyeniyi PO, Akindutire IO, Adegbo DI, et al. (2017) Prevalence of overweight and obesity in Nigerian children. Anthropologist 30: 86-94.

8. O'Malley G, Santoro N, Northrup V, D' Adamo E, Shaw M (2010) High normal fasting glucose level in obese youth: a marker for insulin resistance and beta call dysregulation. Diabetologia 53: 1199-209.

9. Nichols GA, Hillier TA, Brown JB (2008) Normal fasting plasma glucose and the risk of type 2 diabetes diagnosis. Am J Med 121: 519-24.

10. Dagogo-Jack S, Askari H, Tykodi G (2009) Glucoregulatory physiology in subjects with low-normal, high-normal, or impaired fasting glucose. J Clin Endocrinol Metab 42: 222-9.

11. Grandone A, Amato A, Luongo C, Santoro N, Perrone L, et al. (2008) High-normal fasting glucose levels are associated with increased incidence of impaired glucose tolerance in obese children. J Endocrinol Investig 31: 1098-102.

12. Giannini C, Weiss R, Cali A, Bonadonna R, Santoro N, et al. (2012) Evidence for Early Defects in Insulin Sensitivity and Secretion Before the onset of Glucose Dysregulation in Obese youths. Diabetes 61: 606-14.

13. Rogol AD, Clark PA, Roemmich JN (2000) Growth and pubertal development in children and adolescents: effects of diet and physical activity. Am J ClinNutr 72: 521S- 8S.

14. Ashwell MA, Lejeune SRE, McPherson B (1996) Ratio of waist circumference to height may be better indicator of need for weight management. BMJ 312: 377.

15. The International Diabetes Federation (2007) (IDF) consensus definition of the metabolic syndrome in children and adolescents. The International Diabetes Federation, Belgium.

16. McCarthy HD, Ashwell M (2006) A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message-: keep your waist circumference to less than half your height. Int J Obes 30: 988-92.

17. World Health Organization (WHO) (2007) Growth reference 5-19 years, World Health Organization, Geneva, Switzerland.

18. American Diabetes Association (2003) Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus: follow-up report on diagnosis of diabetes mellitus. Diabetes Care 52: 1475-84.

19. Kvaavik E, Tell GS, Klepp KI (2003) Predictors and tracking of body mass index from adolescence into adulthood: follow up of 18-20 years in Oslo Youth Study. Arch Pediatr Adolesc Med 157: 1212-18.

20. Garnett SP, Baur LA, Srinivasan S, Lee JW, Cowell CT (2007) Body mass index and waist circumference in midchildhood and adverse cardiovascular disease risk clustering in adolescence Am J Clin Nutr 86: 549-55.

21. Juonala M, Magnussen CG, Berenson GS, Venn A, Burns TL, et al. (2011) Childhood adiposity, adult adiposity, and cardiovascular risk factors. N Engl J Med 365: 1876-85.

22. Sahoo K, Sahoo B, Choudhury AK, Sofi NY, Kumar R, et al. (2015) Childhood obesity: causes and consequences. J Family Med Prim Care 4: 187-92.

23. Pouliot MC, Despres JP, Lemieux S, Moorjani S, Bouchard C, et al. (1994) Waist circumference and abdominal saggital diameter: best simple anthropometric indices of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. Am J Cardiol 73: 460-8.

24. Reeder BA, Senthilselvan A, Despress JP, Angel A, Liu L, et al. (1997) The association of cardiovascular disease risk factors with abdominal obesity in Canada. Canadian Heart Health Surveys Research Group. CMAJ 157 (Supp 1): S39-S45.

25. Hsieh SD, Yoshinaga H, Muto T (2003) Waist-to-height ratio, a simple and practical index for assessing central fat distribution and metabolic risk in Japanese men and women Int J Obes 27: 610-6.

26. Savva SC, Tornaritis M, Savva ME, Kourides Y, Panagi A, et al. (2000) Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J obes Relat Metab Disord 24: 1453-8.

27. Anumah FO, Mshelia-Reng R, Omonua OS, Shuaibu RA, Odumodu KC, et al. (2019) The Development of Reference Values for Waist Circumfernce and Waist Height Ratios in Nigerian Youths 10-18 Years of Age. J Obes Overweig 5: 201-8.

28. Ledoux M, Lambert J, Reeder BA, Despres JP (1997) Correlation between cardiovascular disease risk factors and simple anthropometric measures. Canadian Heat Health Surveys Research Group. CMAJ 157 (Supp1): S46-S53.

29. Lundgren H, Bengtsson C, Blohme G, Lapidus L, Sjostrom L (1989) Adiposity and adipose tissue distribution in relation to incidence of diabetes in women: results from a prospective population study in Gothenburg, Sweden. Int J Obes 13: 413-23.

30. Al-Daghri NM, Al-Attas OS, Alokail M, Alkharfy K, Wani K, et al. (2014) Does visceral adiposity index signify early metabolic risk in children and adolescents? Association with insulin resistance, adipokines and subclinical inflammation. Pediatric Res 75: 459-63.

31. Faerch K, Vaag A, Holst JJ, HansenT, Jorgensen T, et al. (2009) Natural history of insulin sensitivity and insulin secretion in the progression from normal glucose tolerance to impaired fasting glycemia and impaired glucose tolerance: the Inter99 Study. Diabetes Care 32: 439-44.

32. Bacha F, Lee S, Gungor N, Arslanian SA (2010) From Pre-Diabetes to Type 2 Diabetes in Obese Youth. Pathophysiological characteristics along the spectrum of glucose dysregulation. Diabetes Care 33: 2225-31.

33. Islam AHMW, Yamashita S, Kotani K, Nakamura T, Tokunaga K, et al. (2004) Fasting plasma insulin level is an important risk factor for the development of complications in Japanese obese children-Results from a cross-sectional and a longitudinal study. Metabolism 44: 478-85.

34. Nguyen QM, Srinivasan SR, Xu JH, Chen W, Berenson GS (2008) Changes in risk variables of metabolic syndrome since childhood in pre-diabetic and type 2 diabetic subjects: the Bogalusa Heat Study. Diabetes Care 31: 2044-9.

35. Maffeis C, Pinelli L, Brambilla P, Banzato C, Valzolgher L, et al. (2012) Fasting Plasma Glucose (FPG) and the Risk of Impaired Glucose Tolerance in Obese Children and Adolescents. Obesity 18: 1437-42.