FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 8 No. 6, December, (Special Issue) 2024, pp 438 - 443
DOI: https://doi.org/10.33003/fjs-2024-0806-2873

PREVALENCE OF OVERWEIGHT AND OBESITY AND THEIR CORRELATION WITH FASTING BLOOD GLUCOSE AND BLOOD PRESSURE AMONG FEMALE SECONDARY SCHOOL STUDENTS IN KANO, NIGERIA

***Mukhtar, I. G. and Zaituna, N. Y.**

Department of Human Physiology, Faculty of Basic Medical Sciences, Bayero University, Kano.

*Corresponding authors' email: mukhtargwarzo@gmail.com;imgwarzo.mph@buk.edu.ng

ABSTRACT

Childhood obesity has been linked with adverse cardiometabolic risk. Multiple indices have been used to assess obesity and associated cardiovascular risk. However, relationship between these indices and markers of cardiovascular risk has been inconsistent. This study aimed to determine prevalence of overweight and obesity and their correlation with fasting blood glucose (FBG) and measures of blood pressure among female secondary school students in Kano, Nigeria. One hundred and fifty female students were recruited. Fasting blood glucose was measured using glucose oxidase method. Anthropometric indices and blood pressure measurements were by standard protocols. Mean age of the participants was 15.67 ± 1.30 years (13 – 18 years). Mean systolic, diastolic, and arterial blood pressure were: 115.38 ± 7.62, 71.01 ± 8.34, and 85.65 ± 6.58 mmHg respectively. Mean anthropometric indices were: weight - 48.30 ± 8.85 kg, height - 1.58 ± 0.07 m, BMI - 19.43 ± 3.82 kg/m^2 hip circumference (HC) - 71.69 ± 15.14 cm, waist circumference (WC) - 62.05 ± 10.34 cm, waist to height ratio (WHtR) - 0.40 ± 0.07, and waist-to-hip ratio (WHC) - 0.88 ± 0.28, respectively. Mean FBG was 4.55 ± 0.28 mmol/l. Prevalence of overweight and obesity were: 6.0% and 5.3% respectively. None of the anthropometric indices correlated with FBG or blood pressure. Prevalence of overweight and obesity in adolescent female students in this environment are low and is not correlated with fasting blood glucose or blood pressure.

Keywords: Adolescents, Female, Kano, Prevalence, Obesity

INTRODUCTION

Childhood and adolescence are periods of rapid physical, emotional, and psychological development. Nutritional problems at these critical periods of development may have serious consequences in the wellbeing of a person later in life. One of such nutritional problems that is now of public health importance is obesity. Although preventable, global prevalence of obesity has continued to rise in both developing and developed nations (Ng, *et al.*, 2014; WHO, 2019). From a mere 1% in 1975, global prevalence of childhood obesity rose to 6-8% in 2016 (WHO, 2019). An estimated 41 million under-fives were said to be either overweight and/or obese in 2016 while over 340 million children between the ages of 5-19 years were overweight and/or obese in the same year (WHO, 2019).

Although once considered a disease of the developed nations, various studies have demonstrated rising level of prevalence of childhood obesity and overweight, especially in developing nations (Ng *et al*., 2014 ;Sahoo *et al*., 2015; Seidell *et al*., 2015; Agu *et al*., 2022). In sub-Saharan Africa, the number of overweight children under the age of 5 years was said to have increased by half since the year 2000 (WHO, 2019). Prevalence of overweight and/or obesity in the continent has also risen from 4% in 1975 to a staggering 18% in 2016 (WHO, 2019).

In Nigeria, prevalence of childhood overweight and/or obesity is generally low, but rising (Senanjo and Adejuyigbe, 2007; Musa *et al*., 2012; Yusuf *et al*., 2013; Adebimpe, 2019; Agu *et al.*, 2022). However, in a literature and systematic review of works from different regions of the country spanning a period of 3 decades, Ejike (2014) concluded that prevalence of childhood overweight and/or obesity is low, and has remained stable over that period of time.

Childhood overweight and/or obesity have been linked to many health-related morbidities and mortality later in life. They have been linked to heightened level of risk of non-communicable diseases, such as diabetes, cancers, musculoskeletal disorders and cardiovascular diseases (WHO, 2019). They are also associated with sleep disturbances, breathing difficulties, increase risk of fracture, insulin resistance, poor academic performance in school, depression, and premature death in adult life (Ng *et al*., 2014; Sahoo *et al*., 2015, WHO, 2019; Oluwayemi *et al*., 2021).

The growing prevalence of childhood overweight and/or obesity will pose even more health problems and challenges in developing countries where infectious diseases and undernutrition still persist (Muthuri *et al*., 2014). Childhood and adolescence thus provide a transition period that can be targeted for intervention. This study aimed to determine prevalence of overweight and obesity and their correlation with FBG and measures of blood pressure among female secondary school students in Kano, Nigeria.

MATERIALS AND METHODS

Study area and study population

The study was a cross-sectional school-based descriptive study that was carried out at Government Girls Secondary School Dukawuya, Kano, Nigeria in October, 2019. The study population was all students of the school aged 13–18 years who fulfilled inclusion criteria. Students with history of diabetes, hypertension, sickle cell disease, and those who declined informed consent or assent were not included in the study. A convenience sampling was employed to select Government Girls Secondary School Dukawuyu. A comprehensive list of all students in the school using class registers was obtained and simple random sampling technique via random number table used to recruit participants to the desired sample.

Sample size was calculated using the following formula (Lwanga and Lemeshow, 1991):

$n = Z^2pq/d^2$, where: n = sample size (minimum), Z = standard normal deviate (95% confidence interval) = 1.96, p =

prevalence of obesity among children and adolescents in Kano= 0.84% = 0.0084 (Yusuf *et al*., 2013), q = complimentary probability = (p – 1), d = level of precision = 0.05.
Therefore, n = 13.

Ethical clearance
The study protocol was approved by the Kano state ministry of health (MOH/off/797/T.I/1649) and all participants gave an individual informed consent or assent where applicable. Permission of the management of the school was also obtained before commencement.

Data collection
A data capture form designed to obtain sociodemographic data was used to collect relevant information from the participants. Fasting blood glucose (FBG) was determined by glucose oxidase method using glucometer (Roche Diabetes Care Inc., Indianapolis, USA). Blood pressure was measured with the participants seated comfortably, relaxed, and on the left arm using mercury sphygmomanometer (Accoson™ Ltd., Ayrshire, UK) with appropriate cuff and Littmann® Classic pediatric stethoscope (Minnesota, USA). The appearance of first Korotkoff sound (Korotkoff I) was taken as systolic while its disappearance (Korotkoff V) as diastolic blood pressure.
All anthropometric indices were measured based on the updated version of WHO STEPS Surveillance Manual.[12] Weight was determined with a digital scale, Omron HN286 (Kyoto, Japan). Participants were asked to wear light clothes and the measurement was approximated to the nearest 100 g. A stadiometer was used to measure height. Waist and hip circumferences were measured at a point between the last rib and ileal crest and at the widest part of the buttocks respectively. Body mass index was computed as weight (kg) divided by height (m^2). Equally, WHR was computed as WC divided by HC, all in cm.
Body mass index was classified in accordance with the WHO growth reference scale for school-aged children and early adolescents (de Onis *et al*., 2007):
Underweight = Less than 5^{th} percentile
Normal = 5^{th} to 85^{th} percentile
Overweight = 85^{th} to 95^{th} percentile
Obesity = 95^{th} percentile and above.
Blood pressure classification was based on 2017 recommendations of American Academy of Pediatrics (subcommittee on screening and management of high blood pressure in children) (Flynn *et al*., 2017):
Normal = < 120/80 mmHg
Elevated = 120/80 – 129/80 mmHg
Stage 1 (hypertension) = 130/80 – 139/89 mmHg
Stage 2 (hypertension) = ≥ 140/90 mmHg

Data analysis
Data analysis was performed using the IBM SPSS version 23.0 (Armonk, New York, USA). Association between categorical variables was determined using Chi-square test of association while relationship between quantitative variables was obtained using Pearson's correlation. p value ≤ 0.05 was set as statistical significance.

RESULTS AND DISCUSSION
Socio-demographic information
A total of 150 female students were recruited. Mean age of the participants was 15.67 ± 1.30 years. Majority of the participants were Hausa-Fulani (84.0%) and only 8.7% had family history of diabetes mellitus. Result of socio-demographic information are presented on table 1.

Clinical, laboratory, and anthropometric indices
The participants had mean systolic, diastolic, and mean arterial blood pressure of 115.38 ± 7.62, 71.01 ± 8.34, and 85.65 ± 6.58 mmHg, respectively. Similarly, the participants had mean height, BMI, and weight of 1.58 ± 0.07 m, 19.43 ± 3.82 kg/m^2, and 48.30 ± 8.85 kg, respectively; mean HC, WC, and WHR were 71.69 ± 15.14 cm, 62.05 ± 10.34 cm, and 0.88 ± 0.28, respectively. The mean fasting blood sugar was 4.55 ± 0.28 mmol/l. Results of mean clinical, laboratory, and anthropometric parameters are presented on table 1.

Prevalence of overweight, obesity, and elevated blood pressure
Proportion of those with overweight and obesity was 6.0% and 5.3% respectively while that of underweight was 20.7%. About 12.7% of our participants had blood pressure above normal cutoff point while only 2.0% had hypertension. Result of the proportion of overweight, obesity, and elevated blood pressure is presented in table 2.

Correlation of fasting blood glucose with clinical and anthropometric indices
Fasting blood glucose had no statistically significant correlation with mean arterial blood pressure, diastolic blood pressure, systolic blood pressure, weight, height, BMI, HC, WC, and WHR. Results are presented on table 3.

Correlation of BMI with other clinical parameters
Body mass index was correlated positively with age (r = 0.446, p = 0.001); however, BMI did not significantly correlate with SBP, DBP, and MAP. Result of correlation between BMI and clinical parameters of the participants is presented on table 4.

Table 1: Socio-demographic, clinical, laboratory, and anthropometric indices

Variable		N (%) or Mean ± SD
Ethnicity	Hausa	126(84.0)
	Others	24(16.0)
Family history of DM	Yes	13(8.7)
	No	137(91.3)
Age (years)		15.67 ± 1.30
SBP (mmHg)		115.38 ± 7.62
DBP (mmHg)		71.01 ± 8.34
MAP (mmHg)		85.65 ± 6.58
Weight (kg)		48.30 ± 8.85
Height (m)		1.58 ± 0.07
BMI (kg/m^2)		19.43 ± 3.82
Hip circum. (cm)		71.69 ± 15.14

Waist circum. (cm)	62.05 ± 10.34
WHR	0.88 ± 0.10
FBG (mmol/l)	4.55 ± 0.28

DM = Diabetes mellitus, SBP = Systolic blood pressure, BMI = Body mass index, DBP = Diastolic blood pressure, FBG = Fasting blood glucose, MAP = Mean arterial blood pressure, circum. = circumference, WHR = Waist to hip ratio.

Table 2: Prevalence of overweight, obesity, and elevated blood pressure

Variable		N (%)
BMI (kg/m^2)	Underweight	31(20.7)
	Normal	102(68.0)
	Overweight	9(6.0)
	obese	8(5.3)
Blood pressure (mmHg)	Normal	128(85.3)
	Elevated	19(12.7)
	hypertension	3(2.0)

BMI = body mass index

Table 3: Correlation of fasting blood sugar with clinical and anthropometric indices

Variable	r	p
Age (years)	0.017	0.837
SBP (mmHg)	0.004	0.962
DBP (mmHg)	-0.004	0.963
MAP (mmHg)	-0.002	0.983
Weight (Kg)	-0.123	0.134
Height (cm)	0.013	0.879
BMI (kg/m^2)	-0.133	0.105
Hip circum. (cm)	-0.032	0.699
Waist circum. (cm)	-0.142	0.083
WHR	-0.135	0.098

SBP = Systolic blood pressure, BMI = Body mass index, DBP = Diastolic blood pressure, WHR = Waist to hip ratio, MAP = Mean arterial blood pressure, circum. = circumference.

Table 4: Correlation of BMI with age and blood pressure

Variable	r	p
Age (years)	0.446	0.001*
SBP (mmHg)	0.105	0.199
DBP (mmHg)	0.069	0.400
MAP (mmHg)	0.099	0.228

*Statistically significant variable, MAP = Mean arterial blood pressure, SBP = systolic blood pressure, BMI = Body mass index, DBP = diastolic blood pressure.

Discussion

Our study has demonstrated a fairly low prevalence of overweight and/or obesity among a population of female secondary school students in Kano, Nigeria (6.0% and 5.3% respectively). Despite the reported rising global prevalence of childhood obesity, studies in Nigeria have continued to report lower rates (Ejike, 2014). In their study of over 700 students aged 13-18 years, Yusuf *et al*., (2013) reported a prevalence of overweight and that of obesity to be 1.98% and 0.84% respectively in Kano, Nigeria. In a similar study, Ahmad, Ahmed, and Airede (2013) reported a prevalence of 3.3% and 1.4% for overweigh and that of obesity, respectively, among school adolescents in Sokoto. A similar pattern was also reported by Musa *et al.,* (2012) in Benue state, Nigeria. They found prevalence of overweight and that of obesity to be 9.7% and 1.8%, respectively, among over 3000 school-aged children and adolescents across the state. There is however a sharp contrast to what has been reported from the southern parts of Nigeria. A prevalence of overweight and that of obesity of 6.3% and 4.4% was reported by Eze *et al*., (2018) from Enugu, south-east Nigeria. Senbanjo and Adejiyigbe (2007) also reported similar rate from south-west Nigeria. They found a prevalence of 13.7% and 5.2% respectively for overweight and that of obesity. An even higher rate of 17.7% and 10.7% (for overweight and that of obesity, respectively) was reported among female secondary school students in Onitsa, south-east Nigeria (Agu *et al*., 2022).

In general, our study reported relatively low prevalence of overweight and/or obesity when compared to what has been reported from different parts of Nigeria, especially southern parts of Nigeria. Our sample size of 150 is relatively small compared to those of other studies. The convenience sampling technique used at some stage in this study can also make comparison a bit difficult because the sample may not be a true representation of the studied population. Despite these limitations, Kakale *et al*., (2018) reported a prevalence that is close to what we reported. The higher prevalence in the southern part of Nigeria compared to the north could be explain by differences in socioeconomic development, lifestyle, and physical activity. In spite of these differences however, Adebimpe (2019) reported a pattern similar to that of northern region from Osogbo, north-west Nigeria. The picture of low prevalence of overweight and/or obesity is also similar in other African countries. In a systematic review consisting of about 68 studies from Africa, Muthuri *et al*., (2014), even though noted a rising prevalence, reported a pooled prevalence of overweight and that of obesity of 10.6% and 2.5%, respectively.

Like in many other studies, overweight/obesity was positively correlated with age in our study. Implying that prevalence of overweight and that of obesity increases with age. This agrees with what was reported by Yusuf *et al*., (2013) and Kakale *et al*., (2018) among school children in northwest Nigeria. They both found higher prevalence rates among older children compared to youger ones. Childhood is a period of rapid physical development that is associated with hormonal changes. Rapid growth and development as a result of hormonal changes causes increase in muscle mass, lengthening of long bones and hence height, and increase in fat deposit and redistribution. These changes could explain our finding of positive correlation between BMI and age among our participants.

Prevalence of underweight in our study is quite high compared to that of obesity. Sub-Saharan Africa has indeed been described as a continent facing double burden of diseases (WHO, 2019; Muthuri *et al*., 2014). While the continent continues to struggle with problem of undernutrition, that of obesity is creeping in. Kakale *et al*., (2018) reported even higher prevalence of underweight from the same state of Kano. Developing countries are characterized by high rate of poverty, infectious disease pandemic, poor nutrition, inadequate health facilities and services which can all contribute to stunting, wasting, and hence underweight.

Proportion of those with blood pressure in the hypertensive region among our participants was very low (2%) however, a significant number had elevated blood pressure, 12.7%. Ujunwa *et al*., (2013) reported a similarly high prevalence of prehypertension or elevated blood pressure among adolescents in Enugu, south-south Nigeria. The proportion of those with blood pressure in the hypertensive region in our study is however lower than what was reported from similar studies in Kano (Mijinyawa, Borodo, and Iliyasu, 2008; Also, Asani, and Ibrahim, 2016). In their study of over 2000 primary school children aged 4-14 years in Kano, Also, Asani, and Ibrahim (2016) reported an overall prevalence of hypertension of 3%. An earlier study by Mijinyawa, Borodo, and Iliyasu (2008) among a relatively older cohorts in Kano state reported a higher prevalence of 7%. A similar prevalence of 6.1% was reported by Isezuo *et al*., (2018) among secondary students in Sokoto metropolis. Varying prevalence rates have also been reported from different parts of southern Nigeria. While Uwaezuoke *et al*., (2016) reported a relatively higher rate from Enugu, south-east Nigeria, Okpokowuruk, Akpan, and Ikpeme (2017) reported a relatively lower rate of 3.5% in neighboring city of Uyo, south-south Nigeria. Prevalence of elevated blood pressure and/or hypertension in children and adolescents seems to differ from one study to another probably due to difference in the criteria used to define the disorder. Unsurprisingly, a systematic review and trend analysis of data spanning 4 decades reported varied prevalence rates based on the criteria used to define hypertension (Ejike, 2017). The observed differences between our study and others could therefore be due to the definition of hypertension used in the studies. Another possible source of difference could be the method employed to measure blood pressure. Prevalence of elevated blood pressure and/or hypertension among adolescents in sub-Saharan Africa varied greatly between and within nations. In a meta-analysis of works from 1996 to 2017, Noubiap *et al*., (2017) reported prevalence rate ranging from 0.2-24.8% with pooled prevalence of 5.5%.

Unlike in many other studies, anthropometric indices did not correlate with neither FBG nor blood pressure. Studies have linked overweight and/or obesity with heightened level of risk of hypertension, diabetes, and other cardiovascular diseases. Traditionally, BMI has been used to assess obesity in children and any possible relationship with cardiovascular risk factors. Recent evidences from epidemiological studies have however suggested that measures of abdominal obesity, not BMI, are better predictors of cardiovascular risk in children (Lo *et al*., 2016). Despite the growing interest in this field, relationship between anthropometric indices, FBG, and blood pressure have been inconsistent (Kondaki *et al*., 2011; Wicklo *et al*., 2015). While Agirbasli *et al*., (2011) reported BMI as the best predictor of metabolic syndrome among 9 year old school children, Mehdad *et al*., (2012) found BMI and WC to be better correlates of FBG in obese girls only. However, Park *et al*., (2019) reported that changes in WC, WHtR, BMI, and WHR were associated with significant changes in fasting insulin. Body mass index is a marker of lean body mass and general obesity while WC, WHtR, and WHR are used as indicators of abdominal obesity. Abdominal (visceral) obesity, unlike general (truncal) obesity, is associated with high influx of free fatty acids which lead to altered glucose metabolism, insulin resistance, and elevated blood pressure (Ma *et al*., 2016).

None of the anthropometric indices predicted participants with hypertension using receiver operating curve. We could not assess their performance in predicting diabetes because all the participants had normal FBG. Performance of various anthropometric indices in discriminating elevated blood pressure has not been consistent. Chiolera *et al*., (2013) found the predictive ability of BMI z-scores and WHtR in identifying children, aged 10 – 14 years, with elevated blood pressure to be weak. Thus, a meta-analysis (Ma *et al*., 2016) concluded that performance of anthropometric indices in identifying children with abnormal blood pressure is weak and therefore requires further evaluation.

CONCLUSION

Prevalence of overweight and/or obesity and hypertension among adolescent female secondary school students in Kano is low. Efforts should be made to maintain the current low prevalence or even lower.

ACKNOWLEDGEMENT

We will like to acknowledge the support and cooperation of management, staff, and students of Government Secondary School Dukawuya, Gwale local government area, Kano, Nigeria.

REFERENCES

Adebimpe, W. O. (2019). Prevalence and Knowledge of risk factors of childhood obesity among school-going children in Osogbo, south-western Nigeria. *Malawi Medical Journal*, 31(1), 19-24. https://doi.org/10.4314/mmj.v31i1.4

Agirbasli M, Agaoglu NB, Ergonul O, Yagmur I, Aydogar H, Oneri T. et al. Comparison of anthropometric indices in predicting metabolic syndrome components in children. *Metabolic Syndrome and Related Disorders*, 2011;9(6):453-459. https://doi.org/10.1089/met.2011.0018

Agu, N., Ulasi, T., Okeke, K., Ebenebe, J., Echendu, S., Nriezedi, C., Nwaneli, E., Edokwe, E., Onah, S., Ifezulike, C., & Umeadi, E. (2022). Prevalence of Overweight and Obesity among Secondary Schools Adolescents in Onitsha, Anambra State Nigeria. *International Journal of Medical Science and Clinical Invention*, 9(01), 5891–5899. https://doi.org/10.18535/ijmsci/v9i01.02 .

Ahmad, M. M., Ahmed, H., Airede, K. (2013). Body mass index among school adolescents in Sokoto, North-Western Nigeria. *Sahel Medical Journal*, 16(1), 5-9. https://doi.org/10.4103/1118-8561.112049

Also, U., Asani, M., Ibrahim, M. (2016). Prevalence of elevated blood pressure among primary school children in Kano Metropolis, Nigeria. *Nigerian Journal of Cardiology*, 13(1), 57-61. https://doi.org/10.4103/0189-7969.165167 .

Chiolero A, Paradis G, Maximova K, Burnier M, Bovet P. No use for waist-for-height ratio in addition to body mass index to identify children with elevated blood pressure. Blood Press. 2013;22(1):17-20. https://doi.org/10.3109/08037051.2012.701376 .

de Onis, M., Onyango, A. W., Borgi, E., Siyam, A., Nishida, C., Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization*, 85(9), 649-732. https://doi.org/10.2471/blt.07.043497

Ejike, C. E. C. C. (2014). Child and adolescent obesity in Nigeria: A narrative review of prevalence data from three decades (1983-2013). *Journal of Obesity and Metabolic Research*, 1(3), 171-179. https://doi.org/10.4103/2347-9906.141150 .

Ejike, C. E. C. C. (2017). Prevalence of Hypertension in Nigerian Children and Adolescents: A systematic Review and Trend Analysis of Data from the Past Four Decades. *Journal of Tropical Pediatrics*, 63(3), 229-241. https://doi.org/10.1093/tropej/fmw087

Eze, J. N., Oguonu, T., Ojinnaka, N. C., Ibe, B. C. (2017). Physical growth and nutritional status assessment of school children in Enugu, Nigeria. *Nigerian Journal of Clinical Practice*, 20(1), 64-70. https://doi.org/10.4103/1119-3077.180067 .

Flynn, J. T., Kaelber, D. C., Baker-Smith, C. M., Blowey, D., Carroll, A. E., Daniels, S. R., et al. (2017). Clinical practice guideline for screening and management of high blood pressure in children and adolescents. *Pediatrics*, 140(3), e20171904. https://doi.org/10.1542/peds.2017-1904 .

Isezuo, K. O., Jiya, N. M., Audu, L. I., Ibitoye, P. K., Sani, U. M., Yusuf, T., et al. (2018). Blood pressure pattern and the relationship with body mass index among apparently healthy secondary school students in Sokoto metropolis, Nigeria. *Southern African Journal of Child Health*, 12(3), 105-110. https://doi.org/10.7196/SAJCH.2018.v12i3.1475 .

Kakale, I. S., Umar, U. I., Gwarzo, G. D., Ibrahim, M. (2018). Prevalence of Childhood and Adolescent Overweight and Obesity In Kano State, Nigeria. *EC Paediatrics*, 7(4), 231-238. https://www.researchgate.net/publication/363040828 .

Kondaki K, Grammatikaki E, Pavón DJ, Manios Y, González-Gross M, Sjöstrom M. et al. Comparison of several anthropometric indices with insulin resistance proxy measures among European adolescents: The Helena Study. *European Journal of Pediatrics*. 2011;170(6):731-739. https://doi.org/10.1007/s00431-010-1322-4 .

Lo K, Wong M, Khalechelvam P, Tam W. Waist-to-height ratio, body mass index and waist circumference for screening paediatric cardiometabolic risk factors: a meta-analysis. *Obstetrics Review*. 2016;17(12):1258-1275. https://doi.org/10.1111/obr.12456 .

Lwanga, S. K. and Lemeshow, S. (1991). Sample size determination in health studies: A practical manual. Geneva, Switzerland: *World Health Organization*. Page 1 – 22. https://iris.who.int/bitstream/handle/10665/40062/9241544058 .

Ma C, Wang R, Liu Y, Lu Q, Lu N, Tian Y. et al. Performance of obesity indices for screening elevated blood pressure in pediatric population: Systematic review and meta-analysis. *Medicine*. 2016;95(39):e4811. https://doi.org/10.1097/md.0000000000004811

Mehdad S, Hamrani A, El Kari K, El Hamdouchi A, Barakat A, El Mzibri M. et al. Body mass index, waist circumference, Body Fat, Fasting Blood Glucose in a Sample of Moroccan Adolescents Aged 11-17 Years. *Journal of Nutrition and Metabolism*. 2012;2012:510458. https://doi.org/10.1155/2012/510458

Mijinyawa, M., Borodo, M. M., Iliyasu, Z. (2008). Prevalence of Hypertension among Teenage Students in Kano, Nigeria. *Nigerian Journal of Medicine*, 17(2), 173-178. https://doi.org/10.4314/njm.v17i2.37378

Musa, D. I., Toriola, A. L., Monyeki, M. A., Lawal, B. (2012). Prevalence of childhood and adolescent overweight and obesity in Benue State, Nigeria. *Tropical Medicine and International Health*, 17(11), 1369-1375. https://doi.org/10.1111/j.1365-3156.2012.03083.x

Muthuri, S. K., Francis, C. E., Wachira, L. J. M., LeBlanc, A. G., Sampson, M., Onywera, V. O., et al. (2014). Evidence of an Overweight/Obesity Transition among School-Aged Children and Youth in Sub-Saharan Africa: A Systematic Review. *PlosONE*, 9(3), e92846. https://doi.org/10.1371/journal.pone.0092846

Ng. M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Mergono, C. et al. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*, 384(9945), 766-781. https://doi.org/10.1016/S0140-6736(14)60460-8 .

Noubiap, J. J., Essouma, M., Bigna, J. J., Jingi, A. M., Aminde, L. N., Nansseu, J. R. (2017). Prevalence of elevated blood pressure in children and adolescents in Africa: a systematic review and meta-analysis. *Lancet Public Health*, 2(8), e375-e386. https://doi.org/10.1016/S2468-2667(17)30123-8 .

Okpokowuruk, F. S., Akpan, M. U., Ikpeme, E. E. (2017). Prevalence of hypertension and prehypersion among children and adolescents in a semi-urban area of Uyo Metropolis, Nigeria. *Pan African Medical Journal*, 28:303. https://doi.org/10.11604/pamj.2017.28.303.14396 .

Oluwayemi, I., and Oyedeji, O. (2021). A Ten-Year Review of Childhood Obesity in a Teaching Hospital, South West Nigeria. *Nigerian Journal of Clinical Practice*, 24(6), 841–846. https://doi.org/10.4103/njcp.njcp_595_20 .

Park JH, Mun S, Choi DP, Lee JY, Kim HC. Association between changes in anthropometric indices and in fasting insulin levels among healthy Korean adolescents: The JS high school study. *Diabetes & Metabolism Journal*. 2019;43(2):183-191. https://doi.org/10.4093/dmj.2018.0034 .

Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., Bhadoria, A. S. (2015). Childhood obesity: causes and consequences. *Journal of Family Medicine and Primary Care,* 4(2), 187-192. https://doi.org/10.4103/2249-4863.154628 .

Seidell, J. C. and Halberstadt, J. (2015). The Global Burden of Obesity and the Challenge of Prevention. *Annals of Nutrition and Metabolism*, 66(Suppl 2), 7-12. https://doi.org/10.1159/000375143 .

Senbanjo, I. O. and Adejuyigbe, E. A. (2007). Prevalence of Overweight and Obesity in Nigerian Preschool Children. *Nutrition and health,* 18(4), 391-399 https://doi.org/10.1177/026010600701800408 .

Ujunwa, F. A., Ikefuna, A. N., Nwokocha, A. R., Chinawa, J. M. (2013). Hypertension and prehypertension among adolescents in secondary schools in Enugu, South East Nigeria. *Italian journal of pediatrics*, 39:70. https://doi.org/10.1186/1824-7288-39-70.

Uwaezuoke, S. N., Okoli, C. V., Ubesie, A. C., Ikefuna, A. N. (2016). Primary hypertension among a population of Nigerian secondary school adolescents: Prevalence and correlation with anthropometric indices: A cross-sectional study. *Nigerian Journal of Clinical Practice*, 19(5), 649-654. https://doi.org/10.4103/1119-3077.188706 .

Wicklow BA, Becker A, Chateau D, Palmer K, Kozyrskij A, Sellers EA. Comparison of anthropometric measurements in children to predict metabolic syndrome in adolescence: analysis of prospective cohort data. Int J Obes. 2015;39(7):1070-1078. https://doi.org/10.1038/ijo.2015.55 .

World Health Organization. (2017). The WHO STEPwise approach to noncommunicable disease risk factor surveillance: WHO STEPS Surveillance Manual. Geneva, Switzerland. *WHO*, 2017. https://www.who.int/teams/noncommunicable-diseases/surveillance/systems-tools/steps .

World Health Organization. (2019). Fact sheets: obesity and overweight. *WHO*. Geneva, Switzerland. Assessed from: https.//www.who.int/news-room/fact-sheets/detain/obesity-and-overweight on 19th December, 2023 at 12:40 pm.

Yusuf, S. M., Mijinyawa, M. S., Musa, B. M., Gezawa, I. D., Uloko, A. E. (2013). Overweight and Obesity among Adolescents in Kano, Nigeria. *Journal of the Metabolic Syndrome*, 2(1), 126. https://doi.org/10.4172/2167-0943.1000126 .