Prevalence of overnutrition using Body Mass Index in comparison with Bioelectrical Impedance Analysis among children and adolescents in Benin, Nigeria

ABSTRACT

Aims: To compare the prevalence of overweight and obesity among school children in Egor LGA using BMI and BIA and determine the ability of BMI to predict body fat mass as measured by BIA.

Study design: This was a cross sectional study conducted in Egor Local Government Area of Edo State of Nigeria with1067 children aged 6-18 years recruited from private and public schools. Body mass index was calculated as weight in kilograms divided by the square of height in meters while Body fat was estimated by BIA using a Tanita scale.

Place and Duration of Study: The study took place in selected private and public primary/secondary schools in Egor LGA of Edo State. The study was conducted over a three-month period from October to December 2017.

Methodology: Using multi-stage sampling technique,1067 children aged 6-18 years were recruited from private and public schools in Egor Local Government Area in Benin City, Nigeria. Body fat was estimated by BIA using a Tanita scale, whereas BMI was calculated as weight in kilograms divided by the square of height in meters. Data was analyzed using SPSS version 21.

Results: A total of 1067 pupils consisting of 538 (50.4%) males and 529 (49.6%) females were recruited. The overall prevalence of overnutrition by BMI 13.4% (overweight 9.6% and obesity 3.8%) was comparable to that by BIA 12.4% (overweight 5.4% and obesity 6.9%). BMI showed a strong positive correlation with fat mass, and fat mass index especially in females (0.917, 0.907, $p < 0.000$).

Conclusion: The prevalence of overnutrition using BMI and BIA was comparable. The prevalence of obesity is however underestimated with BMI.

Keywords: [over-nutrition, overweight, obesity, prevalence, children, BMI, BIA

1. INTRODUCTION

Overnutrition which can be classified into overweight, and obesity is now pandemic in childhood and adolescence. Overnutrition which used to be seen as a problem of developed nations is increasing in developing countries and even low-income groups in richer countries.[1,2] This is because of reduced energy expenditure and the shift in these countries towards consumption of refined foods.[3] Many developing countries are experiencing a nutrition transition with an attendant reduction in undernutrition accompanied by a rapid increase in obesity.

In 2014 the WHO estimated that 42 million children under the age of five years were overweight or obese with the rate of childhood overnutrition rising 30% faster in developing

than in richer nations.[4] Childhood overnutrition over the past 30 years has more than doubled in children and tripled in adolescents worldwide[5]. The National Health and Nutrition Examination Survey (NHANES) of 2013-2014 has estimated that 16.2% of children and adolescents in the United States aged 2–19 years are overweight and 17.2% are obese.[6] In a study by De Onis and Blossner, it was reported that in developing countries the prevalence of overweight and obesity among preschool children was increasing rapidly.[7] The result of the South African Youth Risk Behaviour Survey in 2002 reported a prevalence of overnutrition (overweight and obesity) of 21% among 13- to 19-year-olds, with a much higher prevalence among girls (25%) than boys (7%).[8] A 30 year (1983-2013) systematic review, by Ejike et al in Nigeria, of studies on obesity and overweight in children and adolescents aged 2-10 years showed a prevalence of obesity among adolescents only and children and adolescents subgroups to be 0.0-2.8% and 0.0-5.8% respectively, while for overweight in the respective groups they were 1.0-8.6% and 5.0-12.0%.[9] In Sokoto among adolescents aged 10-18 using BIA, Ahmad *et al* reported a prevalence of overweight and obesity of 2.5% and 1.7% respectively[10] while in Benin among children 6-12years the prevalence was 7.7% and 3.1% respectively[11]

Overnutrition is caused by an interplay of genetic, behavioural and environmental factors. The consumption of diets high in fat and a reduction in energy expenditure with a more sedentary lifestyle is by far the major culprit. Overweight and obesity affect all the systems of the body increasing the occurrence of various diseases such as stroke, arthritis, diabetes, cancer and in addition have emotional, mental and social consequences on the health of the individual. It can cause guilt, depression, embarrassment and social isolation.[12] Body mass index which is calculated as weight in kilograms divided by the square of height in meters is an indirect method of measurement of obesity. It is often used to assess adiposity but it does not differentiate between fat and non-fat components of body mass.
Bioelectrical impedance analysis is a direct method of fat estimation, and so is superior to BMI in this respect. Nwizu *et al* carried out a study to relate body mass index to fat in the assessment of overweight and obesity among adolescent Nigerians. They reported that about three quarters (76.2%) of the females who had body mass index in the overweight/obesity range had high body fat in comparison to 44.4% of males ($p < 0.05$). Body mass index related more to body fat in adolescent females than in males.[13]

The aim of this study, therefore, is to compare BMI with BIA in the assessment of overnutrition in children in our locale.

2. MATERIAL AND METHODS

Study design. This was a cross sectional study conducted in Egor Local Government Area of Edo State of Nigeria.

Setting

Egor, which consists of ten political wards has the headquarters in Uselu, and a projected population of 445,095 based on the 2006 census and a projected annual growth rate of 2.8%.[14]
The major occupations of the people include farming, trading and civil service. There are 37 public primary schools, 13 public secondary schools and 143 approved private nursery, primary and secondary schools within the LGA. Egor LGA was chosen because it is centrally located in Benin City and cuts across various socioeconomic strata. The study was conducted over a three-month period from October to December 2017.

Study population

One thousand and sixty-seven apparently healthy primary and secondary school children in Egor LGA aged 6 – 18 years were selected by multi-stage sampling technique for the study. The sample size was calculated using the formula[15]

$n=Z^2(1-\alpha/2)\ P(1-P)/d^2$,
where n is the minimum sample size,
$Z_{1-\alpha/2}$ is the confidence interval constant at 95 percentile confidence interval from a table for two-tailed study=1.96,
P is the best estimate of prevalence. A prevalence of 50 percent was used because there are no known references for ages 6-18 years in primary and secondary school pupils in the locality,
d is the precision value=0.03.
Hence: $n= (1.96)^2(1–0.5)\ (0.5)/0.03=1,067$.

Evaluation of selected pupils

A questionnaire which was pretested in another school not selected for the study was used to collect information on the socio-demographic characteristic of the subjects and their families and on presence of any chronic disease. The socioeconomic class was calculated using the educational status and occupations of the parents as described by Oyedeji.[16]

The selected pupils then had a thorough general examination while the anthropometry was measured. A Seca stadiometer (model 214; Seca Corp, Hanover, MD, USA) was used to measure the height to the nearest millimeter with the subjects standing erect, bare footed and both feet together. The heels, buttocks and upper part of the back touched the scale. The weight was measured to the nearest 100g with the Tanita body fat monitor/scale model SC-240 which displays the body weight and percentage body fat. The pupils were weighed in their school uniforms without cardigan or sweater and with all pockets emptied out. The equipment self-calibrates after each measurement. The bioelectrical impedance analysis was measured with the Tanita scale. The fat mass was calculated from the percentage body fat and body weight. The fat free mass is the body weight minus the fat mass. The fat mass index and the fat free mass index was derived from the fat mass and fat free mass respectively divided by the square of the height.

Data Analysis

Data was analyzed using statistical package for social sciences SPSS version 21.0 (SPSS for Window Inc; Chicago, IL, USA). Mean, standard deviation, standard error of mean was calculated for quantitative variables such as BIA, BMI and independent t-test was used for comparison of mean. The significance of each test was set at $p< 0.05$ and confidence level of 95.0%.

3. RESULTS AND DISCUSSION

A total of 1067 children consisting of 538 (50.4%) males and 529 (49.6%) females participated in the study. The sociodemographic characteristic of the study population is as shown in Table I.

Table I: The socio-demographic characteristics of the pupils

	Public School	Private School	Total
	n=335(%)	n=732(%)	N=1067(%)
Sex			
Male	176(52.5)	362(49.5)	538(50.4)
Female	159(47.5)	370(50.5)	529(49.6)
SEC			

Upper	58(17.3)	300(41.0)	358(33.6)
Middle	155(46.3)	296(40.4)	451(42.2)
Lower	122(36.4)	136(18.6)	258(24.2)
Age group(yrs)			
6-9	145(43.3)	184(25.1)	329(30.8)
10-12	63(18.8)	182(24.9)	245(23.0)
13-15	64(19.1)	184(25.1)	248(23.2)
16-18	63(18.8)	182(24.9)	245(23.0)
Religion			
Christianity	322(96.1)	694(94.8)	1016(95.2)
Islam	13(3.9)	38(5.2)	51(4.8)
Ethnicity			
Bini	136(40.6)	297(40.6)	433(40.6)
Esan	32(9.6)	87(11.9)	119(11.2)
Igbo	38(11.3)	81(11.1)	119(11.2)
Urhobo	39(11.6)	41(5.6)	80(7.5)
Yoruba	27(8.1)	45(6.1)	72(6.7)
Etsako	14(4.2)	35(4.8)	49(4.6)
Others	49(14.6)	146 (19.9)	195(18.3)

SEC = socioeconomic class

There was no significant difference, as depicted in Table II, between the mean age of male pupils (12.00 ± 3.77 years) and the female pupils (11.99 ± 3.72 years, $p = 0.941$).
There was no significant difference between the mean weight of male subjects (40.46 ± 15.61 kg) and the female subjects (41.95 ± 15.82 kg), $p = 0.122$.
The mean height was higher in males (148.06±19.25) than in females (146.79±16.63) but the difference was not statistically significant (p= 0.248), while the mean fat free mass and fat free mass index was statistically higher in males than females, $p<0.0001$.
The BMI, mean percent body fat, fat mass, and fat mass index were higher in females than in males and this difference was statistically significant, $p<0.0001$.

Table II: Mean gender comparison of age and anthropometric indices

Parameter	Male	Female	T	P
Age	12.00±3.77	11.99±3.72	0.074	0.941
Weight_kg	40.46±15.61	41.95±15.82	1.546	0.122
Height_cm	148.06±19.25	146.79±16.63	1.157	0.248
BMI	17.68±3.20	18.67±4.13	4.404	0.000*
Percent_Body_Fat	13.30±5.90	21.26±8.49	17.791	0.000*
Fat_Mass	5.45±4.14	9.96±7.56	12.092	0.000*

Fat_Free_Mass	35.01±13.36	31.99±9.79	4.198	0.000*
Fat_Mass_Index	2.42±1.56	4.31±2.90	13.277	0.000*
Fat_Free_Mass_Index	15.24±2.44	14.42±1.95	6.096	0.000*

***p < 0.05**

Body Mass Index

Table III shows a comparison of mean BMI between males and females according to age. The mean BMI for males and females increased with increasing age except at ages 9 and 12 for males and 16 years for females.

Table III: Mean body mass index of study subjects according to age and gender

Age in years	Male	Mean (Range)	Female	Mean (Range)	t	*p*
6	43	15.19 ± 1.87 (13.0-22.2)	40	15.00 ± 2.05 (12.2-20.8)	0.444	0.66
7	41	15.34 ± 1.61 (12.4-21.6)	41	15.50 ± 1.66 (13.3-20.5)	0.457	0.65
8	42	15.67 ± 1.54 (13.5-20.0)	40	16.00 ± 2.77 (12.9-25.0)	0.675	0.50
9	40	15.46 ± 1.89 (11.0-19.8)	42	16.44 ± 2.90 (12.7-24.4)	1.801	0.08
10	43	16.59 ± 3.16 (13.3-30.1)	39	16.45 ± 2.52 (10.7-22.7)	0.215	0.83
11	40	17.33 ± 2.87 (12.6-25.6)	42	17.03 ± 2.49 (12.3-26.5)	0.501	0.82
12	38	16.96 ± 1.40 (15.2-21.5)	43	18.14 ± 2.54 (14.3-24.5)	2.549	**0.01***
13	42	17.34 ± 1.75 (14.4-22.3)	40	19.71 ± 3.01 (14.4-29.0)	4.378	**0.00***
14	40	18.05 ± 2.63 (14.1-26.8)	42	19.75 ± 2.72 (13.5-27.7)	2.878	0.05
15	46	19.66 ± 2.80 (14.5-26.0)	38	21.97 ± 4.23 (15.5-38.5)	3.006	**0.00***
16	39	20.36 ± 2.12 (16.9-29.2)	43	20.69 ± 3.36 (15.4-34.1)	0.515	0.61
17	41	20.36 ± 3.01 (16.0-32.6)	40	22.23 ± 4.07 (18.3-32.2)	2.358	**0.02***
18	43	21.36 ± 3.88 (16.0-35.8)	39	24.20 ± 4.40 (17.7-40.8)	3.105	3.11
Total	**538**	**17.68±3.20**	**529**	**18.67±4.13**	**4.404**	**0.00**

**** *P* < 0.05**

Prevalence of overweight and obesity based on BMI

Table IV shows age and gender specific prevalence of overweight and obesity according to BMI in males and females.
The overall prevalence of overweight according to BMI was **9.6%** (12.3% for females and 6.9% for males) and was statistically higher in females (χ^2= 9.030, *p*=0.003). The overall prevalence of obesity according to BMI was **3.8%** (5.3% for females and 2.4% for males) and was statistically higher in females (χ^2= 5.974, *p*=0.015).

Prevalence of overweight and obesity based on percentage body fat
Table IV shows age and gender specific prevalence of overweight and obesity according to percentage body fat.
The overall prevalence of overweight according to percentage body fat was **5.4 %** (6.0% for females and 4.8% for males) and there was no statistically significant difference between males and females. (χ^2= 0.768, *p*=0.381). The prevalence of obesity according percentage body fat was **6.9**% (7.2% for females and 6.7% for males) and there was no statistically significant difference between males and females. (χ^2=0.100, *p*=0.752).

Table IV: Age and gender specific prevalence of overweight and obesity according to BMI and BIA

	OVER WEIGHT (OW)						**OBESITY (OB)**					
BMI												
Age group (years)	**Male OW (n)**	**%**	**Female OW (n)**	**%**	**χ^2**	***p***	**Male OB(n)**	**%**	**Female OB(n)**	**%**	**χ^2**	***p***
6 – 9	12(166)	7.2	10(163)	6.1	0.158	0.691	4(166)	2.4	12(163)	7.4	4.360	0.037
10 – 12	10(121)	8.3	16(124)	12.9	1.389	0.239	4(121)	3.3	2(124)	1.6	0.735	0.391
13 – 15	11(128)	8.6	21(120)	17.5	4.371	0.037	1(128)	0.8	4(120)	3.3	2.042	0.153
16 – 18	4(123)	3.3	18(122)	14.8	9.914	0.002	4(123)	3.3	10(122)	8.2	2.780	0.095
Total	**37(538)**	**6.9**	**65(529)**	**12.3**	**9.030**	**0.003**	**13(538)**	**2.4**	**28(529)**	**5.3**	**5.974**	**0.015**
Percentage body fat												
6 – 9	3(166)	1.8	7(163)	4.3	1.726	0.189	13(166)	7.8	4(163)	2.5	4.853	0.028
10 – 12	13(121)	10.7	9(124)	7.3	0.910	0.340	8(121)	6.6	13(124)	10.5	1.172	0.279
13 – 15	3(128)	2.3	6(120)	5.0	1.250	0.264	5(128)	3.9	11(120)	9.2	2.840	0.092
16 – 18	7(123)	5.7	10(122)	8.2	0.596	0.440	10(123)	8.1	10(122)	8.2	0.000	0.985
Total	**26(538)**	**4.8**	**32(529)**	**6.0**	**0.768**	**0.381**	**36(538)**	**6.7**	**38(529)**	**7.2**	**0.100**	**0.752**

Overweight and obesity in the study was defined as BMI equal to and above the adult equivalent for overweight and obesity of Cole et al chart[17]. Overweight/overfat and obese respectively as defined by set criteria based on percentage body fat[18]

Prevalence of overnutrition according to socioeconomic strata
According to Table V, a greater proportion of those in the upper socioeconomic class have overnutrition (18.2%) in comparison to the middle socioeconomic class (10.9%) and the lower socioeconomic class (11.2%). This difference was also statistically significant (P=0.005).

A greater proportion of females in the upper socioeconomic class had overnutrition (17.6%) in comparison to males (9.3%). This difference was also statistically significant (P=0.000). Overnutrition was not significantly associated with the age group, type of school and maternal education of the subjects.

Table V: Association between overnutrition and sociodemographic characteristics using BMI

SEC	Overnutrition(n) n (%)	Normal n(%)	X	P-value
SEC				
Upper	65(18.2)	293(81.8)		
Middle	49(10.9)	402(89.1)	10.513	0.005
Lower	29(11.2)	229(88.8)		
Gender				
Male	50(9.3)	488(90.7)		
female	93(17.6)	436(82.4)	15.782	0.000
Age group				
6-9	38(11.5)	291(88.5)		
10-12	32(13.1)	213(86.9)	1.841	0.606
13-15	37(14.9)	211(85.1)		
16-18	36(14.7)	209(85.3)		
Type of School				
Private				
Public	116(14.6)	676(85.4)	0.600	0.439
Maternal Education	29(10.5)	246(89.5)		
None	15(11.2)	119(88.8)		
Primary	20(10.9)	164(89.1)		
Secondary	52(11.0)	419(89.0)	1.500	0.682
University	56(20.1)	222(79.9)		

Sex-related correlation between BMI and various body fat indices

There is a positive correlation between BMI and various body fat indices as shown in both males and females in Table VI ($p < 0.000$). BMI showed a strong positive correlation with fat mass, and fat mass index especially in females (0.917, 0.907, $p < 0.000$).

Table VI: Sex-related correlation between BMI and various body fat indices

	n	**r**	**F-value**	***p-value***	**R^2**
BMI vs PBF					
Male	538	0.386	94.006	0.000	0.149
Female	529	0.871	1653.812	0.000	0.759
BMI vs FM					
Male	538	0.777	816.202	0.000	0.604
Female	529	0.917	2777.76	0.000	0.841
BMI vs FMI					
Male	538	0.658	409.538	0.000	0.433
Female	529	0.907	2436.493	0.000	0.822
BMI vs FFMI					
Male	538	0.867	1624.874	0.000	0.752
Female	529	0.828	1147.284	0.000	0.685

BMI = Body mass index
PBF= percentage body fat
FM=Fat Mass

FMI = Fat mass index
FFMI = Fat-free mass index

Discussion

The 13.4% overall prevalence of overnutrition obtained from this study using BMI, which is an indirect method of assessment of overnutrition, is comparable with the 12.4% prevalence obtained using BIA, a direct assessment tool of overnutrition. This finding further buttresses the usefulness of BMI as a reliable tool for the assessment of overnutrition in children. No study, to the best of the Researchers' knowledge has reported a similar finding for comparison with this study. It was however, observed that the prevalence of the components of overnutrition, overweight and obesity, obtained from this study using BMI and BIA was different. The prevalence of overweight and obesity as measured by BMI was 9.6% and 3.8% respectively while that obtained using BIA was 5.4% and 6.9% respectively. This finding shows that BMI tended to underestimate obesity which is in consonance with previous studies that have observed the inability of BMI to adequately differentiate body mass composition. A review of literature on the diagnostic value of BMI in the measurement of adiposity by Javed *et al*[19] showed that BMI has a high specificity (0.93) and a lower sensitivity (0.73). This implies that about a quarter of children who are obese will be missed when BMI is used in assessing excess adiposity, as shown in this study where the prevalence of obesity was lower than that obtained using BIA. This finding indicates that in the assessment of obesity using BMI in clinical setting some obese children may be categorized as overweight.

The 3.8% prevalence of obesity as measured by BMI in this study is similar to that obtained by Senbanjo *et al*[20] and Izuora *et al*[21] in Nigeria, and Deren *et al*[22] in Ukraine. Higher prevalence was reported by Karki et al in Nepal[23] and Ismail et al in Tanzania.[24] (7.1% and 6.7% respectively). The different prevalence rates obtained from these studies can be attributed to the different factors associated with obesity which varies from country to country and from region to region. A Review of articles on the factors associated with obesity in adolescents by Narciso *et al*[25] showed a significant association between obesity and factors such as ingestion of sugar-sweetened beverages, skipping of breakfast, increased screen-time, lower socio-economic class and having a parent who is obese. The presence of these enumerated factors differ in magnitude between communities, countries and regions. While obesity is associated with the lower socioeconomic class in developed countries, the reverse is the case in developing countries.[26]

This study has equally observed a higher prevalence of obesity among children from high socioeconomic class in comparison with those from a lower socioeconomic class. A few factors have been attributed to this observation. Children from a high socioeconomic background are more likely to have access to high caloric diet and drinks which have been associated with obesity. Energy saving recreational activities such as video games, increased watching of TV which are sometimes accompanied by snacking are more affordable by children from a high socioeconomic class. Small family size, tertiary parental educational status and higher household income, (attributes found more commonly with families from high socioeconomic class) have been associated with the development of obesity.[27] Trekking to school which is a form of exercise is more common with children from low socioeconomic class which can contribute to a lower incidence of obesity.

Contrary to the finding of this study obesity was associated with a lower socioeconomic class in Mauritius[28] which is a developing country. This difference was attributed mainly to two factors. Refined cereals, full-cream milk, dairy products, and high fat protein sources which provide high calories were cheaper when compared to whole grain cereals, low fat milk and dairy products, which were low in calories. Children from low SES were more likely to afford these calorie-dense diets which promote obesity. It was also observed that children from

families of high socioeconomic status spent more time in physical activities in school which reduced the tendency to obesity.

The mean BMI and the prevalence of obesity were significantly higher in females than their male counterparts which is in consonant with the observation of Keane *et al*[29]. Maruf *et al*[30] however, reported a significantly higher mean BMI in males aged 2-6 years, and in females aged 11-14years and 15-18 years. There was no significant gender difference in the prevalence of obesity across all age groups. Increased prevalence in obesity in females can be attributed to the hormonal effect of estrogen which leads to deposition of fat particularly in peripheral adipose tissues. Reduced physical activities in comparison to males may also be a contributory factor. Ahmad *et al* [27] however, reported a higher prevalence of obesity in males with no statistical gender difference in the mean BMI. This was attributed to a higher consumption of energy in males in contrast to females who exhibit a more restrictive dietary habit. Globally, the prevalence of obesity was higher in males in a vast majority of high income and upper middle-income countries. This was absent in lower middle income and low income countries, to which Nigeria belongs. Shah *et al* [31] in a bid to proffer reasons for gender difference in the prevalence of obesity proposed the influence of sociocultural beliefs and practices and sex related biological differences. Females tended to have more body fat post-partum with a resultant decrease in calorie intake which favours a lower BMI in females. Secondly, females have a higher serum leptin level which leads to reduced appetite and a higher energy expenditure with a resultant decrease in BMI. Thirdly, eating preferences in females tend towards intake of smaller and healthier meals to large portions of calorie dense foods characterized by a feeling of fullness and physical performance. Fourthly, girls tend to have shorter sleep duration, less physical activities and watch more television, all of which favour development of obesity in females. The degree to which these various factors play out in different communities and regions will greatly determine the direction in gender-based prevalence of obesity.

Though body mass index was highly correlated with fat mass and fat mass index in both males and females it was higher in females (r = 0.917; 0.907) than males (0.777; 0.658). This finding compares with that of Srdic *et al* [32] in Serbia.

There was also a high correlation between body mass index and fat free mass index in both males and females but was slightly higher in males (r=0.867 than females (0.828). The above findings are in consonant with the study of Freedman et al[33] where there was a higher correlation between fat mass and BMI in girls in comparison to boys where a higher correlation between fat free mass and BMI was obtained. This implies that body fat contributes more to BMI in females in contrast to males where fat free mass has a greater contribution. This is further corroborated by the finding of a higher mean fat free mass in males than females while females had a higher mean fat mass than males both in this study and that of Freedman's *et al.*[33]

4. CONCLUSION

The overall prevalence of overnutrition obtained from this study using BMI, is comparable with that obtained using BIA. This finding further buttresses the usefulness of BMI as a reliable tool for the assessment of overnutrition in children in poor resource settings.

CONSENT

All subjects provided written informed consent to participate before commencing the study.

ETHICAL APPROVAL

Ethical clearance was obtained from the Ethics and Research Committee of the University of Benin Teaching Hospital (ADM/E22/A/VOL.VII/1348). Written permission was obtained from the Education Authority of the Egor LGA, written informed consent was given by the

parents/guardians while verbal permission was given by the school heads.

REFERENCES

1.WHO. (2004) World Health Assembly. “Global Strategy on Diet, Physical Activity and Health.” http://www.who.int/nmh/wha/59/dpas/en/. Accessed on 3 March 2019.

2.Chopra M, Galbraith S, Darnton-Hill I. A global response to a global problem: the epidemic of overnutrition. *Bulletin of the World Health Organization* 2002; 80: 952-958.

3.Popkin BM. Nutrition in transition: the changing global nutrition challenge. *Asia Pacific Journal of Clinical Nutrition* 2001;101:13-18.

4.World Health Organization. “Double Burden of Malnutrition.” https://www.who.int/nutrition/double-burden-malnutrition/en/. Accessed on 25th March 2019.

5. Centers for Disease Control and Prevention: BMI guidelines with links to the growth charts. cdc.gov/nccdphp/dnpa/bmi/bmi-for-age.html

6.Cheryl DF, Margaret DC, Cynthia LO. Division of Health and Nutrition Examination Surveys. Prevalence of Overweight and Obesity Among Children and Adolescents Aged 2–19 Years: United States, 1963–1965 Through 2013–2014. Available from: https://www.cdc.gov/nchs/data/hestat/obesity_child_13_14/obesity_child_13_14.htm.Accessed on 3 March 2019.

7.De Onis M, Blossner M..Prevalence and trends of overweight among preschool children in developing countries. *American Journal of Clinical Nutrition* 2000;72:1032-1039.

8. Reddy S, Resnicow K, James S, Kambaran N, Omardien R, Mbewu A. Underweight, overweight and obesity among South African adolescents: results of the 2002 National Youth Risk Behaviour Survey. *Public Health Nutrition* 2008:1–5.

9. Ejike ECC. Child and adolescent obesity in Nigeria: a narrative review of prevalence data from three decades (1983 – 2013). *Journal of Obesity Metabolic Research* 2014; 1:171 – 179.

10.Ahmad MM, Ahmed H, Airede K. Assessment of Body Fat Using Leg-to-leg Bioelectrical Impedance Analysis Method among School Adolescents in Sokoto, North-Western Nigeria. *International Journal of Tropical Disease & Health* 2015; 11:1-7.

11.Adam, V, Isah, I. Prevalence and comorbidities of childhood overweight and obesity among school aged children in an urban settlement in Benin City, Nigeria. *Nigerian journal of paediatrics* 2017;44:7-13.

12.The National Institute of Diabetes and Digestive and Kidney Diseases.2019.Available at https://www.niddk.nih.gov/health-information/weight-management/adult-overweight-obesity/health-risks.Assessed on 26 March 2019.

13. Nwizu SE, Njokanma OF, Okoromah CA, David NA. Relationship between bioelectrical impedance analysis and body mass index in adolescent urban Nigerians. *West African Journal of Medicine* 2011 30: 99–103.

14.Population and Housing Tables, Edo State Priority Table Vol.1. National Population Commission. 2006.

15. Stanley L, David WH, Janelle K, Stephen KL. Adequacy of sample size in health studies. Chichester: John Wiley & sons; 1990. [cited 2019 Mar 10]. Available from: www.isbn139780471925170.

16.Oyedeji GA. Socio-economic and cultural background of hospitalised children in Ilesha. *Nigerian Journal of Paediatrics* 1985;12:111-117.

17.Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal* 2000; 320:1240-1253.

18.McCarthy HD, Cole TJ, Fry T. Body fat reference curves for children. *International Journal of Obesity* 2006;30: 598-602.

19.Javed A, Jumean M, Murad MH, Okorodudu D, Kumar S, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents:A systematic review and meta-analysis. *Pediatric Obesity* 2015;3(10):234–244.

20.Senbanjo IO, Adejuyigbe EA. Prevalence of overweight and obesity in Nigerian preschool children. *Journal of Nutrition and Health*.2007;18(4):391-399.

21.Izuora AN, Animasahun BA, Nwodo U, Ibeabuchi NM, Njokanma OF, et al. Assessment of overweight and obesity among Nigerian children and adolescents using triceps skin-fold thickness and body mass index. *Clinical Obesity* 2013;3(3-4):103-111.

22.Deren K, Nyankovskyy S, Nyankovska O, Luszczki E, Wyszynska J, et al. The prevalence of underweight, overweight and obesity in children and adolescents from Ukraine. *Scientific Reports*|2018;8:3625.

23.Karki, A., Shrestha, A. Subedi, N. Prevalence and associated factors of childhood overweight/obesity among primary school children in urban Nepal. *BMC Public Health* 2019;19:1055.

24.Ismail N, Festus K, Jane W, Vincent O. Prevalence of overweight and obesity among Primary School Children Aged 8-13 years in Dar es Salaam City, Tanzania. *Advances in Preventive Medicine* 2016:1-5.

25.Narciso J, Silva AJ, Rodrigues V, Monteiro MJ, Almeida A, et al.Behavioral, contextual and biological factors associated with obesity during adolescence: A systematic review 2019;14:4.

26.Sobal J, Stunkard AJ. Socioeconomic status and obesity: a review of the literature. *Psychological Bulletin Journal.* 1989;105:260–275.

27.Ahmad A, Zulaily N, Shahril MR, Syed Abdullah EFH, Ahmed A. Association between socioeconomic status and obesity among 12-year-old Malaysian adolescents. *PLoS ONE* 2018;13(7): 1371.

28.Waqia Begum Fokeena, Rajesh Jeewon. Is There an Association between Socioeconomic Status and Body Mass Index among Adolescents in Mauritius? *The Scientific World Journal* 2012;2012

29.Keane E, Kearney PM, Perry IJ. Trends and prevalence of overweight and obesity in primary school aged children in the Republic of Ireland from 2002-2012: a systematic review. *BMC Public Health* 2014;14**:**974.

30.Maruf FA, Aronu U, Chukwuegbu K, Aronu AE. Influence of gender on prevalence of overweight and obesity in Nigerian school children and adolescents.*Tanzania journal of Health Research* 2013; 15(4): 1-6.

31.Shah B, Tombeau Cost K, Fuller A, Birkin CS. Sex and gender differences in childhood obesity: contributing to the research agenda. *BMJ Nutrition, Prevention & Health* 2020;3(2):387-390.

32.Srdic B, Obradovic B, Dimitric G, Stokic E, Babovic SS. Relationship between body mass index and body fat in children – age and gender differences. *Obesity Research & Clinical stanley*

33.Freedman DS, Wang J, Maynard LM, Thornton JC, Mei Z, et al. Relation of BMI to fat and fat free mass in children and adolescents. *International Journal of Obesity* 2005;29:1-8.