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RESEARCH ARTICLE

COMPARING THE USE OF BODY MASS INDEX (BMI) AND TRICEPS SKIN FOLD THICKNESS (SFT) IN DETERMINING THE PREVALENCE OF UNDERWEIGHT, OVERWEIGHT AND OBESITY AMONG PRIMARY SCHOOL PUPILS IN ABAKALIKI METROPOLIS OF EBONYI STATE, SOUTH EAST NIGERIA

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ABSTRACT

Background: Body mass index (BMI) and triceps skinfold thickness thickness (SFT) are assessment tools for underweight, a major health problem in developing countries as well as emerging obesity and overweight.

Objectives: To compare the use of BMI and SFT in determining the prevalence of underweight, overweight and obesity among primary school pupils in Abakaliki metropolis of Ebonyi State, South East Nigeria.

Method: Eight hundred and four pupils (415 males, 389 females), aged 6-12 years, in four public and four private primary schools were selected by a multi stage random sampling. Four hundred and twenty-six (53.0%) subjects were in public schools while 378 (47%) were in private schools. Standard methods were used to determine the weight, height and triceps SFT of the participants. BMI values were calculated for each participant and compared with BMI for age and sex from World Health Organisation (WHO 2007) reference standard and SFT values compared with reference curves for triceps SFT in US children and adolescents for age and sex.

The prevalence of underweight, overweight and obesity among our cohorts using BMI were 5.6% and 6.2%, 3% while using SFT, it was 29.2%, 1.6% and 0.9% respectively.

Conclusion: The prevalence of underweight, overweight and obesity using BMI and SFT were not directly related. When subjected to Kappa analysis, it showed only fair agreement (K= 0.23) as values obtained using BMI were not similar to that obtained using SFT. BMI is more sensitive and specific, with minimal inter- and intra- observer errors. It is internationally more accepted standard, therefore preferred to SFT.

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INTRODUCTION

Underweight, overweight and obesity are all forms of malnutrition. (Monyeki *et al*., 2015) Under nutrition is a major cause of underweight and remains a problem in many developing countries. It contributes to more than one half of all child death. (Monyeki *et al*., 2015) While efforts are being made to reduce hunger, these efforts neglect the growing rate of overweight and obesity. Health systems in the developing countries are simultaneously confronting under-and-over nutrition at national levels, within communities and even households. (Rachmi *et al*., 2016) Both under nutrition and over nutrition are linked to a range of adverse health conditions. Underweight children are susceptible to poor infant health, childhood growth problems and compromised mental development (Tzioumis and Adair, 2014) while obese and overweight children are faced with such chronic diseases as stroke, hypertension, cardiovascular diseases, type 2 diabetes mellitus and some cancers in later life. (Nouri Saeidlou *et al*., 2014; Caulfield *et al*., 2004) Underweight, overweight, obesity can be assessed by anthropometry. (Caulfield *et al*., 2004; Stein *et al*., 2014) This includes measurement of skinfold thickness, mid-upper-arm circumference, height and weight and deriving various height and weight based indices such as weight for age, height for age, weight for height and body mass index (BMI). (Benjamin *et al*., 2014; Gortmaker *et al*., 2011) BMI is the most widely recommended surrogate measure of adiposity among

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other indices derived from weight and height. (Popkin, 2001) It is given by the formula

$$BMI = \frac{\text{Weight (kg)}}{\text{Height } (m^2)}$$

World Health Organisation and the Centre for Disease Control and Prevention (CDC) growth charts define obesity as BMI equal to or greater than 95th percentile, overweight as BMI between 85th percentile to less than 95th percentile and underweight as BMI less than or equal to 5th percentile. (Popkin, 2001) Using BMI Z-score, obesity is defined as BMI Z-score greater than or equal to +2SD, overweight as BMI Z-score greater than +1SD (Nurliyana *et al*., 2016) but less than +2SD and underweight as BMI Z-score less than or equal to -2SD for age and sex. (Miller *et al*., 2011) Skinfold thickness, which is a direct measurement of subcutaneous fat, correlates with total body fat. (Stein *et al*., 2014) Some investigators thus define obesity as triceps skinfold equal to or exceeding the 97th percentile, overweight as less than 97th but greater than 90th percentile and underweight as less than or equal to the3rd percentile for age and sex. (Deckelbaum and Williams, 2001) Others describe obesity as triceps skinfold thickness greater than 85th percentile. (Manyanga *et al*., 2014) Several studies have been done on underweight, obesity and overweight using BMI. (Popkin, 2001; Nurliyana *et al*., 2016; Miller *et al*., 2011; WHO, 2017) Few looked at obesity, overweight using SFT. This study compares underweight, overweight and obesity using BMI and triceps SFT in primary school pupils in Abakaliki metropolis of Ebonyi State, South East Nigeria.

MATERIALS AND METHODS

This study was conducted from April to June 2012 in using pupils from four public and four private primary schools in Abakaliki metropolis, Ebonyi state, South- East Nigeria. Abakaliki metropolis is made up of 2 Local government Areas (LGAs) – Ebonyi and Abakaliki LGAs.

Ethical Approval

Ethical approval for the study was obtained from the Research and Ethical Committee of now called Federal Teaching Hospital Abakaliki, Ebonyi State. Permission to carry out the studies in the selected primary schools was obtained from the Ebonyi State Universal Basic Education Board and the Individual school authorities.

Informed Consent

Informed consent was obtained from each parent/guardian of each child studied after they were given study information sheet written in lay language explaining the study, its benefits and possible risks. Every pupil gave assent before being enrolled in the study. The minimum sample size was used for this study was 804.

Sampling procedure

Two public and two private primary schools were used in each LGA based on the ratio of public to private primary schools in the LGAs. In all eight primary schools (4 public, 4 private) were used for the study. A multistage sampling frame was used to select the requisite 804 participants for the study. A semi structured questionnaire completed by parents/subjects was used to obtain information on child's bio data and parent's socio-economic status. The weight, height and tricep SFT of each participant were measured and BMI calculated. The WHO 2007 BMI Z-score for age and sex criteria of <2SD was defined as underweight. (Caulfield *et al*., 2004) The USA reference standard of triceps skinfold thickness equal to or less than the 3rd percentile for age and sex (Deckelbaum and Williams, 2001) was considered underweight. The WHO 2007 BMI Z-score for age and sex criteria of between + I SD and <+2SD was considered as overweight and ≥ + 2SD as obesity. (Caulfield *et al*., 2004) The USA reference standard of triceps skinfold thickness between 90th to 97th percentile for age and sex (Deckelbaum and Williams, 2001) was also considered as overweight and equal to or greater than 97th percentile for age and sex as obesity. Socioeconomic status of each student was determined based on methods proposed by Oyedeji (Organiztion, 2017). Data analysis was done using statistical packages SPSS Inc. Released 2008. SPSS Statistics for Windows, Version 17.0. Chicago: SPSS Inc.

RESULTS

Table I shows the Mean Body Mass Index of male subjects according to age in public and private schools. The mean values were similar between males in public and private schools except for subjects aged 6 years as well as 9 and 10 years ($p<0.05$). Also, in Table II, females had comparable mean BMI values at ages 7, 8 and 11years, (p =0.84, 0.13 and 0.34 respectively). Subjects aged 9 and 10 years in private schools had significantly higher BMI values than their counterparts ($p <0.001$). Table III and IV show the SFT values of the study population. Both males and females in private schools had consistently higher values when matched for age and sex with their counterparts in public schools, ($p < 0.05$), except at age 11 year in males which was comparable, (p=0.06). However, the mean SFT of female subjects aged 6 and 12 year could not be compared because there were no subjects of such ages in public and private schools respectively. Table V shows the prevalence of underweight, overweight and obesity in private and public schools using BMI. More subjects were underweight in the public schools when compared to those in private schools (8.5% vs 2.4%). On the other hand, more subjects were overweight in private schools, when compared to public schools (10.6% vs 2.3%). Obesity was recorded only in private schools. Table VI. Prevalence of underweight, overweight and obesity in private and public schools using SFT Table VII compared the prevalence of underweight, overweight and obesity using BMI and SFT. Underweight was observed more using SFT in the study population. Although there was no finding of obesity in the public school using both BMI and SFT, there was no direct relationship between using BMI or SFT to assess body weight. These comparisons were subjected to kappa analysis. (Owa *et al*., 1997) The result was 0.23, showing only fair agreement. (< 0.02= poor agreement, 0.21-0.04= fair agreement, 0.41- 0.60 = moderate agreement, 0.61-0.80 = good agreement and 0.81-1.00 = very good agreement). (Owa *et al*., 1997)

DISCUSSION

BMI is a ratio of the body weight to the square of the height. In this study, BMI values in the participants increased with age as expected. (Brook, 1971) The BMI values for males in private schools were higher than those of their counterparts in public schools when matched for age and sex.

Table 1. Mean body Mass Index (BMI) of male subjects by age in public and private schools

	Public				Private							
Age	N	Mean	Range	95% CI	N	Mean± SD	Range	95% CI	diff	t	df	p-value
6	40	14.6±1.3	12.1-17.4	14.15-14.99	59	15.3±1.3	9.0-17.3	14.93-15.62	-0.71	-2.61	97	0.01
7	16	15.4±0.8	13.9-16.5	14.89-15.83	28	15.9±1.4	13.8-17.8	15.37-16.42	-0.53	-1.39	42	0.17
8	23	16.0±0.9	14.1-18.0	15.56-16.35	38	15.5±2.2	13.4-23.8	14.78-16.25	0.44	0.89	59	0.38
9	22	15.8±1.4	13.4-18.3	15.14-16.40	27	18.0±2.8	14.0-23.4	16.91-19.11	-2.24	-3.43	49	<0.001
10	24	15.8±1.1	13.8-17.9	15.34-16.23	23	17.0±2.2	14.8-23.6	16.01-17.89	-1.17	-2.35	45	0.02
11	30	16.0±0.9	14.1-17.6	15.64-16.36	3	16.3±0.2	16.0-16.4	15.69-16.84	-0.26	-0.46	31	0.64
12	66	16.8±1.7	13.7-21.8	16.37-17.22	16	17.1±1.7	14.0-20.9	16.26-18.07	-0.37	-0.78	80	0.43

Table 2. Mean body Mass Index (BMI) of female subjects by age in public and private schools

	Public				Private							
Age	N	Mean	Range	95% CI	N	Mean± SD	Range	95% CI	diff	t	df	p-value
6	-	-	-	-	29	16.1±2.1	13.5-20.4	-	-	-	-	-
7	12	15.6±0.9	14.0-16.9	15.07-16.20	33	15.8±2.0	13.4-22.7	16.05-16.48	-0.12	-0.20	43	0.84
8	20	15.1±1.3	13.2-17.2	14.51-16.70	29	16.1±2.7	13.3-24.7	15.08-17.10	-0.99	-1.54	47	0.13
9	43	15.4±1.2	13.4-17.8	14.98-15.72	23	17.4±2.8	13.7-24.7	16.15-18.57	-2.01	-4.07	64	0.001
10	34	15.9±1.5	13.6-20.6	15.41-16.48	54	12.2±3.0	14.3-25.4	17.36-19.02	-2.24	-4.00	86	0.001
11	34	19.9±2.7	2.0-18.5	14.92-16.81	16	16.5±1.0	14.5-18.9	15.99-17.07	-0.66	-0.95	48	0.34

Table 3. Skin fold thickness value of the male subjects by age in private and public school

	Public				Private							
Age	N	Mean± SD(mm)	Range± SD(mm)	95% CI	N	Mean± SD(mm)	Range± SD(mm)	95% CI	diff	t	df	p-value
6	40	5.6±2.5	2.1-11.0	4.75-6.35	59	6.7±1.7	4.1-12.3	6.24-7.11	-0.71	-2.70	97	0.010
7	16	4.3±2.2	2.2-9.1	3.13-5.43	28	6.5±2.5	3.0-11.3	5.58-7.50	-0.26	-3.06	42	<0.001
8	23	4.7±2.0	2.3-9.1	3.82-5.56	38	7.4±4.6	3.2-32.4	5.84-8.89	-2.67	-2.61	59	0.010
9	22	6.0±3.1	2.3-13.3	4.63-7.37	27	9.3±3.8	2.1-15.4	7.77-10.81	-3.29	-3.25	47	<0.001
10	24	5.2±2.2	2.3-10.4	4.35-6.07	23	7.9±3.8	4.2-18.0	6.29-9.59	-2.78	-3.09	45	<0.001
11	30	4.5±1.6	2.3-7.3	3.88-5.08	3	6.5±3.3	2.8-8.9	1.59-14.66	-2.05	-1.92	31	0.06
12	66	5.7±1.9	3.4-12.4	5.39-6.32	16	10.4±3.9	5.4-18.8	8.32-12.44	-4.52	-6.79	80	<0.001

Table 4. Skin fold thickness value of female subjects by age in private and public school

	Public				Private							
Age	N	Mean± SD(mm)	Range± SD(mm)	95% CI	N	Mean± SD(mm)	Range± SD(mm)	95% CI	diff	t	df	p-value
6	-	-	-	-	29	8.5±1.4	`6.4-11.7	`6.4-11.7	-	-	-	-
7	12	5.1±2.8	2.2-12.1	3.31-6.81	33	8.4±4.3	3.5-21.1	6.85-9.91	-3.32	-2.48	43	0.020
8	20	6.5±2.2	2.4-9.4	5.41-7.49	29	11.0±4.7	5.4-22.2	9.17-12.78	-4.52	-3.92	47	<0.001
9	43	6.1±2.3	2.3-11.3	5.37-6.76	23	12.6±7.2	6.4-33.2	9.43-15.69	-6.49	-5.45	64	<0.001
10	34	6.7±3.8	2.1-22.8	5.35-7.98	54	11.6±4.0	5.4-22.9	10.54-12.74	-4.97	-5.77	86	<0.001
11	34	6.5±4.1	2.1-22.4	5.09-7.96	16	10.2±3.7	2.5-17.2	8.21-12.15	-3.65	-3.02	48	<0.001

Table 5. Prevalence of underweight, overweight and obesity in private and public schools using BMI

	Public schools	Private schools	Total
Underweight	36 (8.5%)	9 (2.4%)	45 (5.6%)
Normal	380 (89.2%)	305 (80.7%)	685 (85.2%)
Overweight	10 (2.3%)	40 (10.6%)	50 (6.2%)
Obesity	-	24 (6.3%)	24 (3.0%)

Table 6. Prevalence of underweight, overweight and obesity in private and public schools using SFT

Public school		Private school	Total
Underweight	202(47.4%)	33(8.7%)	235(29.2%)
Normal	222(52.1%)	327(86.5%)	549(68.3%)
Overweight	2(0.5%)	11(2.9%)	13(1.6%)
Obesity	-	7(1.9%)	7 (0.9%)

Table 7. Measurement of agreement between BMI using WHO standard and SFT using US standard

	BMI			SFT		
	Public	private	total	public	private	total
Underweight	36(8.5%)	9(2.4%)	45(5.6%)	202(47.4%)	33(8.7%)	235(29.2%)
Normal	380(89.2%)	305(80.7%)	685(85.2%)	222(52.1%)	327(86.5%)	549(68.3%)
Overweight	10(2.3%)	40(10.6%)	50 (6.2%)	2(0.5%)	11(2.9%)	13(1.6%)
Obesity	0(0%)	24(6.3%)	24(3.0%)	0(0%)	7(1.9%)	7(0.9%)

Similarly, females in private school also had higher BMI values than their counterparts in public schools. In all, females had higher values when compared with males. In this regard, the findings in the current study are similar to those reported by Owa and Adejuyigbe (Miller *et al*., 2011) as well as Ansa and colleagues (Popkin, 2001) who also found that BMI in both sexes increased with age. The triceps SFT values of the study population in the present study increased progressively with age. Both males and females in private schools had consistently higher values when matched for age and sex with their counterparts in public schools. The progressive increase of the SFT of the study population could be explained by the steady physical growth experienced by the mid-childhood when they gain about 3 to 3.5kg/year in weight and 6cm/year in height (Centers for Disease Control and Prevention, 2017). Higher values in females could be explained by the fact that females have more adipose tissues than males. In the present study the overall prevalence of underweight, overweight and obesity using BMI Z score for age and sex were 5.6% (3.5% of males, 2.1% of females), 6.2% (3.1% of males, 3.1% of females) and 3.0% (1.2% of males, 1.7% of females) respectively. Prevalence of underweight was low and when compared with other Nigerian (Opara *et al*., 2010) and international studies (Araoye, 2003; Oyedeji, 1985) were found to be at a much lower level. The prevalence of overweight though raised, was lower when compared with other studies. (Araoye, 2003; Oyedeji, 1985; Landis and Koch, 1977) The prevalence of obesity in the present study was also lower compared to some Nigerian studies. (Miller *et al*., 2011; WHO, 2017) Increasing urbanization with life style changes might be responsible for the observed increased prevalence of overweight and obesity in our cohorts. However, the poverty rate in Ebonyi state may be responsible for the observed comparatively lower rates in our study group. This was reflected in the SEC (Socio-Economic Class) of the Using the SFT in the current study, the overall prevalence of underweight, overweight and obesity were 29.2% (15.7% of males and 13.6% of females), 1.6% (0.5% of male and 1.1 % female) and 0.9% (0.1% of males and 0.7% of females) respectively. Underweight was found more in males in public schools. Overweight was more in females who were in private schools. Obesity was found only in private schools with females more affected than males. This may be related to the higher adipose tissue mass in females compared to males Similar studies done by Akesode and Ajibode (Manyanga *et al*., 2014) in Abeokuta reported overweight and obesity rates higher in males. The weight, height, BMI and SFT of female subjects aged 6 and 12years were not obtained in the present study because there were no subjects of such ages in public and private schools respectively. For those aged 6 years in public schools, the possible explanations could be that, these children who are likely to come from lower socio-economic class are seen by their parents to be too young to be enrolled into schools while females aged 12 years in private were not recorded possibly because pupil in private school and likely to come from upper socio-economic class and are enrolled earlier into school, therefore complete their primary education before 12 years of age. Since the reference curve for SFT corresponding to the CDC Growth Chart for children above five years of age were not published with the other growth variables, researchers had to provide reference percentiles for triceps and sub scapular SFT that directly corresponded to the CDC 2000 Growth Chart for US children above five years. (Prentice, 1998; Ansa *et al*., 2008; Isaranurug, 1999) These may likely explain the high prevalence of underweight using the SFT, Since the US children used may be of a relatively higher SEC with comparatively better nutrition and higher fat cell mass. (Glew *et al*., 2003)

In this study, underweight was observed more using SFT when compared to the use of BMI. This may be due to the American reference standard used for SFT in the current study since American children are fatter than their counterparts. (Glew *et al*., 2003) Using Kappa analysis (Owa *et al*., 1997), there was only fair agreement (K=0.23) between BMI and SFT. This further explains the discrepancy in the prevalence of underweight, overweight, obesity and strengthens the case for the use of universally accepted BMI standard rather than the American SFT in our own environment. The higher prevalence of underweight using SFT compared to BMI further demonstrates the fair agreement between BMI and American SFT. Most Nigerian studies use BMI in assessing overweight and obesity (WHO, 2017; Opara *et al*., 2010; The NHS information Centre, 2017; Sanchez-Cruz *et al*., 2013) few used SFT (Manyanga *et al*., 2014) but none has used SFT to assess underweight. These may be related to this fair agreement. WHO/NCHS still recommends the use of BMI percentiles or BMI Z score in determining nutritional status. (Organiztion, 2017) It is described as the best surrogate measure of adiposity among other indices derived from height and weight measurements. (Thibault *et al*., 2013) It is simple to use, quick, effective and applies to adult men and women, as well as children. While it does not directly measure body fat, it is more accurate at approximating degree of body fat than weight alone. (Brook, 1971; Addo and Himes, 2010)

Conclusion

The prevalence of underweight, overweight and obesity using BMI was markedly different from the values obtained using SFT. When subjected to Kappa analysis (K=0.23), it showed only fair agreement. BMI is preferred to SFT since there is no internationally accepted standard for SFT. Also SFT is associated with inter- and intra- observer errors which could give inappropriate results. When compared to SFT, BMI is more sensitive and more specific. (Cronk and Roche, 1982)

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