

Comparison of Body Mass Index between Pubertal and Prepubertal Females in Okrika

Opuogulaya Richard^{1*}, Ekiyor Tari¹, Aisueni Florence¹, Richard Alice²

1 School of Applied Sciences, Rivers State Polytechnic, P.M.B. 20, Bori, Nigeria.

2 State School, Ogan-Ama, Okrika, Nigeria.

Abstract

This research work is aimed at examining the effect of pubertal development on body fat in females. 920 female students drawn from 5 secondary schools in Okrika of Rivers State in Nigeria were used as respondents. 460 of these are pubertal while the other 460 are prepubertal. With the aid of a questionnaire, their pubertal or prepubertal status; i.e. presence of pubic hair and/or breast bud, commencement of menstruation was gotten. Their height and weight was also gotten. BMI was calculated for prepubertal and pubertal females and compared statistically. The mean BMI of pubertal females, 19.7, is arithmetically higher than that of prepubertal females, 17.7 and the difference between the mean BMI is very statistically significant ($P < 0.05$). For each age, the BMI of pubertal females was found to be higher than that of prepubertal females and as exemplified by the age groups 12 years and 13 years, the differences between the mean BMI for each age was found to be significant ($P < 0.05$). Irrespective of the pathway the respondents took to puberty, adrenarche or thelarche, the BMI of pubertal females were significantly ($P < 0.05$) higher than that of prepubertal females. BMI significantly ($P < 0.05$) increased with progression in pubertal development. The BMI of pubertal females is greater than the BMI of prepubertal females: hence pubertal females have greater body fat than prepubertal females. Females that have reached puberty and are undergoing pubertal development should be careful not to give in wholly to weight reduction programmes.

Keywords: BMI, Pubertal, Prepubertal, Body fat.

1.0 Introduction

The aspect of science which deals with the measurement of size, weight and proportions of the human body is known as anthropometry (Dorland's Illustrated Medical Dictionary, 2000). Measurement of the human body arises due to extensive variations existing within human population. The differences in characteristics shown by humans among several others include weight, linear dimension, shape and colour (Taylor, Green & Stout, 1997). Anthropometry deals with the physical form of variation.

Most times, single anthropometric parameters do not give a circumspect view of the body form. For this reason, it is common to find two or more anthropometric measurements that correlate to form an index. Somatometry is an aspect of anthropometry and deals with the measurement of the dimensions of the entire body (Miller-Keane Encyclopaedia..., 2003). Height, weight and body circumferences are important parameters of somatometry. Height and weight have been used to alternatively measure body fat.

Body mass index (BMI), which is the body weight divided by the square of the height, is a convenient and reliable indicator of body fat (Ganong, 2003). BMI was originally developed in 1832 by Adolphe Quetelet (Eknoyan, 2008). Expressed mathematically, $BMI = \text{Weight (Kg)} / \text{Height}^2 (\text{m}^2)$.

BMI is considered an alternative to direct measure of body fat and a high BMI value can be an indicator of high body fat (Centre for Disease Control, CDC).

The international classification of adult (20 years and above) status according to BMI is;

Classification/Category	BMI value (Kg/m ²)
Underweight	< 18.50
Normal	18.50-24.99
Overweight	≥ 25
Obese	≥ 30

(WHO: Global Database of BMI)

Adult BMI values are age and sex independent but may not correspond to the same degree of fatness for all populations due to different body proportions (WHO: Global Database of BMI, 2006). For children and teens (2-19 years), the BMI value is interpreted relative to that of other children of the same age and sex as compared percentiles (CDC). Differences in BMI between persons of the same age and sex are usually due to body fat (Ministry of Health & Nutrition, Sri Lanka).

Puberty is the period of life at which the ability to reproduce begins. It is the stage of development when genitalia reach maturity and secondary sex characteristics appear (Mosby's Medical Dictionary, 2009). It consists of dynamic processes that involve psychosocial issues, secondary sex characteristics and stature or body composition (Sanfilippo & Jamieson, 2008). It has no set age of commencement (National Health Service, NHS) and may begin from 8 to 14 years in females (Peter, 1980; Burrows, Diaz & Mezzo, 2004). The first sign of pubertal changes may be observed before 9 years in girls (Taranger, Engstrom, Lichtenstein & Svenberg-Redegren, 1976) while to Wheeler (1991), the first sign of puberty, development of breast, appear 8 to 13 years. Krista et al (2010), said 10.9 and 10.95 years is the median age at which breast and pubic hair begin to develop; obesity being a contributing factor for earlier onset of puberty in girls (Kaplowitz, Slora, Wasserman, Pedlow & Herman-Giddens, 2001). Baker (1985) has noted that the onset and progression through pubertal stages is more related to weight than chronological age in females. Females reach full maturational stage at mean age 14.7+/-1.3 years and 14.4+/-1.4 years of breast bud and pubic hair development (Fakeye & Fagbule, 1990). Within four years of starting puberty, most girls reach full maturity (NHS) completing puberty by age 12.4 to 16.8 years (Peter, 1980). The duration of puberty depend on the time it begin; the earlier the onset, the longer the duration (Marti-Hennerberg & Vizmanos, 1997).

Normal pubertal development is characterized by major physical alternations, skeletal growth being the most striking (Wheeler, 1991). Growth spurt of 3 to 5 inches a year are common (Harvard Health Publication, nd) pubertal growth accounting for 20% of final adult height in females (Neinstein, nd). In females, about 50% of lifetime total body calcium is deposited into bones during the first half of puberty (John, nd) making peak height velocity an early event (Taranger et al., 1976). At puberty, both sexes gain weight due to somatic growth and deposition of minerals in the bones (John, nd), fat mass increases in girls at the late stages of puberty (Wheeler, 1991). Pubertal weight gain accounts for 50% of the female adult body weight (Neinstein, nd) and from menarche to 18 years, girls become fatter as normal menstrual function is lost due to weight loss (Frisch & McAuthur, 1974). Relative weight increases are a consequence of rather than a determinant of age at menarche (Demarath et al., 2004).

BMI is associated with biological and not chronological age during puberty (Burrows et al., 2004), its value in girls depend on pubertal degree of maturation (Bini et al., 2000). Normal puberty require a particular threshold ratio of fat to lean mass (Rose & Frisch, 1984) pubertal maturation being associated with greater height, weight and body mass index (Morrison et al., 1994). Age adjusted body mass index contributes significantly to waist circumference, hip circumference and waist/hip ratio (Hamner et al., 1991); in both sexes body mass index and waist circumference increased during puberty while fat-mass percentage increased steadily in females only (Lu et al., 2012).

Menarcheal females have greater mean BMI than premenarcheal females (Vitalle et al., 2003) while females who enter puberty through thelarche pathway had greater skinfold thickness, BMI and percent body fat a year before pubertal onset as well as throughout puberty as compared to those of adrenarche pathway (Biro et al., 2003).

Postmenarcheal females have BMI higher than same age premenarcheal females to have been engaged in activities so as to lose weight (Abraham & O 'Dea, 2001). Premenarcheal gymnast have lower BMI and less body fat as compared to menarcheal gymnast (Klentrou & Plyley, 2003); gymnast also have a significantly delayed age at menarche, less body fat, were shorter and lighter than non-gymnast (Lindholm, Hagenfeldt & ringertz, 1994). Significant differences occur in mean BMI when children of the same chronological age but in different Tanner stages are compared (Burrows et al., 2004) and because of this, it will be required that the evaluation of BMI be done only within the same sexual stages in adolescence (Yalcin & Kinik,1999).

2.0 Method

Respondents for this research work were drawn from five secondary schools all in Okrika of Rivers State in Nigeria. 1200 female students of the age range 10-19 years responded. The essential information needed from

the respondents were their height and weight; pubertal or prepubertal status; aged and their local government areas. This information was used to formulate a questionnaire.

As we got to the schools after that permissions were granted and with the help of a female teacher, female students were congregated. They were taught about puberty, its signs and morphological changes. The questionnaires were issued them and they were instructed how to fill them. Height of the respondents were measured by making them stand barefooted and erect against the measuring tape; fixed to a door, their eyes facing straight ahead. A 12 inch metric rule was placed over their vertex and the height read off in meters.

A weight measuring scale was used to measure the weight of the respondents. The respondents were asked to remove their sandals, stand squarely and in an erect position on the scale. Their weight was read off in kilograms with the aid of the pointer.

The respondents were asked to submit their questionnaires to us directly during which breast examination was done by sight and palpation by the female teacher. Their questionnaires were marked yes (for those with breast bud) and No (for those without breast bud). Questionnaires that have vital questions i.e. 1, 6, 8, 10, & 11 not filled and those in which the respondent age is above 17 years were discarded during sorting. We made an assumption that any questionnaire that is completely & correctly filled; has the respondent age within the range of 10-17 years had every information in it valid. 920 students, 460 pubertal females and 460 prepubertal females, were the final respondents used after sorting.

Body mass index was calculated for 920 respondents; 460 pubertal, 460 prepubertal. The calculated data was then statistically analysed.

3.0 Result

In the course of this work, 920 respondents (460 prepubertal and 460 pubertal females) were used and their BMI computed. For the comparison of mean, the Z-test was used. The Z-test allows in its usage statement of hypothesis.

Statements of Hypothesis:

Null hypothesis (H_0): it states that there is no significant difference between the means being compared i.e. $U_1 = U_2$.

Alternative hypothesis (H_1); it states that there is significant difference between the means being compared i.e. $U_1 \neq U_2$

Throughout our analysis, we used 0.05 level of significance and 95% confidence level. At 0.05 level of significance, the critical value or tabulated value of Z (Z-tab) for a two tailed test is ± 1.96 and this value was used throughout our analysis.

The acceptance or rejection of the statement of hypothesis (i.e. H_0 and H_1) is dependent on

1. The values of Z calculated (Z Cal or Z score) and the critical value (Z-tab). If the positive value of Z Score is higher than + 1.96 or it's negative value less than - 1.96 the null hypothesis is rejected.
2. The value of significance level and P-value. If P-value is lower than the value of the significance level, the null hypothesis is rejected but if it is higher, the null hypothesis is accepted.

The alternative hypothesis is accepted whenever the null hypothesis is rejected.

Table 1: Mean (\bar{x}) BMI and Frequency for each Age of Pubertal and Prepubertal Females:

Age	PREPUBERTAL FEMALES		PUBERTAL FEMALES	
	Frequency	\bar{x} BMI	Frequency	\bar{x} BMI
10	22	18.76	19	18.91
11	183	18.1	17	18.75
12	136	17.2	61	18.44
13	104	17.5	135	18.6
14	15	18.2	102	20.5
15			42	21.4
16			62	21.1
17			22	21.4

Mean BMI for prepubertal females is 17.7

Mean BMI for pubertal females is 19.7

As can be seen from the table, the mean BMI for each age are markedly greater in females that are pubertal as compared to those that are prepubertal.

Table 2: Statistical values and mean age for pubertal and prepubertal females:

	PUBERTAL FEMALES	PREPUBERTAL FEMALE
Mean (\bar{x})	19.7	17.7
Standard deviation (SD)	3.7	2.9
Standard error (SE)	0.172	0.135
Variance (SD^2)	13.69	8.41
Number of observation	460	460
Mean age	13.7	11.8

The Z-test was used to compare the mean BMI of pubertal and prepubertal females. At 0.05 level of significance, Z score 9.12 was greater than Z-tab 1.96. P-value which was less than 0.00001 is far less than the significant level. This has shown that the difference between the mean BMI of pubertal and prepubertal females is statistically very significant; the mean BMI of pubertal females being greater.

To examine whether the differences in mean BMI for each age group is statistically significant, the age group 12 and 13 was chosen.

Table 3: Statistical values of pubertal (12 & 13 years) and prepubertal (12 & 13 years) females:

	PUBERTAL FEMALES		PREPUBERTAL FEMALES	
	Age 12	Age 13	Age 12	Age 13
\bar{x}	18.4	18.6	17.2	17.5
SD	3.08	3.65	2.26	3.35
SE	0.3893	0.31	0.1936	0.35
SD ²	9.23	13.32	5.12	12.46
Number of observation	61	135	136	104

When the mean BMI was compared for the age group 12 years of prepubertal and pubertal females, the Z score 2.76 was found to be greater than the critical value of 1.96. The P-value, 0.0058 is also less than the 0.05 level of significance. Significant difference exists between the two mean, the mean BMI of age group 12 years for pubertal females being greater than the prepubertal 12 years females. For the age group 13, the Z score 5.03 gotten is higher than the critical value 1.96. The P-value less than 0.00001 is far less than the significance level of 0.05. The difference between the two mean BMI of the age group 13 is statistically extremely significant. The mean BMI of pubertal 13 years old females being higher than that of prepubertal 13 years old females.

The hormonal basis of pubic hair development is distinct from that of breast development but the trend for early pubic hair development in females is nevertheless very similar to the trend for early breast development. Some females enter puberty through thelarche pathway, some through adrenarche pathway while some have asynchronous development. We examined whether significant difference existed statistically between the mean BMI of prepubertal females and females with only pubic hair on the one hand and also of prepubertal females and females with only breast on the other hand.

Table 4: Statistical values of prepubertal and pubertal (only breast and only pubic hair) females:

	PREPUBERTAL FEMALES	PUBERTAL FEMALES	
		Only breast	Pubic hair only
\bar{x}	17.7	19.9	19.4
SD	2.9	4.67	3.74
SE	0.135	0.575	0.372
SD ²	8.41	21.81	13.99
Number of observation	460	66	101
Mean age	11.8	11.3	11.2

At 0.05 level of significance, when the mean BMI of females with only pubic hair was compared to prepubertal females, the Z score 4.36 was found higher than the Z-tab 1.96. The P-value 0.000014 is less than the level of significance. The mean BMI of females with pubic hair only is higher than that of prepubertal females. 3.73 is the Z score gotten when the mean BMI of females with breast only was compared with prepubertal females and this is higher than 1.96 the value for Z-tab. P-value 0.0002 is less than the significance level. The differences

between the mean BMI is statistically very significant, the mean BMI for females with breast only being higher than that of prepubertal females.

Menarche is an event that occurs approximately two years after the onset of puberty. Comparison was made between the mean BMI of menarcheal females (\bar{x} =20.9; n 182) and that of prepubertal females (\bar{x} =17.7; n 460). The Z score for this comparison, 10.03 is greater than Z-tab of 1.96. P-value less than 0.00001 is far less than the 0.05 level of significance. The difference between these mean is statistically extremely significant. Mean BMI for menarcheal females is higher than that of prepubertal females.

Among pubertal females, 460 respondents, an examination was made to find if significant differences existed between the mean BMI of premenarcheal females and menarcheal females.

Table 5: Statistical values of menarcheal and premenarcheal females:

	MENARCHEAL FEMALES	PREMENARCHEAL FEMALES
\bar{x}	20.9	19
SD	3.09	4.04
SE	0.23	0.244
SD ²	15.2	16.48
Numbers of observations	182	278
Mean age	14.9	12.8

At 0.05 level of significance, the Z score 5.01 was found higher than the critical value 1.96 confirming the existence of statistically significant difference. The level of significance 0.05 is higher than the P-value which is less than 0.00001. The mean BMI of menarcheal females is higher than the mean BMI of premenarcheal females.

4.0 Discussion

Several earlier studies have indicated that differences existed in body fat between pubertal females and those that have not reached puberty. The results presented in this research work provide further support. From the result, the mean BMI for pubertal females was 19.7 while that for prepubertal females was 17.7. The difference between these two means is very statistically significant ($P < 0.05$). The BMI of pubertal females is higher than that of prepubertal females and since BMI is a reliable indicator of body fat (Ganong, 2003) and an alternative to direct measure of body fat (CDC), pubertal females have higher body fat.

At puberty and during pubertal development, females exhibit distinctive morphological characteristics; weight is gained due to somatic growth and mineral deposition in bones (John, nd), changes occur in body composition, fat mass increases at the later stage (Wheeler, 1991). Wheeler (1991) noted that skeletal growth is a striking pubertal characteristic while according to Neinstein (nd) pubertal growth accounts for 20% of final adult height and weight gain at puberty accounts for 50% of an adult's ideal weight. All these changes associated with pubertal development do not occur in prepubertal females.

The result of this study also shows that for each age, pubertal females have higher mean BMI as compared to prepubertal females. The age group 12 and 13 years clearly showed that the differences between each age group mean BMI is significant ($P < 0.05$). A difference in BMI among persons of the same age and sex is due to body fat (Ministry of Health & Nutrition, Sri Lanka).

Females enter puberty either through thelarche or adrenarche pathway. Whichever pathway is followed, the development of secondary sexual characteristics caused by hormones do manifest. The findings reported here documented significant differences ($P < 0.05$) in mean BMI of females with breast only as compared to

prepubertal females. It was also found that significant difference ($P < 0.05$) existed between the mean BMI of females with pubic hair only and the mean BMI of prepubertal females.

Menarche is a late event in girls that occur after peak height velocity (Taranger et al., 1976) and generally occurs within two years of the onset of breast development (Wheeler, 1991). The findings of this research work also revealed that significant difference ($P < 0.05$) existed between the mean BMI of menarcheal and prepubertal females. All these result buttress the fact that the body mass index and hence the body fat of pubertal females is higher than that of prepubertal females.

This research also document that the difference between menarcheal females mean BMI as compared to the mean BMI of premenarcheal females was significant ($P < 0.05$). From menarche to age 18 years, girls relatively become fatter (Frisch & McAuthor, 1974) as fat mass increases in girls in the late stages of puberty (Wheeler, 1991). This may be due in part to the fact that the level of oestrogen at the early stages of puberty is low when compared to its level in mid and late puberty.

5.0 Conclusion

The body mass index and hence the body fat of pubertal females is higher than that of prepubertal females: this is the finding of this research work. The mean BMI of pubertal females, 19.7, is arithmetically higher than that of prepubertal females, 17.7 and the difference between these two mean is very statistically significant ($P < 0.05$). For each age, BMI of pubertal females was found to be higher than that of prepubertal females and irrespective of the pathway taken to puberty, pubertal BMI is higher than prepubertal BMI.

Body fat increased with pubertal development: this is shown by the significant ($p < 0.05$) difference between mean BMI of menarcheal & premenarcheal females. Increase in body weight during pubertal development is a biological phenomenon and not due to reckless living. Adolescent females are advised not to give in completely to weight reduction programmes during pubertal development.

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APPENDIX

QUESTIONNAIRE

(Please tick or answer as appropriate)

1. Age
2. Sex
3. Present class
4. L.G.A
5. Marital Status
6. Have you experienced menstruation (menses) before? Yes No
7. If yes, at what school age / class
8. Have you notice hairs in your armpit and / or pubic area Yes No
9. If yes, at what school age / class
10. Weight
11. Height
12. Have you been admitted in a hospital before? Yes No
13. What is your meal status
Three square

Others