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SEXUAL DIMORPHISM: INVESTIGATION OF THE VARIATIONS IN BODY WEIGHT, HEIGHT, WAISTLINE AND BMI IN A NIGERIAN GROUP BETWEEN AGE FIFTEEN AND TWENTY

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Abstract: Sexual dimorphism is a term used to describe the phenotypic difference between males and female of the same species. In humans this term describes features that basically differentiate the male and the female sexes morphologically. This investigation was aimed at examining the nature and extent of Sexual Dimorphism relative to weight, height and waistline in the target population. Sexual dimorphism is in the mainstream of biomedical research because of the importance of its applications across several areas of human endeavour. The need for specific data that will accurately and adequately present and represent the nature, pattern and extents of sexual dimorphism in the Nigerian population- a nation that accounts for one of the largest negroid populations of the world is considered paramount to science and its applications. 520 randomly selected volunteers within the target population were considered and data were taken based on relevant parameters. Weights were recorded using the Adult Weight Scale, Platform XH- Model [ZT-150A]; heights with the use of the scale meter rule and waistline size with the aid of the rubber tape rule while taking necessary measures and precautions to ensure accuracy. BMI for each subject was calculated using the values of height and weight obtained (BMI = Weight (kg) / [Height (m)]^2. All calculations were done using the SI units and results were analysed and compared using descriptive statistical methods. It was found that sexual dimorphism was evident and varies with age based on the selected parameters. Sexual dimorphism in forms of weight, height and waistline presents significant variations in the target population.

Keywords: Sexual Dimorphism Height Weight Waistline Nigeria BMI.

INTRODUCTION

Sexual dimorphism is a term used to describe the phenotypic difference between males and female of the same species. In humans this term describes features that basically differentiate the male and the female sexes. This investigation was aimed at examining the nature and extent of Sexual Dimorphism relative to weight, height and waistline in the study group. In addition to variation in sex, genetic and environmental factors have been reported to have observable effects on weight, height and body sizes of people especially across races and groups of populations. To this end, globally generalized data as well as reports from other population groups, races and regions of the world required being checked, analysed and compared with the data obtained from a particular population. Sexual dimorphism is in the mainstream biomedical research because of the importance of its applications across several areas of human endeavour.

Genetically, sexual dimorphism is primarily as a result of the Y chromosome- the sex variation determining factor. Sexes are primarily determined by the sex chromosomes X and Y; the X determines the female sex while the Y chromosome determines the Y sex giving a genotype of XY or XX for the male and female sexes respectively. This is however modulated by a number of post-fertilization life events especially by virtue of various interactions between the formed

human and the environment. Other genetic factors associated with races, populations and anomalies could play observable roles as well. While sexual dimorphism have been reported to manifest in several forms and functions; it is important to note that the emphasis of this investigation is form. More specifically it primarily has to do with the musculoskeletal and body mass forms of dimorphism as observable in the height, weight, waistline and the BMI.

Sexual dimorphism in human body composition is evident from fetal life, but well defined primarily during puberty. At birth, males have a similar fat mass to females but are longer and have greater lean mass. Sexual dimorphism differences remain detectable during childhood-before puberty (Faulkner *et al.*, 1993; Nelson *et al.*, 1997; Taylor *et al.*, 1997; Mast *et al.*, 1998; Kirchengast 2002; Wells, 2007); however, females enter puberty earlier and undergo a more rapid pubertal transition, whereas boys have a substantially longer growth period (Wells, 2007). Very important and arguably post-pubertal most obvious variations between males and females are features related to reproductive role. Hence sexual dimorphism becomes more pronounced after puberty (Loomba-Albrecht and Styne 2009); implying that puberty marked a critical point of radical difference (Haqq and Donahoe 1998). This is also associated with production of sex-specific hormones (Rosenbaum and Leibel 1999; Gatford *et al.*, 1998). These with respect to forms would include gonadal differentiation, genital differentiation, development of the breast in the female and very relevant to the current study- the differentiation of muscle mass and height. Other phenotypic variations are more related to life functions and natural roles on the basis of gender.

Physical sexual dimorphism in adult humans is quite observable in the regions of the lower half of the face, the chest, the waist and hips. In the United States, among citizens above twenty years of age, the male was reported to weigh 15% more than females on the average (Ogden *et al.,* 2004) and they are also about 15cm taller (Gustafsson and Lindenfors, 2004). While men have larger waist relative to their hips, women generally have larger hips than men. Males generally have also been found to have higher muscle-mass to body-mass ratio (Maughan, 1983). Males develop muscles around the chest more than the hips especially in adult life; though the extents vary greatly on the basis of body use. Females were reported to be 52-66% as strong as males in the upper body and about 70-80% as strong in the lower body (Miller *et al.,* 1993).

Musculoskeletal structures of the male are denser than the female's. This largely accounts for the variation in the average body mass for the genders and would normally over shadow the usually increased adipose deposition- in the hips and trunk especially- that occur in the female. The pelvis shape and size would play a major role in the dimorphism observed in the lower body. In the male the pelvis is more massive, stronger, deep and narrower whereas it is lighter, wider and shallower in the female. The typical type for the male is the android while for the female it is gynecoid (Moore and Dalley, 2006). These are adaptations primarily for reproduction and natural roles. Body Mass Index (BMI) is a value calculated from a person's weight and height; and it fairly measures the body fatness for most people (CDCP, 2014).

Kirchengast (2010) wrote that in humans: males and females differed significantly in body composition throughout life. More so at pre-puberty, girls exhibited a significantly higher amount of body fat and a significantly lower amount of lean body mass than their male counterparts. He further added that these features of gender dimorphism would continue

throughout life. He further reported the average lean body mass difference between male and female humans less than thirty to be 11kg; and throughout life, values were consistently higher for males. In several species of organisms, the females are usually larger than their male counterparts; however, in mammals commonly the opposite is true as the males are typically larger (Bulte and Bloin-Demers, 2009). While earlier in life, during childhood, variations in body weight is primarily associated with lean mass, in late childhood and during adolescence, the variations are more associated with body fat. Furthermore it has been reported that across growth intervals greater height gain is being more associated with higher lean but not fat mass (Bann *et al.,* 2014).

Sexual dimorphism in humans is exhibited throughout life either before puberty or after (Faulkner *et al.,* 1993; Nelson *et al.*, 1997; Taylor *et al.*, 1997; Mast *et al.*, 1998; Kirchengast 2002; Wells 2007; Kirchengast, 2001). It is only important to note that during puberty and adolescence sexual dimorphism in body composition becomes increasingly obvious (Loomba-Albrecht and Styne 2009). Furthermore during adulthood, more feature of body dimorphisms are established to distinguish between the males and the females (Wells 2007); several of which have to do with reproduction.

MATERIALS AND METHODS

The heights of subjects was measured and recorded in meters (m) using the height scale or rule of the Adult Weight Scale, Platform XH- Model [ZT-150A] used for the weight. The weight was measured and recorded in kilograms (kg). The waistline was measured with the aid of the tape rule; this also was recorded in meters. BMI (Body Mass Index) for each subject was calculated using the formula $BMI = W/H^2$ (CDCP, 2014; NIH, 2014) where H is the Height in meters and W, the weight in kilogram. All measurements and recordings were taken and used in the SI units. Mean value for each age within the range selected for the research was calculated, presented, analysed and critically evaluated using suitable descriptive and inferential statistical methods.

RESULTS

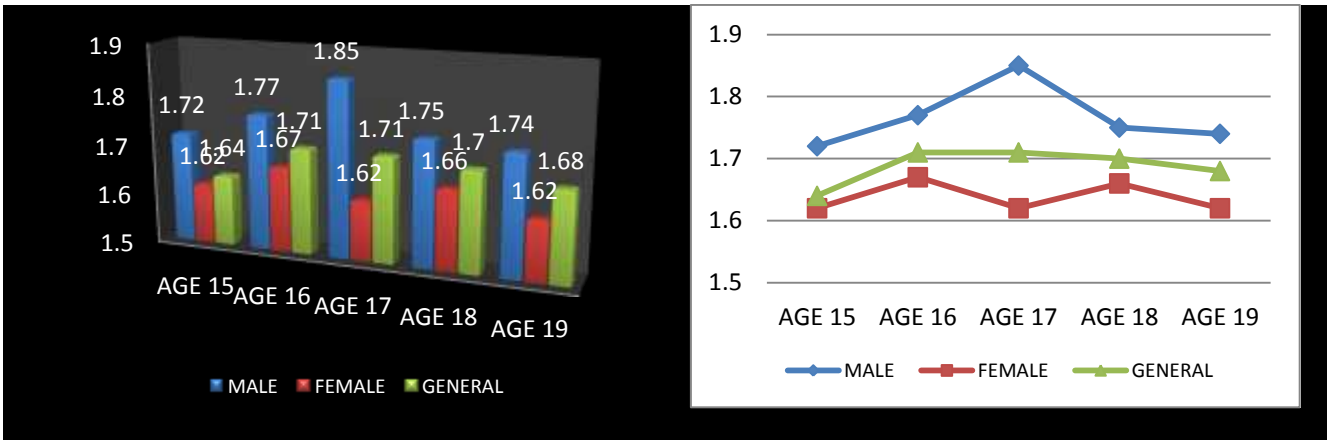

Figure 1A: Bar chart illustrating the average height for each age and sex for the study group; males have higher average heights across the ages

Figure 1B: Line chart illustrating the average height for each age and sex for the study group to show relationships and trends across the ages; males consistently maintain the trend of greater heights across the ages

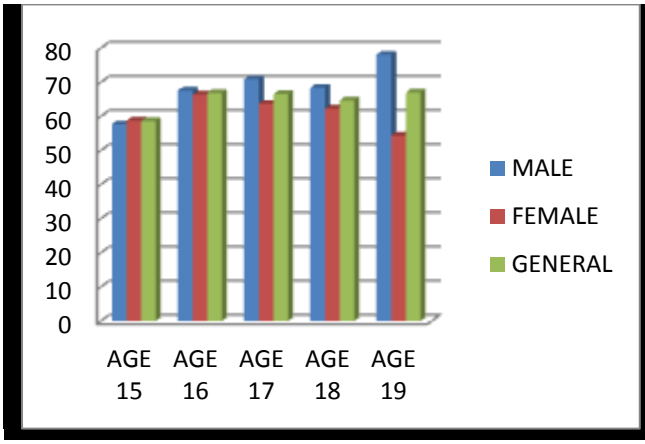

Figure 2A: Bar chart illustrating the average weight for each age and sex for the study group; males maintain a consistently higher average weights for each age

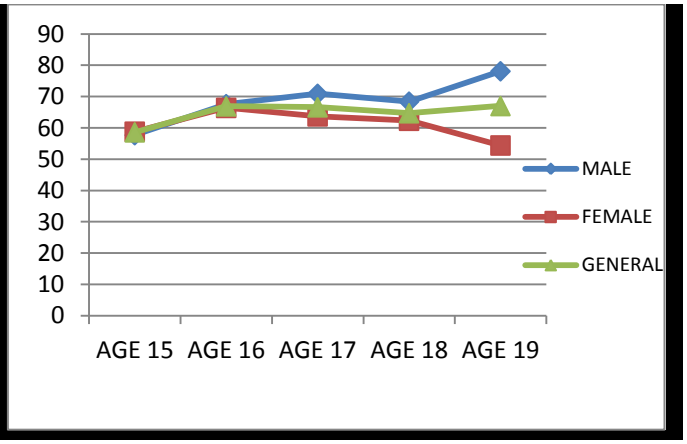

Figure 2B: Line chart illustrating the average weight for each age and sex for the study group to show relationships and trends across the ages; the trend shows a steady increase in the weights of the males relative to the females across the ages

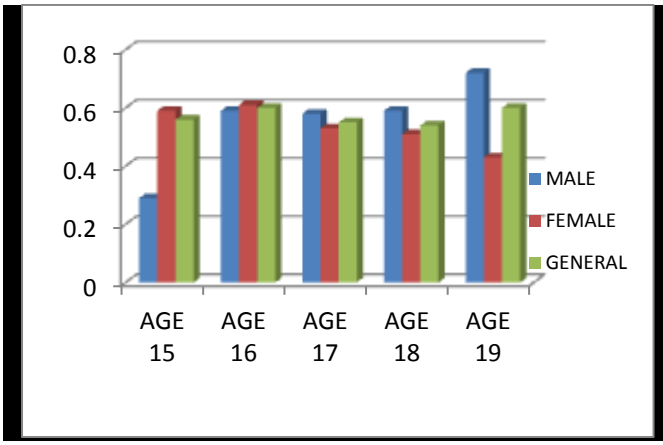

Figure 3A: Bar chart illustrating the average waistline for each age and sex for the study group; males have broader waistline as from about age 16

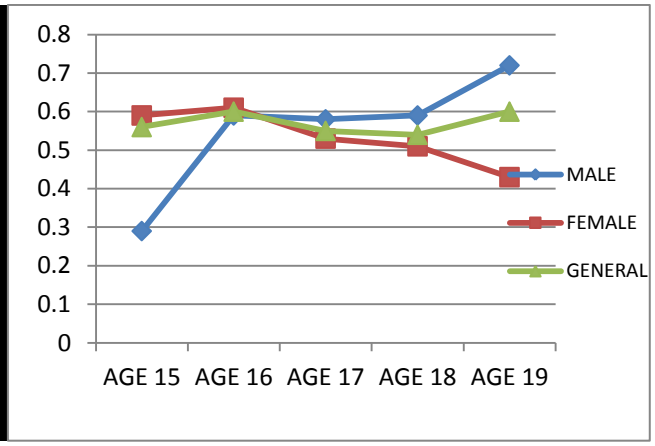

Figure 3B: Line chart illustrating the average waistline for each age and sex for the study group to show relationships and trends across the ages; males maintain an upward trend relative to the females up to the late teenage

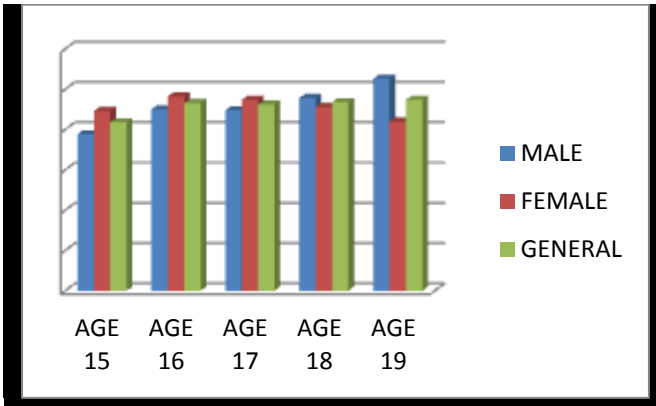

Figure 4A: Bar chart illustrating the average BMI for each age and sex for the study group; females have higher BMI until between ages 17 and 18when the males catch up and over take.

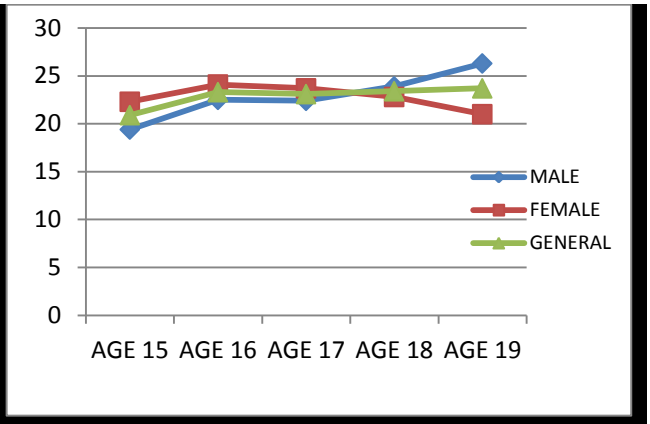

Figure 4B: Line chart illustrating the average BMI for each age and sex for the study group to show relationships and trends across the ages; females maintain a higher BMI trend until between 17 and 18. Pattern of trend suggest a continuation till some years further.

Discussion

Males generally have greater average heights i.e. they are taller across all the age groups considered. Consequently, the average for each age group was always lower than that of the male sex and always higher than that of the female sex. The male sex of the population, right from age fifteen maintained a consistent trend of greater height till late teenage- 19. These observations infer that the males within this study groups are on the average generally taller than the females. While the report of Gustafsson and Lindenfors (2004) showed a difference of the average of 15cm (0.15m) between male and female heights of same ages among Americans who were above 20 years; the current Nigerian data shows an average difference of 10cm (0.1m) between males and females of same age, however, in late teenage except for an observed increased variation to about twice the ones recoded for other ages for age 17 (See Figure 1). The trend chart (figure 1B) suggests that the variations in average heights for the sexes had been established before the age of fifteen and maintained almost steadily till the late teenage of nineteen. It is also interesting to note that the height gain trend appears fairly steady; suggesting that the peak height velocity was already passed- this was reported to be about 14 for males and 12.5 for females (Barnes, 1975; Tanner, 1965).

The female sex has just a slightly higher weight than the male at 15 and the male appears to overtake at 16; after this, the male sex maintained a higher body weight than the female till 19 (Figure 2A and B). A striking observation is that the trend pattern in this variation is that the male body weight tends to increase probably as much as the female body weight appears to decrease especially as from age sixteen. These trends tend to produce a relatively consistent trend in the general population average weight. This also suggests that males in the studied group still had steady and relatively more rapid increase in weight in the late teenage; whereas the females on the average would have likely attained their full teenage potentials of heights at about fifteen to sixteen years.

Observations from figure 3A and 3B show that (age 16 appears to be a more statistically convenient point to start comparison, relatively) as from the age of 16, the male sex consistently

has a grater width or circumference of their waistline and the difference appear to increase with age. An interesting observation here is that this is contrary to the layman's assumption that the female sex would always have a broader waistline. The fact here points to the fact that the enlargement in the lower trunk and upper lower limbs aspect of the female relative to the male begins from below the waistline. Anatomically, this would include the pelvis, gluteal regions posteriorly and the upper thigh laterally and anteriorly. This corroborates the fact that sexual dimorphism is also a factor of reproductive roles to a large extent; hence much of dimorphism takes place around the pelvic region, which is important for conception of pregnancy, as well as physical factors of attraction associated with copulation

Females had greater BMI from the age of 15 to the age of 18. However, after this, the male sex has a greater BMI at 19; these can be observed in Figure 4A and 4B. The shorter height of the female relative to their body mass would obviously be responsible for their higher Body Mass Index relative to the male sex. However, as there comes increase in age, the male though taller also acquire more body mass especially due to increased bone mass due to increased heights and increase in musculature- a natural tendency due to masculinity, hence they tend to catch up with the female's BMI at about 18 and increase beyond thereafter as seen on the charts. It has been noted that the male human could always have more lean muscle mass than the female (Forbes 1987; Malina *et al.*, 1999; Kyle *et al.,* 2001; Greil, 2006; Shen *et al.*, 2009); females could however increase their body mass through adipose tissue or fat accumulation (Kirchengast, 2010) Such fat accumulation is typically subcutaneous and typically of the lower trunk. Fat accumulation supports the female to meet the demands of reproduction, especially in pregnancy and during lactation (Frisch 1985; Ellison 1990; Kirchengast and Huber, 2001). More so, adipose tissue functions even exhibit sexual dimorphism (Luque-Ramırez *et al.,* 2013). It however appears from the current results that such fat accumulation that could amount to greater overall body mass for the female and subsequently translate to higher BMI on the average would be beyond the age of 19. This is in line with several previous publications as most female humans do not enter active reproduction until late teenage of ever after.

CONCLUSION

Sexual dimorphism is exhibited in all studied features- height, weight, waistline and BMI. The trends for each studied features also exhibited patterns that could indicate the probable extents to which certain features would be exhibited in either sex in adults. The results are interesting as they are one of the few reports of sexual dimorphism studies for this age group in the population represented by the study group.

Table 1: The Heights of Subjects Across the Ages and the Variations between the Average Male and Female Ages

	Male	Female	General	Male – Female Height Difference
Age 15	1.72	1.62	1.64	0.10
Age 16	1.77	1.67	1.71	0.10
Age 17	1.85	1.62	1.71	0.23
Age 18	1.75	1.66	1.7	0.09
Age 19	1.74	1.62	1.68	0.12

Table 2: The Weights of Subjects between Ages 15-19 and the Variations between the Average Male and Female Weights for the Ages

	Male	Female	General	Male – Female Weight Difference
Age 15	57.7	58.8	58.6	1.1
Age 16	67.6	66.4	66.9	1.2
Age 17	70.9	63.7	66.6	7.2
Age 18	68.4	62.3	64.7	6.1
Age 19	78.1	54.4	67	23.7

Table 3: The Waistline Circumference of Subjects between Ages 15-19 and the Variations between the Average Male and Female Waistline Circumferences for the Ages

	Male	Female	General	Male – Female Waistline Difference
Age 15	0.29	0.59	0.56	0.3
Age 16	0.59	0.61	0.6	0.02
Age 17	0.58	0.53	0.55	0.05
Age 18	0.59	0.51	0.54	0.08
Age 19	0.72	0.43	0.6	0.29

Table 4: The BMI of Subjects between Ages 15-19 and the Variations between the Average Male and Female BMI Values for the Ages

	Male	Female	General	Male – Female BMI Difference
Age 15	19.4	22.3	20.9	2.9
Age 16	22.5	24.1	23.3	1.6
Age 17	22.4	23.7	23.1	1.3
Age 18	23.9	22.8	23.4	1.1
Age 19	26.3	21	23.7	5.3

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