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Anthropometric Variations in the Frame-Size of Adolescent Male Nigerian School Children in Urban Lagos

Ibeabuchi NM, Mbagwu SI, Adhlakun SA, Olayemi TA, Aniah J and Adeyemi O.

Department of Anatomy, College of Medicine, University of Lagos
Correspondence: Ibeabuchi NM.

Corresponding Author: Dr. Ibeabuchi NM

E-mail:mikeonyibe@yahoo.co.uk; mibeabuchi@unilag.edu.ng;
Tel: +2348030536784

ABSTRACT

Limited information is available about the skeletal frame-size of urban dwelling adolescent West African children. This study assessed variation in truncal skeletal breadths of adolescent male Nigerian children from two different socioeconomic backgrounds in urban Lagos. Anthropometric measurements of biacromial, bicristal, bitrochanteric and chest breadths were taken from 354 adolescent male school children aged 10-17 years selected from public and private schools in urban Lagos using a systematic random method according to protocols recommended by the International Society for the Advancement of Kinanthropometry (ISAK). The socioeconomic status (SES) of the subjects was classified on the basis of attendance of either fee paying private or non fee-paying public schools. The data obtained was collated and analyzed for mean and standard deviation, whilst the variations between independent groups were analyzed using students t-test. Statistical significance was set at $p < 0.05$. The mean values of measurements are as follows; biacromial breadth= 28.7 ± 3.2 - 42.8 ± 4.2 ; bicristal breadth= 19.53 ± 1.8 - 25.6 ± 1.7 ; bitrochanteric breadth= 21.9 ± 1.9 - 28.9 ± 2.1 ; chest breadth= 16.9 ± 0.7 - 25.1 ± 2.3 . Statistically significant differences were observed in the mean biacromial, bicristal, bitrochanteric and chest breadths between age-matched private school boys as compared to the public school boys. The findings indicate that the patterns of variations in skeletal truncal morphology among urban adolescents may reflect variation in lifestyle patterns existing among this population, suggesting an anthropometric uniqueness of the adolescent males in urban Lagos and thus underlining the need for an own morphologic norm for this population. Wider based cross-sectional studies would be beneficial at this stage.

Keywords: Truncal Skeletal breadths, Variation, Males, Adolescent, Urban Lagos.

INTRODUCTION

The skeletal frame size is a description of the supportive structure of the skeleton that is used to adjust for skeletal mass and size in measures of body composition and weight. As estimated by the biacromial, bicristal, bitrochanteric and chest breadths thus, provide an indication of the robustness of the truncal skeleton¹. The variations in body size is associated with variation in the rate of biological maturation², differential growth of body segments arising from changes in the sensitivity of bone growth plates to the effects of growth promoting and inhibiting factors at different periods during development, and at different sites of the skeleton³. The relevance of morphological frame-size estimation in human subjects has been highlighted in studies where anthropometric body composition indices are correlated with physiological body composition measure studies. In the previous study¹, frame-size measures were significantly and positively associated with all body-composition and bone mineral measures in bivariate analyses. Thus, in assessing severe and chronic malnutrition, where there are gross morphologic disturbances, skeletal frame-size estimates may be useful proxy estimates of the first (endomorph) and second (mesomorph) components of the Heath and Carter somatotype^{4,5}.

Socioeconomic background and lifestyle factors may influence patterns of nutritional intake, the patterns of physical activity and the other environmental stresses which affect the development of the skeletal frame during growth⁶⁻⁸. While it has been long recognized that much of what is currently known about the growth among African children is based on data that are tainted by the adverse environment endemic to Africa^{9,10}, the non availability of a comprehensive anthropometric data base for adolescent growth for the African population remains a current and major challenge for growth research^{11,12,13}. Further, the widening margin of the inequalities between the poor and the better-off appears to be manifesting in the varying patterns of physical growth^{14,15}.

Frame-size data in the adolescent age-group are scarce in the literature, as the majority of studies have focused

on the young adults¹⁶⁻²³. The literature regarding the status of truncal skeletal frame size among adolescent Nigerians is scanty. The aim of this study, therefore, was to describe the pattern of physical growth in skeletal frame size using truncal breadths, to compare the findings with known data and to assess the possible influence of varying socioeconomic backgrounds.

MATERIALS AND METHODS

This cross-sectional study involved 354 male volunteers aged 10-17 years selected by multi-stage stratified random sampling from two secondary schools, the University of Lagos International School (representing the middle/high income SES group) and Oduduwa Secondary School, Mushin, (representing the low SES group) according to a classification protocol modified from previous studies.^{24,26} Since the "caste system" of marriage, which restricts intermarrying across "caste" barriers, is rarely practiced in West Africa and marriage laws in Nigeria do not restrict conjugal relationships across ethnic groups or social class, the subject population was considered a heterogeneous Mendelian population from Christian, Moslem or traditional African and sociocultural backgrounds born through conjugal relationships that do not restrict transmission of genetic traits from parent to offspring in any specifically defined manner^{27,28}. From school records and the response to individualized questioning, the ethno-cultural distribution of the biological parentage of the study participants indicated same-ethnic group Nigerians (61%), mixed-ethnic Nigerians (36%) and mixed Nigerian trans-nationals represented less than 3% of the study sample. The Nigerian ethnic nationalities represented included Yoruba, Ibo, Edo, Urhobo, Itsekiri, Ijaw, Ibibio, Efik, Annang, Igala, Hausa-Fulani, Nupe, Idoma and Tiv. Excluded from the study were pure-breed Caucasian, African and Near East Semitics (Jews and Arabs) and Far East Asian children; the acutely-ill and the physically challenged; children on any form of continuous medication; children with poor health conditions that manifested with overt signs of stunted growth or physical emaciation or excessively obese children. The anthropometric variables measured included biacromial breadth, bi-iliocrystal breadth, chest breadth and bitrochanteric breadth according to the protocols recommended by the International Society for the Advancement of Kinanthropometry²⁹ and later adapted for Nigerian schools³⁰ (Ibeabuchi et al., 2006). All data was analyzed for mean, standard deviation and median whilst the differences between independent groups were analyzed by T-test using the MicrosoftTM Excel[®] statistical package on desktop computers located in the Department of Anatomy of the College of Medicine of the University of Lagos.

RESULTS

The results show that the mean, median and standard deviation of biacromial breadth for all age groups are presented by school type in table 1. The last two columns provide comparative data from two US

databases. It shows that the differences in biacromial breadth between PUB and PRB were significant ($p < 0.05$) at all age groups 10-12 years and at 14-17 years with a decrease at age 13 years. The results were all consistently between 5th and 95th percentiles of the US Reference Data³¹ and are well within ± 2 s.d. of the National Health and Nutritional Examination Survey (NHANES III) 1988-1994 data³².

Table 2 shows the mean, median and standard deviation of bicristal breadth for all age groups by school type. The last column to the right provides comparative US Reference Data. It shows that the differences in bi-iliocrystal breadth between PUB and PRB were significant ($p < 0.05$) at all age groups from 13-16 years, with a decrease at age 11 and 17 for the private school boys. Public school boys showed a decrease at 17 years and a steady increase from 10-16 years. There was a statistically significant difference from ages 11-17 years with the private school boys having higher values. The results are also consistently between the 5th and 95th percentile of the US reference data^{33,34}.

Table 3 shows the mean, median and standard deviation of bitrochanteric breadth for all age groups by school type. The last column to the right provides comparative US Reference Data. It shows that the differences in bitrochanteric breadth between PUB and PRB were significant ($p < 0.05$) at all age groups from 10-16 years. There were also consistently within ± 2 s.d. of the National Health and Nutritional Examination Survey (NHANES III) 1988-1994 data as adapted from Frisancho³².

Table 4 shows the mean, median and standard deviation of chest breadth for all age groups by school type. Chest breadth measures of the private boys increased from 10-15 years and at 17 years in the private school boys while in the public school boys, an increase was observed from 10-12 years, and 15-17 years. Statistically significant differences were observed at ages 10, 12 and 16 years with the public school boys having a higher chest breadth.

The figures (1-4) shows the median curves for the breadths measured indicating the pattern of growth and variations between the two different socioeconomic backgrounds as indicated by the school type across the ages of the subjects that participated in the study. The results are summarized in the tables and figures below.

Table 1 : Summary of the Descriptive and Inferential Statistics of the Biacromial Breadth (cm)

Age Range	PRB	PUB	US REFERENCE ^a	NHANES III
(years)	Mean±SD(Median)	Mean±SD(Median)	Median only	Mean±SD
9.51-10.50	29.7±6.0 (32.1)	28.7±3.2 (29.1)	30.0	31.2 ± 3.59
10.51-11.50	32.4±2.0 (32.5)	28.19±2.8* (28.9)	32.0	32.6 ± 3.52
11.51-12.50	32.8±1.9 (32.5)	29.20±3.2* (28.7)	33.0	34.4 ± 4.26
12.51-13.50	32.5±3.1 (33.4)	30.56±2.3*(30.35)	33.5	35.9 ± 4.84
13.51-14.50	34.0±3.7 (35.2)	30.93±3.5*(31.2)	35.1	37.7 ± 4.65
14.51-15.50	36.9±2.4 (37.4)	34.89±2.3* (36.2)	37.0	38.8 ± 4.19
15.51-16.50	38.28±2.8 (37.6)	33.38±4.9* (34.8)	38.2	39.9 ± 4.72
16.51-17.50	42.8±4.2 (40.2)	36.7±4.6* (36.1)	40.3	40.8 ± 4.17

*Differences significant at p<0.05; PRB = Private school boys; PUB = Public school boys; US Reference ^a = Data adapted from McCammon, 1970; NHANES=National Health and Nutritional Examination Survey (US) 1988-1994. Adapted from Frisancho (2011)

Table 2: Summary of the Descriptive and Inferential Statistics of the Bicular Breadth (cm)

Age Range	PRB	PUB	US REFERENCE ^b
(years)	Mean±SD (Median)	Mean±SD (Median)	Median only
9.51-10.50	24.0±5.5 (22.3)	19.53±1.8 (19.2)	22.0
10.51-11.50	22.3±2.7 (21.7)	19.8±1.0*(19.8)	23.0
11.51-12.50	21.9±2.2 (21.3)	20.0±1.9*(20.1)	24.1
12.51-13.50	22.9±3.4 (21.9)	20.1±3.7*(20.1)	24.3
13.51-14.50	23.2±1.4 (23.0)	20.7±1.4*(20.4)	24.9
14.51-15.50	24.7±1.9 (24.5)	21.8±1.6*(21.4)	25.2
15.51-16.50	25.6±1.7 (25.4)	23.7±2.0*(23.9)	25.4
16.51-17.50	25.5±0.6 (25.4)	23.5±1.3*(23.8)	25.5

*Differences significant at p<0.05; PRB = Private school boys; PUB = Public school boys; US Reference ^a data adapted from Malina and Roche, 1983

Table 3: Summary of the Descriptive and Inferential Statistics of the Bitrochanteric Breadth (cm)

Age Range	PRB	PUB	NHANES III
(years)	Mean±SD (Median)	Mean±SD (Median)	Mean±SD only
9.51-10.50	24.7±1.5 (24.7)	21.9±1.9* (21.8)	21.7± 3.93
10.51-11.50	24.6±2.0 (24.6)	22.7±1.7* (22.7)	22.8± 4.19
11.51-12.50	24.4±3.7 (24.6)	23.2±1.90 (22.9)	24.3± 4.69
12.51-13.50	25.4±1.9 (25.2)	23.2±1.9* (23.3)	25.3± 4.98
13.51-14.50	26.5±1.7 (26.4)	22.2±5.0* (23.4)	26.6± 7.21
14.51-15.50	27.9±2.1 (27.9)	24.5±4.8* (24.3)	27.0± 5.14
15.51-16.50	28.9±2.1 (29.6)	27.4±1.9* (27.4)	27.4± 5.68
16.51-17.50	28.2±2.5 (27.7)	28.2±2.5 (27.7)	27.7± 5.96

*=significant at p<0.05; PRB = Private school boys; PUB = Public school boys; NHANES III =National Health and Nutritional Examination Survey (USA) Database 1988-1994. Adapted from Frisancho (2011)

Table 4: Summary of the Descriptive and Inferential Statistics of the Chest Breadth (cm)

Age Range (years)	PRB Mean±SD(Median)	PUB Mean±SD (Median)
9.51-10.50	16.9±0.7 (16.9)	19.7±1.83* (20.1)
10.51-11.50	17.9±1.8 (17.7)	20.7±1.4 (20.7)
11.51-12.50	19.3±2.7 (18.9)	21.7±2.6* (21.4)
12.51-13.50	20.3±2.3 (20.7)	21.6±1.8 (21.2)
13.51-14.50	21.2±3.0 (21.9)	22.3±2.1 (22.2)
14.51-15.50	22.5±3.8 (22.3)	22.8±2.1 (22.3)
15.51-16.50	21.6±3.2 (20.4)	24.9±1.9*(25.3)
16.51-17.50	25.1±2.3 (25.4)	25.1±2.3 (25.4)

*=significant at p<0.05; PRB = Private school boys; PUB = Public school boys

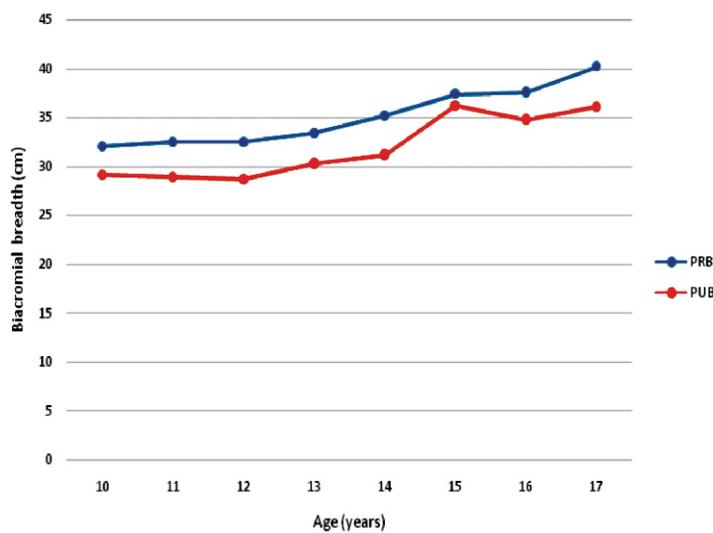


Figure 1: Median distance curve of size attained in biacromial breadth of adolescent males in urban Lagos. PRB=Private School Boys; PUB=Public School Boys

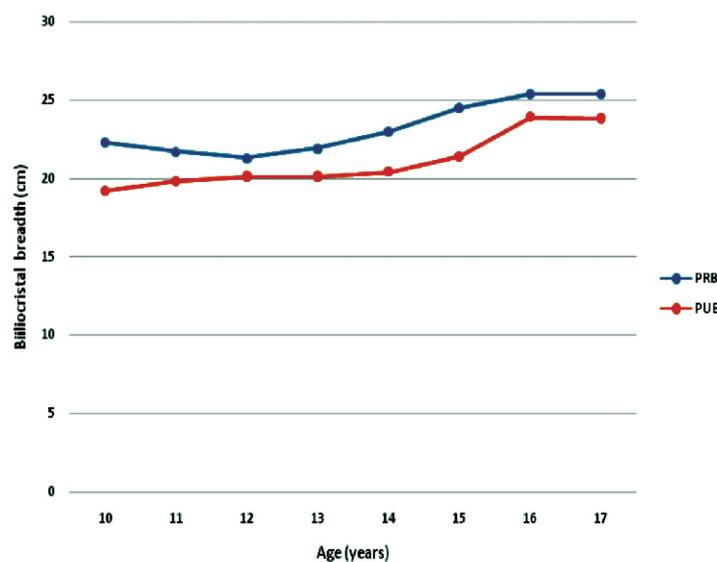


Figure 2: Median distance curve of size attained in bi-iliocrystal breadth of adolescent males in urban Lagos. PRB=Private School Boys; PUB=Public School Boys

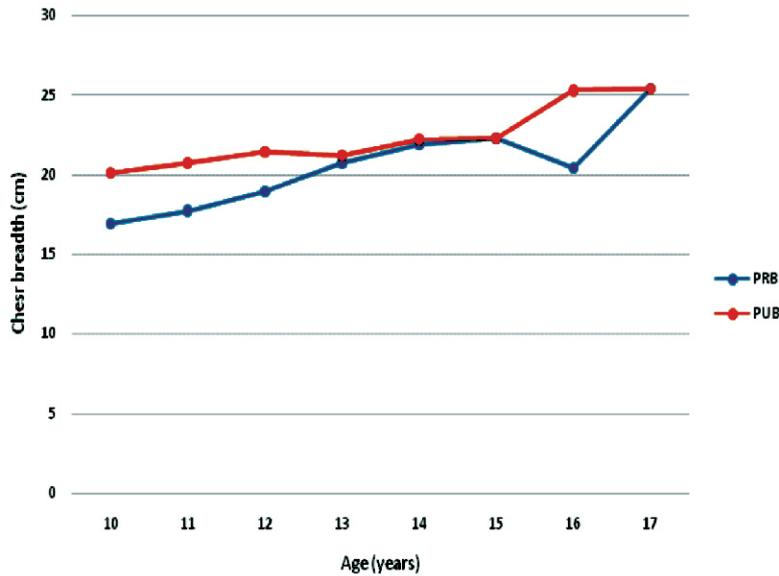


Figure 3: Median distance curve of size attained in chest breath of adolescent males in urban Lagos. PRB=Private School Boys; PUB=Public School Boys

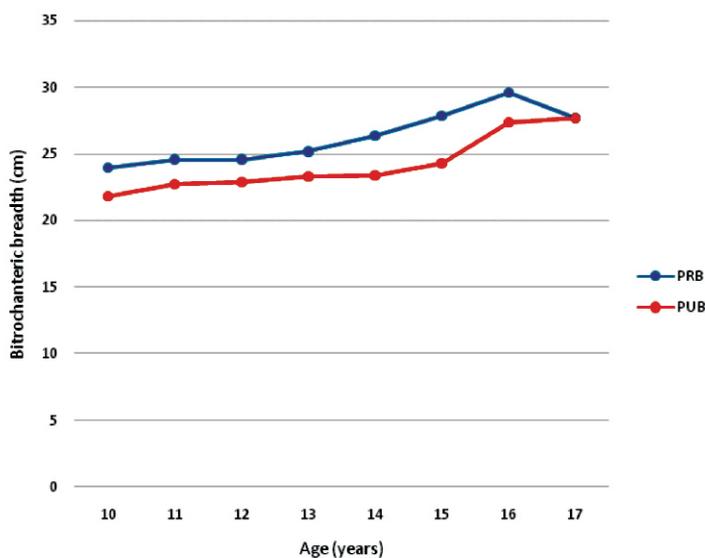


Figure 4: Median distance curve of size attained in bi-trochanteric breath of adolescent males in urban Lagos. PRB=Private School Boys; PUB=Public School Boys

DISCUSSION

Growth changes reflect overall health and nutritional status³⁵ and the estimation of change in body dimensions is an important measure of the level of socio-economic development of communities and nations³⁶. While international reference standards remain important for the assessment and interpretation of the nutritional status of any community, it has been suggested that they be validated by systematically developed local normative data to enable meaningful comparison³⁷⁻³⁹.

Urban Lagos adolescent private male schoolchildren (PRB) recorded higher mean values than their public

school counterparts (PUB) in all parameters measured (bicristal, biacromial and bitrochanteric breadths) except the chest breadth. Our data (tables 1 and 2) further indicates that PRB had bi-acromial breadth and bi-iliocristal 50th percentile values quite comparable to the US reference group data^{31, 32}. The data in table 3 indicates that chest breadth variation follows a rather mixed pattern. Significant chest breadth variations between PRB and PUB at ages 10-12 years are followed by non-significant differences from age 13-15 years. The differences become significant again at 16 years. Given the non-availability of international reference data to compare, our capacity to rationalize the findings would only be limited to conjecture at this stage.

Table 4 shows that the variation between PRB and PUB in trochanteric breadths is statistically significant at all age groups compared except at age 17 years. The bitrochanteric breadth means for both PUB and PRB lie between the 5th and 95th percentiles of the NHANES III reference data while the 50th percentile values of our study samples are quite comparable. It may be useful to note that in the NHANES III reference data, bitrochanteric breadth is referred to as Bi-iliac breadths. The graphical presentations in figures 1-4 permit graphic visualizations of the patterns of variations shown in the tables.

The patterns of age-related variations in our study are consistent with the findings in more recent studies^{40, 41} among European male samples of similar age groups, suggesting that inter-ethnic or racial variation in skeletal frame size may be less pronounced than that within-population variation, especially when comparing the variation between samples drawn from the socio-economic extremes^{42, 43}. However, biacromial breadth mean values in this study were higher than those obtained from the Wroclaw growth study in Poland⁴⁴, suggesting that the different patterns of inter-ethnic variations within the same population do occur.

The variation in biacromial, bi-iliocrystal and bitrochanteric breadth observed in our study may reflect the variations associated with the onset of the adolescent growth spurt³⁴. Generally, discussions in the literature of the adolescent growth spurt tend to focus primarily on stature, in part because of the relative wealth of data on this dimension between early childhood and young adulthood and also because most other body dimensions follow a growth curve similar to that of stature⁴⁵⁻⁴⁷. However, variations occur in the timing of growth spurts in other dimensions relative to the growth spurt in height. The models used to estimate adolescent parameters for stature have been used to derive ages at peak velocity and peak velocities for several body dimensions⁴⁸⁻⁵⁰ and ages at peak velocity for body dimensions are most often related to the age at the peak height velocity to illustrate the sequence of changes during the adolescent growth spurt. From data which includes primary references, sample sizes, and methods of deriving the parameters of the growth curves for several North American and European adolescent populations^{1, 51, 52} and extensively reviewed by frequently cited authorities^{1, 52}, the differences in timing are related, in part, to differences in body composition, which is heavily dependent on nutritional status. The adolescent body mass (weight) spurt in boys includes principally gains in stature, skeletal tissue, and muscle mass³⁴. Thus, variation in this parameter would partly explain the variations in skeletal frame estimates among the study sample as our findings also suggest that children from the low socioeconomic background may have a higher body lean mass. However, the fact that the differences were not significant across age and school type in the study sample suggests that other factors may also be at play including physical

adaptation to environment stressors.

The finding of no significant difference in chest breadth measures between PRB and PUB is noted. The observed age-related increments in chest breadth are consistent with similar observations in Mexico⁵³. Although international norm reference data for chest breadth measurement are not readily available at this time, chest breadth was included in our study because the measure has been shown to provide useful indication of frame size and lean body mass and as an estimate of relative weight; it is better correlated with body mass than with stature^{54, 55}. Previous studies of frame size summarized by Chumlea et al., have identified variation in stature and body mass as confounders of chest breadth since these influence subcutaneous body fat, muscle distribution, as well as visceral fat content.

Some anecdotal evidence which could partly explain the observed variation may be adduced from the public domain. It suggests that in the less economically endowed neighborhoods of the urban Lagos, due to heavy population congestion, the lack of free access to direct public water supply causes many children to travel considerable distances with buckets on their heads in search of potable water. Further, the lack of standardized playgrounds compels children to adopt "Open Street" playgrounds, encouraging free roaming and engage in heavy physical activities, street-sprinting and football, street-hawking which such activity result in the preferential build-up of the upper chest muscles. In an environment inundated with poor nutrition, some of the children, who are shorter and thinner, have also adapted to this physical lifestyle by developing wider chests.

Our design of the current study did not control for other confounding factors such as maturity status, skeletal age, body fat distribution and physical activity status of the study participants³. Thus, variation in correlations between tissue width and skeletal age across chronological age groups suggest that differences between children of contrasting maturity status becomes more pronounced with age^{56, 57}. It was also been indicated that in boys classified on the basis of difference between skeletal age and chronological age, skeletal age was in advance of chronological age by an average of 1.4 years in early maturing boys and behind chronological age by 1.1 years in late-maturing boys suggests that as our subjects were only classified on difference in chronological age, there may have been a dilutional effect of mixing early- and late-maturers in the same chronological age group. This has been corroborated by more recent studies on estimated ages at peak velocity and peak velocities for stature, weight and components of body composition in Canadian adolescents of contrasting maturity status⁵⁸.

The roles of other factors including family characteristics, climate and low altitude and their

probable combined effect in masking the underlying growth pattern of urban Lagos adolescent schoolchildren and as such has manifested in the pattern of variation observed has been discussed extensively in previous work^{12, 13, 59}. However, the specific proportional contributions of these factors, other than genetics, are yet to be characterized.

CONCLUSION

This study has reported the anthropometric variation in skeletal frame size measures of adolescent male Nigerian school children in urban Lagos. The observed variation may reflect lifestyle patterns as well as genetic variations existing among this population. The findings suggest an anthropometric uniqueness of the adolescent males in urban Lagos and thus underlines the need for an own morphologic nomogram for this population. The prospect of frame-size estimates as useful proxy measures of total body fat and fat free mass where direct estimation facilities are not available has been highlighted. As there is limited data for skeletal frame size measures for this population, the findings of this study could serve as a useful reference data in growth research, general clinical practice and where relevant major forensic investigation.

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