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Middle Finger Length as a Predictor of Standing Height Among Adolescents in Yenagoa, Bayelsa State, Nigeria

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Abstract

Background: Accurate height measurement is crucial for paediatric nutritional assessment, growth monitoring, and clinical decision-making. When direct measurement is difficult, surrogate anthropometric indicators such as middle finger length (MFL) may provide practical alternatives.

Objectives: To evaluate the relationship between MFL and standing height among adolescents in Yenagoa, Bayelsa State, and to develop predictive equations including sex- and age-specific models.

Methods: This cross-sectional study included 1,222 adolescents (10–19 years) from selected secondary schools. Standing height and MFL were measured using WHO-standardized procedures. Pearson correlation assessed the relationship, and linear regression produced predictive equations. Analyses were performed for the total population, by sex, and across three age groups (10–13, 14–16, 17–19 years). Agreement between measured and predicted height was assessed using Bland-Altman analysis.

Results: A moderate positive correlation was observed between MFL and height ($r = 0.672$, $p < 0.001$). The overall predictive equation was $\text{Height} = 89.782 + 8.819(\text{MFL})$ ($R^2 = 0.452$). Sex-specific models demonstrated slightly higher correlation in males ($r = 0.685$) than in females ($r = 0.659$). Age-stratified analyses showed stronger correlations in older adolescents.

Conclusion: MFL is a practical predictor of standing height in Nigerian adolescents. Sex- and age-specific models improve predictive accuracy, offering utility in clinical, public health, and forensic contexts.

Keywords: *Anthropometry, Height, Middle Finger length, Regression model, Stature estimation, Nigeria.*

Introduction

Anthropometry is fundamental to paediatric practice for monitoring growth, assessing nutritional status, and guiding clinical management. Standing height is particularly important for calculating body mass index (BMI), determining drug dosages, and assessing growth patterns.^{1,2} Direct height measurement may be

difficult in children with spinal deformities, musculoskeletal injuries, or acute illnesses requiring immobilisation. Alternative anthropometric measures, including arm span, tibial length, foot length, and hand dimensions, are frequently used in such circumstances as proxies.^{1,3-4} Middle finger length (MFL) is advantageous because they are easily accessible and the procedure requires minimal training and

equipment compared with arm span, sitting height or lower limb measurements.⁴

Studies from different populations have shown that regression models⁵ based on hand and finger measurements can predict stature with acceptable accuracy, although prediction equations vary with age, sex, ethnicity, and geographical location.⁴⁻⁶ MFL is less affected by posture and spinal deformities. Multiple studies have demonstrated a significant positive correlation between hand measurements and standing height, but there is very limited published research specifically focused solely on MFL in Nigeria.⁷ Adolescence, characterised by rapid growth and hormonal changes, can influence body proportions.⁶ This study aimed to determine the correlation between MFL and standing height among adolescents in Yenagoa and develop population-specific predictive equations, including sex- and age-stratified models.

Methods

This cross-sectional study was conducted in Yenagoa, Bayelsa State, Nigeria, from March to September 2023. The participants were apparently healthy adolescents aged 10 – 19 years, drawn from selected secondary schools in Yenagoa, using a multistage sampling technique. Adolescents with physical deformities affecting height or hands, with congenital hand anomalies or chronic illnesses affecting growth, were excluded.

Anthropometric measurements

Standing height was measured using a stadiometer, with participants barefoot and the head in the Frankfurt plane. MFL was measured from the midpoint of the proximal flexion crease at the base of the left middle finger (metacarpophalangeal crease) to the fingertip (apex). The distance between these two landmarks, measured using a Vernier calliper

with the finger fully extended, is recorded. The measurements were taken by the researcher and research assistants twice and averaged.³

Sample size determination

A minimum sample size was calculated using the Fisher's z-transformation formula below:⁸

$$n = ((Z\alpha + Z\beta)/C)^2 + 3$$

Where:

$$C = 1/2 \ln \left[\frac{1+r}{1-r} \right]$$

n = minimum sample size

Z α = Standard normal deviate corresponding to a 95% confidence interval (1.96)

Z β = Standard normal deviate for desired power (0.84 for 80% power)

r = correlation coefficient from the study on the relationship between hand dimensions and stature among adolescents by Usman *et al.* = 0.668.⁸

The value of C was calculated as 0.807.

Therefore, $n = ((1.96 + 0.84)/0.807)^2 + 3 = 16$. This became 18 after making an adjustment for a 10% non-response rate.

Sampling technique

A four-stage sampling technique was used. A list of all secondary schools obtained from the Post-Primary School Management Board and the Ministry of Education showed a total of 37 private and 17 public schools across the 15 wards in Yenagoa LGA. The schools were stratified into public and private secondary schools.

Stage 1: Selection of wards

The names of the 15 wards were written on pieces of paper and put in a basket. An independent observer selected seven of the 15 wards in Yenagoa LGA (i.e., 46%, representative of the total wards) using simple random sampling (closed ballot) with the help of an independent observer. Any ward picked was not returned until the seven wards had been selected.

Stage 2: Selection of schools

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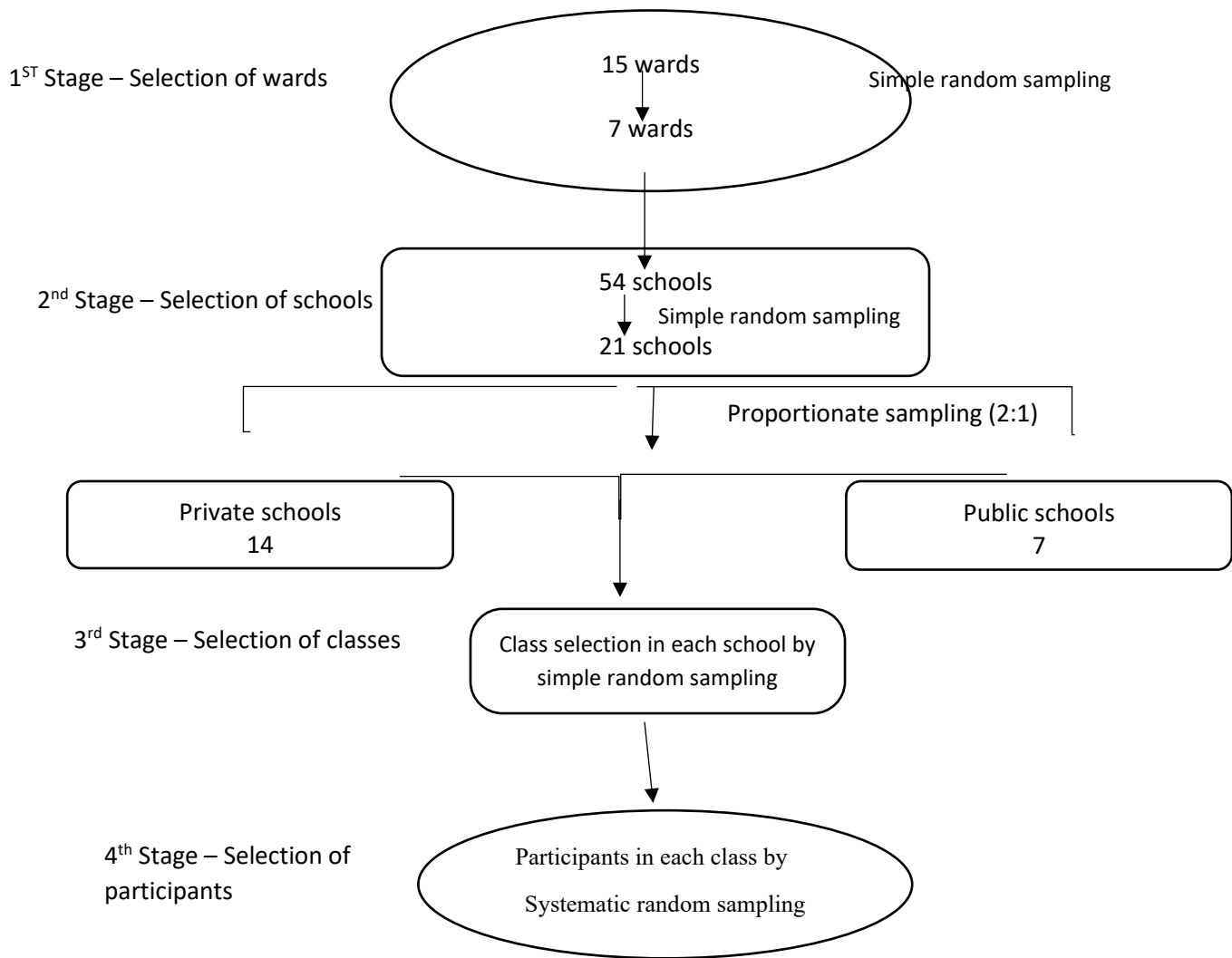


Figure 1: Schematic diagram showing the methods used at each sampling stage

There are 54 secondary schools in Yenagoa LGA, comprising 50 co-educational, two all-boys, and two all-girls. The schools in each of the seven selected wards were stratified into public and private. There are 17 public (including the all-boys and all-girls schools) and 37 private schools in Yenagoa LGA. Based on the number of private and public schools in each of the selected wards, 21 schools were proportionately selected (in a ratio of $\approx 2:1$) using a computer-generated table of random numbers. In other words, for every public

school selected, two private schools were selected.

The sample population in each of the selected schools was taken by proportional allocation based on the school enrolment using a sampling fraction. The sampling fraction was calculated thus:

$$sf = y/N$$

Where: y = population in each school

N = total population of all selected schools (7432)

Sampling Fraction (sf) = (population in each school)/(total population of all selected schools)
The (sf) was multiplied by the sample size ($n = 1,161$) to get the total sample population for the school.

Stage 3: Selection of class

In each selected school, simple random sampling was used to select an arm of each class (JSS1-SS3) for schools with more than one arm. Where there were no arms, the whole class was selected.

Stage 4: Selection of participants

The number of participants selected in each class was calculated based on the total number of students in the class (proportional to population size). In the selected class arms, with the help of the class teachers, the list of pupils between 10-19 years (as at last birthday) was obtained from the class registers. Thereafter, a process of systematic random sampling was used to select the participants.

Ethical considerations

Ethical approval for the study was obtained from the State Ministry of Education, Ministry of Health, as well as the Niger Delta University Teaching Hospital Ethics Committee. Written parental consent and adolescent assent were obtained.

Statistical analysis

The data were analysed using SPSS version 26. Descriptive statistics summarised demographics, height, and MFL, while Pearson correlation tests assessed relationships. Linear regression produced predictive equations for total population, sex, and age groups. Model validation was performed using 10-fold cross-validation. Predictive performance was assessed using the coefficient of determination (R^2), root mean square error (RMSE), mean absolute error of estimate (MAE), and standard error of estimate (SEE). Agreement between measured and predicted height was further evaluated using Bland-Altman analysis with calculation of the

mean bias and 95% limits of agreement. Statistical significance was set at $p < 0.05$.

Results

Sociodemographic characteristics of participants

One thousand two hundred and twenty-two adolescents participated in this study. There were 547 (44.8%) males and 675 (55.2%) females, giving a male-to-female ratio of 1:1.2. Two hundred and twenty-six (18.5%) participants were aged 10–13 years, 812 (66.5%) were aged 14–16 years, while 184 (15%) were aged 17–19 years (Table I).

Table I also shows that of the 1,222 participants, 813 (66.5%) and 409 (33.5%) were recruited from private and public schools, respectively. Sixty-seven per cent lived in urban areas, 52% belonged to the lower socioeconomic class, and 39% were from polygamous families.

Correlation between MFL and height

The study population comprised 1,222 adolescents (547 males and 675 females) with a mean age of 14.8 ± 2.3 years, showing slightly higher mean height and middle finger length (MFL) in males (158.8 ± 12.4 cm; 7.5 ± 0.9 cm) compared to females (155.8 ± 11.6 cm; 7.3 ± 0.8 cm). There was a significant positive correlation between MFL and height in both males ($r = 0.685$) and females ($r = 0.659$), with a similar overall correlation ($r = 0.672$). These relationships were statistically significant across all groups ($p < 0.001$), as shown in Table II.

Age-stratified correlation and regression analysis

Age-stratified analysis demonstrated a progressive increase in the strength of correlation between middle finger length (MFL) and height with advancing age, from $r = 0.612$ in 10–13 years to $r = 0.723$ in 17–19 years, with corresponding increases in coefficients of determination ($R^2 = 0.374$ to 0.511). The

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regression models showed consistent linear relationships across age groups, with increasing slope coefficients, indicating greater predictive accuracy of MFL for height in older adolescents. Sex-specific models revealed comparable

predictive capacity, with slightly higher explanatory power in males ($R^2 = 0.469$) than females ($R^2 = 0.435$), while the overall model demonstrated moderate predictive strength ($R^2 = 0.452$) (Table III).

Table I: Sociodemographic characteristics of participants

Sociodemographic characteristics	No. of respondents (n = 1222)		Male (n = 547)		Female (n = 675)	
	n	%	N	%	N	%
Age						
10-13 years	226	18.5	103	18.8	123	18.2
14-16 years	812	66.5	364	66.5	448	66.4
17-19 years	184	15	80	14.6	104	15.4
Type of School						
Public	409	33.5	181	33.1	228	33.8
Private	813	66.5	366	66.9	447	66.2
Place of residence						
Urban	821	67.2	363	66.4	458	67.9
Rural	401	32.8	184	33.6	217	32.1
Family Type						
Monogamous	270	22.1	122	22.3	148	21.9
Polygamous	477	39	202	36.9	275	40.7
Single/Separated/Divorced	475	38.9	223	40.8	252	37.3
Socioeconomic Class (SEC) of parents						
Lower SEC	632	51.7	289	52.8	343	50.8
Middle SEC	362	29.6	172	31.4	190	28.2
Upper SEC	228	18.7	86	15.7	142	21

Table II: Correlation between MFL and Height

Variable	Age (Years)	Height (cm)	MFL (cm)	R	P-value
Male (n=635)	14.9±2.4	158.8±12.4	7.5±0.9	0.685	<0.001
Female (n=587)	14.7±2.2	155.8±11.6	7.3±0.8	0.659	<0.001
Total (n=1222)	14.8±2.3	157.4±12.1	7.4±0.9	0.672	<0.001

Bland-Altman analysis

The Bland – Altman analysis demonstrated excellent agreement between measured and predicted height, with a mean bias of only 0.002cm, indicating virtually no systematic

overestimation or underestimation by the regression model. The RMSE and SEE values of approximately 6.18cm indicated moderate prediction accuracy. The MAE of 4.89cm

demonstrates that the average absolute prediction error was < 5cm.

Table III: Age-stratified correlation and regression analysis

Group	Regression Equation	Age-stratified correlation (r)	R ²
Age			
10-13 years	Height = 87.345 + 8.550 (MFL)	0.612	0.374
14-16 years	Height = 90.784 + 8.820 (MFL)	0.701	0.485
17-19 years	Height = 92.501 + 9.012 (MFL)	0.723	0.511
Sex			
Male	Height = 91.237 + 8.942 (MFL)		0.469
Female	Height = 88.112 + 8.678 (MFL)		0.435
Total	Height = 89.782 + 8.819 (MFL)		0.452

Table IV: Bland-Altman Analysis and Validation of the Regression Model

Parameter	Value
Sample size (n)	1222
Mean bias (Measured – Predicted Height)	0.002cm
Standard Deviation (SD) of Differences	6.18cm
95% Confidence Interval of Bias	-0.34 to +0.35 cm
Lower – Upper limit of Agreement	-12.11 cm to +12.11 cm
Root Mean Square Error (RMSE)	6.18cm
Mean Absolute Error (MAE)	4.89cm
Standard Error of Estimate (SEE)	6.18cm

Discussion

This study demonstrated a significant positive correlation between middle finger length and standing height among adolescents in Yenagoa, Bayelsa State. The correlation coefficient ($r = 0.672$) indicates a moderate to strong association, suggesting that middle finger length can serve as a reliable proxy for stature estimation in this population. The regression model developed in this study showed that the middle finger length accounted for 45.2% of the variability in height. This finding is comparable with previous anthropometric studies that demonstrated significant predictive relationships between hand dimensions and stature.⁹⁻¹³ This may be further explained by the biological relationship between

digital growth and overall skeletal development.¹³⁻¹⁶ During adolescence, rapid growth in long bones and body segments occurs, with measurable relationships between limb dimensions and height. Linear growth during puberty is influenced by growth hormone, Insulin-like growth factor-1, thyroid hormones and sex steroids, all of which affect skeletal maturation.^{15,18,19}

As the phalanges and metacarpals undergo ossification in parallel with long bones of the limbs, finger length reflects cumulative skeletal growth and therefore correlates with height.²⁰ Adolescence represents a period of rapid somatic growth characterised by peak height velocity and

sexual dimorphism in body proportions. The inclusion of participants aged 10–19 years captures this dynamic phase, making the findings particularly relevant for paediatric practice.^{21, 22}

The strength of correlation observed in this study is comparable to findings from other populations. Studies in Indian, Turkish, and European adolescents have reported correlation coefficients ranging from 0.60 to 0.80 between hand dimensions and stature.^{19, 23, 24} Research among Nigerian adults has also shown significant relationships between hand length, arm span, and height.²⁵⁻²⁸ However, anthropometric relationships vary across ethnic and geographic populations due to genetic background, nutritional status, socioeconomic conditions, and environmental influences.²⁹⁻³¹ For instance, African populations generally exhibit relatively longer limbs compared with trunk length, an adaptation linked to climatic and evolutionary factors.^{8, 31} Therefore, locally derived prediction equations are essential for accuracy and clinical applicability.³²

Studies involving adolescents and young people have reported positive relationships between hand dimensions and stature.^{9, 14-16} However, anthropometric relationships may vary across ethnic and geographic populations because of genetic background, nutritional status, socioeconomic conditions and environmental influences.²⁷⁻²⁹ locally derived prediction equations are, therefore, important for population-specific application.

From a clinical perspective, the ability to estimate height using finger length has important implications. Accurate stature measurement is required for calculating body mass index, assessing nutritional status, determining drug dosages, evaluating growth disorders, and interpreting pulmonary function tests.³²⁻³⁴ In certain situations, such as severe scoliosis, limb

deformities, neuromuscular disorders, contractures, or acute trauma, direct measurement of standing height may be impractical or impossible. Alternative methods such as arm span, knee height, and sitting height have traditionally been used as proxies.^{10, 14, 16} However, these methods may require more space, specialised equipment, or patient mobility. Finger length measurement offers advantages due to its simplicity, portability, low cost, and minimal patient discomfort.^{18, 20}

The findings are also relevant in forensic and disaster victim identification contexts, where incomplete remains may be encountered. Estimation of stature from body parts is a well-established practice in forensic anthropology.^{5,6,24} Although the present study focused on living adolescents, the derived regression equation may contribute to forensic databases for Nigerian populations. Sex-related differences in anthropometric relationships have also been reported in several studies, with males generally exhibiting larger body dimensions and different proportionality patterns compared with females.^{7,25} Hormonal influences during puberty contribute to these differences, as testosterone promotes greater skeletal growth in males, whereas oestrogen accelerates epiphyseal closure in females.²⁶⁻²⁸ Although the current study developed sex-specific prediction equations, future research should validate and refine these equations to improve accuracy.

Nutritional status is another important determinant of growth and body proportions. Chronic malnutrition, recurrent infections, and socioeconomic deprivation can impair linear growth, leading to stunting.^{27, 28} Conversely, improved nutrition and health care are associated with secular increases in height over generations.^{27,29,30} The Niger Delta region has unique environmental and socioeconomic characteristics that may influence growth patterns, including

dietary habits and exposure to environmental pollutants. Incorporating nutritional assessments in future studies would provide deeper insight into factors affecting anthropometric relationships in this population.

The relatively significant coefficient of determination ($R^2 = 0.452$) indicates that nearly half of the variability in height can be explained by middle finger length alone. While this demonstrates substantial predictive ability, it also suggests that other factors—such as genetic potential, overall limb proportions, and environmental influences—contribute to stature. Multivariate models incorporating additional anthropometric parameters may improve predictive accuracy. The findings in this study support the utility of MFL as a surrogate anthropometric measure for stature estimation when direct height measurement is not feasible.

This study has several strengths. The large sample size enhances statistical power and generalizability within the study area. Standardised measurement techniques minimised measurement error, which is a common challenge in anthropometric research. The focus on adolescents, especially MFL, fills a gap in Nigerian literature, as most previous studies have involved adults.

Limitations

The study was conducted in a single geographical area, which may limit generalizability to other populations and/or other ethnic groups in Nigeria. Inter-observer variability, although minimised, cannot be completely excluded.

Conclusion

This study suggests that middle finger length is a significant and practical predictor of standing height among adolescents in Yenagoa. The findings support the use of simple hand measurements as surrogate indicators of stature in

clinical, public health, and research settings. For paediatricians, particularly in resource-limited environments, this method offers a convenient tool for growth assessment when direct measurement is not feasible.

Authors' Contributions: OMA conceived and designed the study along with AFO. BIJ did the literature review. OMA, BIJ and AFO did data curation, analysis and interpretation. OMA drafted the manuscript, while BIJ and AFO revised the draft for sound intellectual content. All the authors approved the final version of the manuscript.

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