Original Research Article

Does upper Arm length, Arm Span, and foot length serve as good predictors for stature? A cross-sectional study among Northern Nigerians.

Abstract

Background: Stature estimation is an important identification process necessary when dissembled body parts are found. The study is important in the field of physical and forensic anthropology and for industrial design. The study aims to determine if upper arm length, foot length, and arm span would be good predictors for stature among northern Nigerians.

Method: The study adopted a descriptive cross-sectional design using a multi-stage random sampling technique. 400 northern Nigerians (200 males and 200 females) were involved in the research and data were collected via direct anthropometric method using a stadiometer, and meter rule. The data obtained were analyzed using the IBM SPSS and probability was stated ($p<0.05$).

Results: The findings of the study show that males have a mean value for the statue, upper arm length, foot length, and arm span as 171.97±6.68 cm, 32.62±2.55 cm, 25.76±1.17 cm, 181.72±7.83 cm respectively, and females were 163.33±5.96 cm, 35.23±2.19 cm, 23.04±1.51 cm, and 168.67±6.68 cm for standing height, upper arm length, foot length, and arm span. Displaying sexual differences and age-related differences ($p<0.05$). The upper arm was found a weak predictor for stature ($R=0.045$, $SEE=7.66$), foot length and arm span were good predictors

of stature (R=0.73, SEE=5.24 and R=0.83, SEE=4.25). Multivariate, the upper arm length, foot length, and arm span show a better predictor for stature (R=0.85, SEE=4.07).

Conclusion: the foot length and arm span are good predictors for stature univariately while would be better predicted using upper arm length, foot length, and arm span combined

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Also expand the conclusion little bit

Keywords: forensic anthropology, upper arm length, stature estimation, Northern Nigerians, foot length and arm span

Introduction

Anthropometric measures have advanced in building biological profiles such as stature, sex, and ancestry for identification and classification purposes [1]. Building a biological profile has been validated in various places on different races due to well-defined measurements of the population that have been established. However, there is a concern that different ethnic, races, and countries have a dearth in the literature relating to the metric dimensions of the body and this has further resulted a numerous challenges and implantation becomes rarely impossible because no established dimensions. Environmental, genetic, cultural, diet, and hormonal factors could influence an anthropometric dimension of a specific population rendering it inaccurate to use obtainable data in another population[2-4]. This study aims to generate anthropometric dimensions and evaluate how well are they in the prediction of stature.

The upper arm length, foot length, and arm span are parameters of interest in this study, the upper arm length is a vertical measurement that runs from the lateral tip acromion down to the distal part of the arm (lateral and medial epicondyle) and has been used for some medical application such as nutritional assessment, body proportions, prosthetic fittings, muscle wasting

and so on. Several authors have conducted anthropometric studies and have reported inconsistent values across different populations [5-10].

The foot length has been explored widely for various reasons; mostly for shoe design and forensic approaches. It also has some medical applications in pediatric growth assessment and prosthetic designs. Among different populations, the findings are inconsistent [11-14]. The arm span is not excluded, findings also have variation in different populations and time [15-17].

The variation observed further suggests that even in a particular population, diet, and lifestyle then could also be attributed. However, considering the numerous works that abound in different populations and the dearth of literature on northern Nigeria. This has motivated the interest of this study to generate anthropometric dimensions and predict stature using the parameter for forensic and industrial applications.

Materials and Methods

Study Design

This study adopted a cross-sectional descriptive study design where it was used to obtain data on the standing height, upper arm length, foot length, arm span, and age of northern Nigeria. The study comprised four hundred Nigerian northerners currently residing in Kano State, Nigeria where two hundred were males and another two hundred were females.The age interest of the study ranges from 17 years to 40 years.The study lasted for a period of six months (January 2024- June 2024), the first three months were used to collect the data and the second phase (the last three months) was used to manage and design the manuscript of the study. KanoCity in Kano State, Nigeria was used as a sample frame to draw subjects from different northern states of Nigeria.

Sampling size and techniques

Four hundred Nigerian northerners were recruited via multi-stage random sampling techniques to ensure all subjects had an equal chance of being selected and the minimum sampling size was determined using the Taro Yamane formula for quantitative research.

Selection Criteria

In the course of the study, the researcher only recruited subjects whose grandparents and parents were of Nigeria'snorthern origin, between the age interval of 17 years to 40 years, and had no morphological defect that could alter the stature or the areas of measurements. Lastly, only subjects who consented to participate by filling out the consent form were allowed. The study further excluded subjects whose origin is from northern Nigeria and had some morphological defect that could alter stature and the measured part of interest. The subjects who failed to consent were also excluded from the study.

Method of Data collection

Data were collected via a semi-structured descriptive questionnaire following a personal interview and direct measurements of the body dimensions. The questionnaire was designed in two sections; A containing the bio data of the subjects, and Section B, the under-listed parameters of interest and the scoring system. The personal interview was adopted to ensure the subjects met the inclusion criteria and also to validate that the information given was correct. Using a ZT-160 stadiometer the height of the subjects was measured, and a non-stretchable and a mega-size caliper were used to measure the upper arm length and foot length. A meter rule was also used to measure the arm span. All measurement follows the international standard of anthropometric measurements.

Anthropological landmarks

- **Standing height:** it is a vertical measurement of the human body that runs from the vertex of the head to the sole when the subject is standing upright in an anatomical position.
- **Upper arm length:** this measurement runs from the lateral tip acromion down to the distal part of the arm (lateral and medial epicondyle)
- **Foot length**. This is the measurement of the foot from the big toe to the distal talus of the leg
- **Arm span;** this is a horizontal measurement of the human body from the tip of the third finger/digit to the opposite tip of the third finger/digit

Method of Data Analysis

The data obtained from the study were subjected to the International Business Machine Statistical Package for Social Science (IBM SPSS version 25), and the results were presented as mean±standard deviation. T-test and ANOVA were used as inferential statistics to evaluate the sexual and age-related differences, and univariate and multivariate analysis was done to estimate stature via individual parameters and combined parameters. A probability less than 0.05 was considered statistically significant ($p<0.05$) and 95% was denoted as the confidence interval level.

Results

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The study comprised four hundred northern subjects between the ages 17- 40 years and Table 1, shows the descriptive statistics of the parameters for Northern Nigeria. The results present that the minimum and maximum standing heights were 148 cm and 191.2cm respectively with a

mean value of 167.65cm, the upper arm length has a mean value of 33.93cm whereas the minimum and maximum values are 23cm and 45.3cm. The foot length was measured and our result presented that the minimum, maximum, and mean values were 18.6 cm, 34.1cm, and 24.40cm respectively. The arm span had a mean value of 175.19 cm with minimum and maximum values of 150cm and 201 cm respectively.

Table 2. explores the sexual differences observed in the studied parameters among Northern Nigeria and the results present that male has a mean value for standing height, upper arm length, foot length, and arm span as 171.97±6.68 cm, 32.62±2.55 cm, 25.76±1.17 cm, 181.72±7.83 cm respectively. While the females show 163.33±5.96 cm, 35.23±2.19 cm, 23.04±1.51 cm, and 168.67±6.68 cm for standing height, upper arm length, foot length, and arm span. The comparison between the males and the females further shows that there are statistical differences observed in standing height, upper arm length, foot length, and arm span ($p<0.05$).

Table 3, explores the age-related differences in standing height, upper arm length, foot length, and arm span and our findings show that the mean value increases with the increase in age. However, the findings have displayed statistical age-related differences in Standing height, upper arm length, foot length, and arm span ($p<0.05$).

Table 4. Present the univariate regression for stature estimation (S) among northern Nigeria and our findings explore that upper arm length is a weak predictor for stature (R=0.045, SEE=7.66), the foot length showed a strong predictor for stature where the R was observed as 0.73 and SEE was 5.24. and the arm span also shows a strong correlation and a good predictor for stature (R=0.83, SEE=4.25). The collinearity has shown that upper arm length, foot length, and arm span are not closely related to stature and could be used as a predictive value (VIF<2.5). From the univariate regression, our study generated models for stature estimation using the upper arm

length, stature could be predicted as S=(163.34) +Al(0.13), using foot length, S=(96.49)+FL(2.92) and using Arm span= (53.40)+AS(0.65).

Table 5 showed the multivariate linear regression for stature estimation (S) among northern Nigeria across the sexes and the finding from our study shows that upper arm length, foot length, and arm span are good predictors of stature (R=0.85, VIF<2.5 and SEE<1). For the female population, the result showed that upper arm length, foot length, and arm span were good predictors for stature (R=0.77) with SEE of the studied parameters observed (SEE<1) which further indicates the accuracy of the prediction and the VIF of the upper arm length and foot length was VIF<2 indicating that the parameter is not closely related to the stature and could serve as a good predictors for stature. Among the male population, the upper arm length, foot length, and arm span display a good predictor for stature estimation (R=0.78) with each parameter having SEE less than 1. The collinearity has also shown that upper arm length, foot length, and arm span are accurate and better predictors for stature (VIF<2).

Table 1. Descriptive Statistics of the Parameters for Northern Nigeria

	min	**max**	**Mean**	**SEM**	**SD**
Age(year)	17	40	22.458	0.2002	4.0042
S (cm)	148	191.2	167.657	0.3832	7.664
AL (cm)	23	45.3	33.928	0.1358	2.7169
Fl (cm)	18.6	34.1	24.402	0.0959	1.9175
AS (cm)	150	201	175.198	0.4888	9.776

Min= minimum, max=maximum, S=standing height, AL=upper Arm Length, FL=foot length, AS=Arm span, SEM=Standard Error Mean, SD=standard deviation.

Table 2. Sexual differences in the parameters among Northern Nigeria

SEX	Male	Female	T score	p-value	Inference
S	171.97±6.68	163.33±5.96	13.65	0.0001	Sig
AL	32.62±2.55	35.23±2.19	-11.01	0.001	Sig
FL	25.76±1.17	23.04±1.51	20.19	0.001	Sig
AS	181.72±7.83	168.67±6.68	17.92	0.0001	Sig

S=standing height, AL=upper Arm Length, FL=foot length, AS=Arm span, Sig= significant (p<0.05)

Table 3. Age-related differences in the parameters among Northern Nigeria

	<= 17.0	18.0 - 24.7	24.8 - 32.3	32.4+	F	p-value	Inference
S	160.75±5.30	166.95±7.69	170.06±7.06	170.96±6.98	4.88	0.002	Sig
AL	33.00±1.41	34.26±2.73	32.80±2.53	32.92±1.31	7.04	0.0001	Sig
FL	22.80±1.69	24.15±1.92	25.20±1.63	25.89±1.67	9.90	0.0001	Sig
AS	166.70±6.08	173.93±9.47	179.55±9.62	180.33±9.22	9.07	0.001	Sig

S=standing height, AL=upper Arm Length, FL=foot length, AS=Arm span, Sig= significant (p<0.05)

Table 4 univariate linear regression for Stature estimation (S) among Northern Nigeria

parameters	B	R	R^2	SEE	Sig. F Change	Collinearity Tolerance	VIF
(constant)	163.34						
AL	0.13	0.045	0.002	7.6658	0.368	0.92	1.08
(constant)	96.49						

FL	2.92	0.73	0.53	5.24	0.0001	0.34	2.50
(constant)	53.40						
AS	0.65	0.83	0.69	4.25	0.0001	0.41	2.46

S=standing height, AL=upper Arm Length, FL=foot length, AS=Arm span

Table 5 Multivariate linear regression for stature estimation (S) among Northern Nigeria

Model	Parameters	B	SEE	R	R^2	Sig	Tolerance	VIF
All sexes	(Constant)	49.595	4.402			.000		
	AL	.169	.078	0.85	0.72	.032	.922	1.085
	FL	1.048	.169			.000	.398	2.514
	AS	.495	.033			.000	.407	2.460
Female	(Constant)	53.651	6.972			.000		
	AL	.318	.173	0.77	0.59	.068	.518	1.929
	FL	1.249	.213			.000	.724	1.381
	AS	.413	.062			.000	.430	2.325
Males	(Constant)	43.721	7.771			.000		
	AL	.012	.133	0.78	0.60	.928	.792	1.263
	FL	.945	.314			.003	.678	1.475
	AS	.570	.051			.000	.581	1.720

a. Dependent Variable: STANDING HEIGHT

S=standing height, AL=upper Arm Length, FL=foot length, AS=Arm span

Discussion

The present study took account of the sex-related differences in the study parameters of the Northern Nigeria currently residing in Kano city in Kano State, Nigeria. Our findings present that male has a mean value for standing height, upper arm length, foot length, and arm span of 171.97±6.68 cm, 32.62±2.55 cm, 25.76±1.17 cm, and 181.72±7.83 cm respectively. While the

females show 163.33±5.96 cm, 35.23±2.19 cm, 23.04±1.51 cm, and 168.67±6.68 cm for standing height, upper arm length, foot length, and arm span. The implication of the finding shows that males have higher mean values in standing height, upper arm length, foot length, and arm span compared to females. The comparison between the males and the females further shows that there are statistical differences observed in standing height, upper arm length, foot length, and arm span ($p<0.05$). The reasons for the differences in physical measurements between the males and females, as shown in our findings; standing height, upper arm length, foot length, and arm span, could be genetic, hormonal, and evolutionary reasons. Genetically, males and females have distinct makeups that guide how they grow, leading to noticeable physical variations. Hormones also play a big role, testosterone in males encourages the growth of bones and muscles, resulting in taller heights, longer limbs, and larger feet, while estrogen in women creates different growth patterns and fat distribution[4, 5]. From an evolutionary perspective, these physical differences have evolved to support various roles. Growth spurts also happen differently for males and females; males usually experience these spurts later but for a longer period, leading to more significant overall growth. Finally, sexual dimorphism, or the inherent differences in size and appearance between males and females, has evolved through natural and sexual selection pressures[5].These factors could be said to contributeto the sexual differences observed in the study. The findings of this study agree with the findings from Asiwe et al., [5] that upper arm length is significantly different in sexes among the Mgbidi population of Imo State, Nigeria. Among northern India, Singh et al., [18] also reported that stature was statistically significant with sex, in Iran and Pakistan, Gh et al., [19] findings were consistent with our study that upper limb extremity measurements were significant with sex. Krauss et al., [20] on the anthropometry of the foot reported that sexual differences exist in foot measurements, and

amongthe Ikwerre and Okirrika ethnic groups of Rivers State, Asiwe et al., [3] have reported that standing height has a significant difference between males and females.

Table 3, explores the age-related differences in standing height, upper arm length, foot length, and arm span and our findings display statistical age-related differences in Standing height, upper arm length, foot length, and arm span ($p<0.05$). However, Between the ages of 17 and 40, changes in standing height, upper arm length, foot length, and arm span are usually minimal compared to the more dramatic growth seen in childhood and adolescence. By 17, most people have finished growing, so major increases in height or limb length are uncommon. However, subtle changes can still happen due to factors like posture, spinal compression, and muscle mass. Over time, poor posture, muscle imbalances, and gravity can cause slight reductions in height, especially as people approach their late 30s and early 40s. Muscle mass peaks in the late teens to early 20s and can gradually decline with age if not maintained through regular exercise, affecting measurements of the upper arm, foot, and arm span.Foot length can change due to weight gain, which might cause the arches of the feet to flatten slightly, increasing foot size. Hormonal changes, although less pronounced than during puberty, can still impact body composition by affecting muscle mass, fat distribution, and bone density. Lifestyle choices like diet, exercise, smoking, and alcohol consumption greatly influence overall health and body measurements. Poor nutrition or lack of physical activity can lead to muscle loss and changes in body composition. Chronic health conditions or injuries, such as osteoporosis, which may start to develop in the late 30s and early 40s, can also contribute to these subtle changes. The findings of the study agree with Li et al., [21], Tomassoni et al., [22], and Echeita et al., [23] that there are age-related differences observed in the foot. Rezende et al., [24], Perissinotto et al., [25] and López-Ortega and Arroyo, [26] findings were consistent with our study.

The studied parameter has shown a high level of sexual and age-related difference providing a better understanding of the parameters. However, the study explores to evaluate if upper arm length, foot length, and arm span could serve as a good predictor for stature. Table 4, shows the univariate regression of upper arm length, foot length, and arm span and the findings present that upper arm length is a weak predictor for stature (R=0.045, SEE=7.66), the foot length wasa strong predictor for stature where the R was observed as 0.73 and SEE was 5.24. and the arm span also shows a strong correlation and a good predictor for stature (R=0.83, SEE=4.25). The collinearity has shown that upper arm length, foot length, and arm span are not closely related to stature and could be used as a predictive value (VIF<2.5). Our findings are consistent with Gardasevic et al., [27], Arifi et al., [28], Supare et al., [29], Gupta et al., [30], Dorjee and Sen, [31], and Esomonu et al., [32] that arm span is indeed a good predictor for stature. Kanchan et al., [33], Sanli et al., [13], Ozden et al., [34], and Sen and Ghosh, [35] further reported in their study on the estimation of stature using foot length that foot length is a predictor for stature estimation. However, the findings from our study disagree with Asiwe et al., [5] whose study reported upper arm length was a good predictor for stature among the Mgbidi population of Imo State, Nigeria. The findings could be contradicting but according to Asiwe et al., [5], they emphasize that muscle mass and body composition could affect and influence the estimation of stature.

Table 5, evaluates the multivariate regression for stature estimation, and the findings present that good predictors of stature include upper arm length, foot length, and arm span (R=0.85, VIF<2.5, and SEE<1) when combined. Upper arm length, foot length, and arm span were good predictors of stature (R=0.77) for the female population. The SEE of the studied parameters was observed (SEE<1), indicating prediction accuracy. The VIF of the upper arm length and foot length was

VIF<2, suggesting that the parameters are not closely related to stature and could be useful predictors of stature. With each measure having a SEE smaller than 1, the male population's upper arm length, foot length, and arm span all show promise as predictors for stature estimate (R=0.78).The findings further suggest that for both males and females, the upper arm length, foot length, and arm span are good predictors for stature and this agrees with Asiwe et al., [5], Gardasevic et al., [27], Arifi et al., [28], Supare et al., [29], Gupta et al., [30], Dorjee and Sen, [31], Esomonu et al., [32], Kanchan et al., [33], Sanli et al., [13], Ozden et al., [34], and Sen and Ghosh, [35] among the different population.

Conclusion

The study has shown sexual and age-related differences in standing height, upper arm length, foot length, and arm span among the northern Nigerians residing in Kano. The univariate regression revealed that foot length and arm span are better predictors of stature and when combined, the multivariate regression revealed that but for males and females the upper arm length, foot length, and arm span were good predictors for stature estimation.

Consent

A written consent was distributed to all the subjects explaining the nature of the research and only those who consented were allowed to participate in the study. The consents were retrieved and preserved by the authors.

Ethical consideration

The study was approved by the research and ethics committee of the University of Port Harcourt, Port Harcourt Nigeria.

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