



Original article

Arm span and hand length: Reliable indices of stature estimation

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ABSTRACT

Introduction: Human height is a sexually dimorphic trait that can be estimated using various anthropometric indicators. **Materials and Method:** The study cohort which comprises of 500 (250 men and 250 women) healthy subjects who fall within the age range of 20 and 49 years, were selected randomly. Their standing stature, weight, hand length and arm span were measured. **Results:** Findings reveals that Height of male subjects was significantly ($p < 0.05$) higher compared to that of females, the mean arm span values of male subjects were significantly ($p < 0.05$) higher compared to that of females. Mean arm span values was observed to exceed stature. A strong positive correlation value of $r = 0.431$ for males, $r = 0.747$ for females was obtained in this study between the height and arm span parameters. The mean hand length of males was significantly ($p < 0.05$) higher compared to that of the females. A strong positive correlation value between the height and hand length parameter $r = 0.093$ for males, $r = 0.442$ for females was also obtained. A regression formula of height for males was $\text{Height} = 52.78 + (0.64) \text{Arm span}$ and for females, $\text{Height} = 61.2 + (0.59) \text{Arm span}$ was deduced. **Conclusion:** Arm span and Hand length are useful racial markers and will be of clinical and forensic anthropological significance when dealing with the study population. This study shows that though both arm-span and hand length can be used in estimation of the height of males and females, arm-span remains the most reliable. The regression equations can be used in amputees or dead accident victims and can be applied in medicolegal issues with accurate results.

KEYWORDS: Arm span, Hand length, Stature estimation

INTRODUCTION

Human height is a classic anthropometric quantitative trait notable for its ease of measurement, approximately normal distribution and relative stability in adulthood and thus has been the target of extensive research across many fields of science [1]. It is a sexually dimorphic trait [2] which serve as an indicator of nutritional quality and closely correlates with health components [3] [4] hence in regions of poverty or warfare, environmental factors like chronic malnutrition during childhood or adolescence may result in delayed growth and/or marked reductions in adult stature even without the presence of any of these medical conditions.

Anthropometric indicators are often used as alternatives to estimate body height, predicting age-related loss in body height [5] [6] and extensive research has been carried out on height as an important measure of determination of basic energy requirements, standardization of measures of physical capacity and adjusting drug dosage, and evaluation of children's growth, prediction and standardization of physiological variables such as lung volumes, muscle strength, glomerular filtration and metabolic rate [7] [5] hand and foot lengths [8] [9] sitting height and knee height [10] [11] length of the sternum [12], vertebral column length [13], length of scapula [14], arm span [15] as well as cranial sutures [16] etc. Arm span was found to be the most reliable [17] [18] though the relation between arm span and stature is found to vary from race to race [19] [20].

In Nigeria however, the use of arm span length for stature estimation has been studied in numerous ethnic groups of Nigeria [21] [22] [23] [24] [25] with the studies showing a positive correlation of using arm-span length to stature.

Hand length as a parameter for stature estimation has been found to also be a valuable alternative and of great scientific importance to investigators in the field of anthropometry, forensic pathology, orthopedic surgery and ergonomics. Its use also extends to estimation of age-related loss in height, prediction of body weight status and body surface area [26] [27] [28] [29] [30] [31] [32].

METHODS AND MATERIALS

The present study was undertaken in Enugu state, Southeast Nigeria. Ethical approval for the study was granted by the Ethics and Research committee of Faculty of Basic Medical Sciences, College of Medicine, Enugu State University of Science and Technology.

500 subjects comprising 250 (50%) female and 250 (50%) male within the age range 20 and 49 years of age were randomly recruited into this study. This age group was chosen because the growth of an individual ceases by this age and there is no age-related loss in body height at this age. Informed verbal consent was sought and obtained. Subjects who did not consent, possessing skeletal deformities, physical disabilities, past history of skeletal injuries, diseases affecting bones and joints, on any form of hormonal medications, were not purely of Igbo origin by both parents and grandparents were excluded. Left-handed students were also excluded to maintain uniformity since the effect of hand dominance on hand measurements has been suggested [33].

Subjects' bio-data of age and gender were recorded. The stature, hand length and weight of the sample group were measured by same person to avoid inter-observer bias. The subjects were asked to stand barefooted and heels together in anatomical position with the head in Frankfort plane and back straight as possible so that the heels, buttocks, shoulders and the head touched the wall. The arms were hung freely by the sides with the palm facing the thighs.

After asking the subject to take a deep breath[18]and holding it, the height of the subject was measured between the vertex and floor[34] using a measuring scale (steel plate) placed against the head and wall to determine maximum height on the wall, and this was marked. The subject was then told to breathe and to step away from the wall. The height was then measured from the floor to the mark on the wall with steel tape which represents the stature in centimeters to the nearest 0.1 centimeters using the metric system [35].

Hand length dimension was taken on the right side of each individual using a manual sliding caliper, the subjects were asked to place their hands supine on a flat hard horizontal surface with fingers extended and adducted. Then the hand length was measured as a straight linear distance between midpoint of the distal crease of wrist joint and distal end of the most anterior projecting point that is tip of the middle finger [34].

The weight measurements of the subjects were taken with weighing scale. The weight gotten for each subject was recorded in kilograms.

Arm span was measured with a flexible steel tape from the tip of the middle finger on one hand to the tip of the middle finger on the other hand with the individual standing with the back to the wall with both arms abducted to 90°, the elbows and wrists extended and the palms facing directly forward [36].

Readings were taken to the nearest 0.1 centimeters. Each subject was measured twice. When the two measurements for each parameter agreed within 0.4 centimeters, their average was taken as the best estimate for the true value. When the two initial measures did not satisfy the 0.4 centimeters criterion, two additional determinations were made and the mean of the closest records was used as the best estimate.

RESULTS

A total of 500 subject participated in this study. This comprises 250 (50%) female and 250 (50%) male. Table 1 shows the mean ± standard deviation of male and female subjects. No significant ($p>0.05$) difference in the age of the female subjects compared to the male. The mean height of male subjects was significantly ($p<0.05$) higher compared to that of the females. The mean weight of male subjects was significantly ($p<0.05$) higher compared to that of the females. There was no significantly ($p>0.05$) difference in the BMI of the female subjects compared to the male.

Table 1: Mean± SD of the measured anthropometric parameters by sex.

	Female Mean± SD	Male Mean± SD	F	P-Value
AGE	26.0±26.9	26.9±5.9	3.202	0.74
HEIGHT	168.0±7.8	172.7±8.1	48.602	0.000
WEIGHT	71.9±12.6	75.1±11.7	9.603	0.002
BMI	25.6±4.5	25.2±4.0	1.346	0.247
ARM SPAN	180.0±9.9	187.7±14.9	35.335	0.000
HAND LENGTH	19.0±1.1	21.4±12.0	4.309	0.038

The mean arm span of male subjects was significantly ($p<0.05$) higher compared to that of the females. The mean hand length of male subjects was significantly ($p<0.05$) higher compared to that of the females. Table 2 shows the relationship between height and the measured variables. A significant ($p\text{-value}=0.001$) positive correlation between height and the following: weight, BMI,

arm span, and hand length with height. Arm span had the highest correlation value in females ($r=0.747$, $p<0.001$) and males ($r=0.431$, $p<0.001$).

Table 2. Correlation between height and the measured variable.

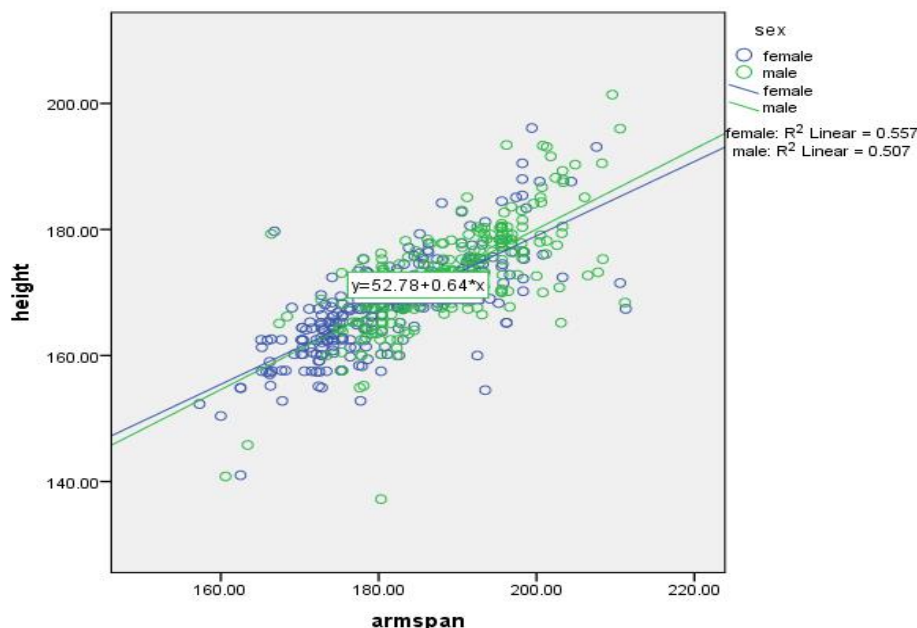
	HEIGHT			
	Female		Male	
	r	p-value	r	p-value
Age	0.112	0.076	0.085	0.179
Weight	0.193	0.002	0.418	0.000
BMI	0.360	0.000	0.236	0.000
Arm span	0.747	0.000	0.431	0.000
Hand length	0.442	0.000	0.093	0.144

Findings shows that Height of male subjects was significantly ($p<0.05$) higher compared to that of females, the mean arm span values of male subjects were significantly ($p<0.05$) higher compared to that of females. Mean arm span values was observed to exceed stature. A strong positive correlation value of $r=0.431$ for males, $r=0.747$ for females was obtained in this study between the height and arm span parameters as shown in table 3 and graph 1. The mean hand length of males was significantly ($p<0.05$) higher compared to that of the females. A strong positive correlation value between the height and hand length parameter $r=0.093$ for males, $r=0.442$ for females was also obtained.

Table 3. Regression Equation for estimating for arm span

S	Regression Equation	R ²	r	p-value
Female	Height=61.2 + (0.59)Arm span	0.557	0.747	0.000
Male	Height=52.78 + (0.64)Arm span	0.507	0.431	0.000

Graph.1: Regression analysis showing that only the arm span predicted height in both males and females with positive correlation



DISCUSSION

Stature estimation from different human body parts such as the head, upper and lower extremities (Hands, trunks, arms, foot, etc.) is well known in scientific literature to have varying degrees of positive correlation. The use of arm-span and hand length in stature estimation has been reported in numerous researches to have positive correlations with racial variation [20] [22] [37] [32].

Estimation of height using various physical measurements has been attempted previously [38] [21] [23] [24] [25]. However, linear regression equations using arm span length specific on the Igbo ethnic group for stature estimation though expedient in conditions where measurement for stature cannot be obtained due to lower limb deformities, spinal deformities, acquired physical deformity etc. has been lacking.

In this study which consisted of 500 subjects of Igbo ethnic group, weight and mean height of male subjects was significantly ($p<0.05$) higher compared to that of the females. This concurs with the findings of Eveleth and Tanner [2], that men are taller than women in all human population.

The results of this study showed that the mean arm span values of male subjects were significantly ($p<0.05$) higher compared to that of the females. Mean arm span values was also observed to exceed stature in South East Nigerian adults. This is consistent with other studies [20] [39] [19] [40] [41] [42]. Standard procedures were applied in this study hence the larger differences between the arm span and stature values are unlikely due to systematic error in measurement or the likelihood that the arm span of our cohort sample was affected by a pathological condition.

A strong positive correlation value of $r=0.431$ for males, $r=0.747$ for females was obtained in this study between the height and arm span parameters. Correlation between arm span and stature was observed in males and females of our cohort ($p<0.001$) consistent with other studies which found strong associations between arm span and stature [43] [5] [43] [41] [44]. The arm span therefore seems to be a reliable indirect physical measurement for estimating stature. However, such prediction estimates may vary across races thus warranting the need for similar studies in different ethnic groups and regions.

Consistent with other studies, the hand length described in this study could be used as surrogate measurement for estimating the stature of an individual. The mean hand length of male subjects was significantly ($p<0.05$) higher compared to that of the females. A strong positive correlation between the height and hand length parameter $r=0.093$ for males, $r=0.442$ for females was also obtained in this study

A regression formula of height for males was $\text{Height}=52.78 + (0.64) \text{ Arm span}$ and for females $\text{Height}=61.2 + (0.59) \text{ Arm span}$ was deduced. These values are useful racial markers and will be of clinical and forensic anthropological significance when dealing with the Igbo people.

CONCLUSION

We conclude that though both arm-span and hand length can be used in estimation of the height of both males and females in South East Nigeria, arm-span remains the most reliable. The regression equations so derived can be used in cadavers or an amputee with fairly accurate results. This can be helpful in medico- legal cases as well as cultural anthropological studies.

Conflicts of interests: None declared by authors

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