

Correlation between the arm-span and the standing height among males and females of the Khasi tribal population of Meghalaya state of North-Eastern India

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ABSTRACT

Introduction: The estimation of relationship between the arm span and the standing height has been an important tool in anthropometric measurements especially in cases where direct measurement of stature is not possible. **Objective:** To find the relationship between the arm-span and the standing height of both males and females in the population of Khasi tribal population of Meghalaya. **Materials and Methods:** The study involved 400 numbers (272 males and 128 females) of healthy human volunteer subjects belonging to Khasi tribe of Meghalaya. The standing height and arm-span were measured for each individual and analyzed. **Result:** Of the 400 healthy volunteers, 272 (68%) were males and 128 (32%) were females with age ranged from 25 to 45 years. Height and arm span in males (159.68 ± 4.12 cm and 166.30 ± 4.27 cm, respectively) were found to be significantly ($p < 0.001$) higher than females (149.96 ± 3.04 cm and 155.77 ± 3.13 cm respectively). The Pearson correlation coefficient (r) between height (cm) and arm span (cm) showed significant positive correlation in both male ($r = 0.988$, $P < 0.001$) and female ($r = 0.991$, $P < 0.001$) study subjects. The regression equation was Height = $1.060 + 0.954$ (Arm span); $R^2 = 0.976$; SEE = 0.646 for male. For female subjects the regression equation was found as Height = $0.150 + 0.962$ (Arm span); $R^2 = 0.983$; SEE = 0.400. **Conclusion:** Arm-span can be used as one of the most reliable parameter in both males and females for obtaining the stature of an individual in alternative to the height.

Keywords: Arm span, height, Khasi, North- Eastern India

Introduction

Anthropology is the study of mankind that studies different aspects of human life like the origin, physical and cultural development, biological characteristics, social customs and beliefs

of humankind. Anthropology has many sub-branches and one of those is the biological or physical anthropology. Physical or biological anthropology branch deals with the biological, evolutionary and demographic function of human.^[1]

The most fundamental and unique features Indian population structure is the division of its population into multiple levels viz castes, tribes and religion within any particular geographical location. Moreover, each of these castes, tribes and religious groups are again sub-divided into a various subunits like sub-castes or sub-tribes. The continuous process of the

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subdivision and/or amalgamation/admixture in the Indian population of different geographical region has been described in literature by two different models: fusion and fission.^[2,3] There are a number of reasons and processes associated with such type of subdivisions and subsequent maintenance of their endogamy with specific group identity.^[4,5]

The demographic structure of northeast India which comprises seven states Assam, Manipur, Meghalaya, Arunachal Pradesh, Mizoram, Nagaland and Tripura are distinct from other parts of India. The north eastern region is surrounded by foreign territories like Bhutan, Tibet-China, Burma, and Bangladesh on the north-south and the east. The total population of northeast India, according to 1991 census is nearly 32 million, which constitute 3.73% of population of India as a whole.^[6]

Meghalaya is one of the small states of India with an area of 22,430 sq. kms. and a population of 29,66,889 (2011 Census).^[7] Called the 'Scotland of the East', by the colonial rulers long ago, it is a region of unsurpassed scenic beauty, waterfalls and mountains, lakes and valleys. The most of the people belongs to the three major tribal groups – the Khasis (34%), the Garos (30.5%), and the Jaintias (18.5%). The term Khasi is included in the group of matrilineal and Mon-Khmer speaking people who presently inhabit the East and the West Khasi Hills and the Jaintia Hills district of Meghalaya. The Khasi tribe is also called 'Children of the Seven Huts', as it consists of seven sub-tribes namely: Khyntiam, Pnar, Bhoi, War, Maram, Lyngngam and Diko. Physiognomically, the Khasis are mainly Austro-Mongoloid but with marked presence Caucasoid features with lesser Negroid features. However, the pure Mongoloid physical features like the presence of epicanthic folds in the eyes are lacking in the Khasis.^[6-8]

Identification of an individual is one of the most important elements of all medico-legal cases. Different types of characteristics can be used to identify a person. The primary characteristics used for identification of an individual are age, sex and stature of the person.^[9] Stature or body height is one of the most important and useful factor to narrow down the missing person's identity. Researchers from the published literatures have been reported the effectiveness of using various body parameters in predicting body height^[10-12] and the arm span was found to be the most reliable indices^[13] although, the association was found to be varying from race to race.^[14,15] Additionally, height is also required for determination of basic energy requirements, standardization of measures of physical capacity and for adjusting drug dosage. Estimation of height has got immense importance in predicting the age related loss in stature, identifying individuals with disproportionate growth abnormalities and skeletal dysplasia or height loss due to surgical interventions on the spine.

However, the exact height of an individual cannot measured directly in some situation due to deformities of lower limb or in patients who have undergone amputation or shortening due to

fractures, in cases with highly decomposed or mutilated bodies or in cases of mass disasters where only part (s) of body is/are available. In all these circumstances, an estimation of the height has to be done with the help of other anthropometric body parameters.

The aim of the present study was to find out the correlation between the arm-span and the standing height among males and females of the Khasi tribal population of Meghalaya state of northeast India and to derive regression formulae for calculating the height of male or female with the help of arm-span.

Materials and Method

In this study we had taken 400 numbers (272 males and 128 females) of healthy human volunteer subjects of 25-45 years age group belonging to Khasi tribe of Meghalaya, working in the North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences (NEIGRIHMS), Shillong as staff at different cadres without having any musculoskeletal diseases or any surgery related to limbs or vertebral column. Study was conducted within the premises of NEIGRIHMS from January 2014 to December 2014. This age group was selected because by the age of 25 year the ossification of all bones are completed while after the age of 45 year the height of an individual decreases due to ageing process as well as postmenopausal osteoporosis is more common in female after the age of 45 year. The subjects were selected by simple random procedure and informed, written, witnessed consent in vernacular of each individual was taken prior to inclusion in the study.

Anthropometric measurements

A team of two trained doctors (1 for measurement and 1 record keeping) obtained anthropometric measurements among the above mentioned normal healthy subjects. Standing height was measured by using standard anthropometric protocols.^[16] Height of the subjects were measured in standing erect anatomical position with bare foot and head in the Frankfort plane from crown to heel by using stadiometer. In the same position mentioned above the arm-span was measured with the help of flexible steel measuring tape from the tip of the middle finger of one hand to the opposite hand of the individual with his both arms abducted to 90° while the elbows, wrists, metacarpophalangeal and interphalangeal joints were in fully extended position and palms were faced anteriorly. Each measurement was taken twice and the mean of them was taken as the true value for the corresponding observation. All the measurements were taken at the morning session to avoid the diurnal variation of the measurements.^[17]

Ethics

The study was approved by the Institutional Ethics Committee (NEIGR/IEC/2012/122 dated 12-02-2013). Voluntary informed written consent was procured from all the participants of the study.

Statistical analyses

The collected data were analyzed statistically by using Microsoft Office Excel 2007 and Microsoft Graph Chart software. The means and standard deviations (SD) were calculated for both anthropometric variables. A comparison of means of body heights and arm spans between the sexes was carried out using a t-test. The relationships between body height and arm span were determined using Pearson's correlation coefficients. Linear regression analyses were then performed to examine the extent to which arm span can reliably predict body height. Finally, these relationships were plotted as scatter diagram. Statistical significance was set at $P < 0.05$.

Results and Observations

A total of 400 subjects were studied in this study from January 2014 to December 2014. Of these, 272 (68%) were males and 128 (32%) were females (male: female ratio = 2.1:1). The age of the recruited volunteer ranged from 25 to 45 years. Height and arm span in males (159.68 ± 4.12 cm and 166.30 ± 4.27 cm respectively) were found to be significantly ($p < 0.001$) higher than females (149.96 ± 3.04 cm and 155.77 ± 3.13 cm respectively). Anthropometric parameters in male and female are shown in Table 1.

Table 2 shows the correlation and regression analyses between Body Height and Arm Span among the study subjects. The Pearson correlation coefficient (r) between height (cm) and arm span (cm) showed significant positive correlation in both male ($r = 0.988$, $P < 0.001$) and female ($r = 0.991$, $P < 0.001$) study subjects. The regression equation was $\text{Height} = 1.060 + 0.954 (\text{Arm span})$; $R^2 = 0.976$; $\text{SEE} = 0.646$ for male. For female subjects the regression equation was found as $\text{Height} = 0.150 + 0.962 (\text{Arm span})$; $R^2 = 0.983$; $\text{SEE} = 0.400$. Figures 1 and 2 shows the linear regression plot of height and arm span in female and male study subjects, respectively.

Discussion

In different parts of India, different authors used the arm span and long bones of an individual of different age group to determine the height of the individual.^[18-29] But best of our knowledge, no study has been conducted and published about the association of arm span and standing height among the ethnic people of Meghalaya. In our observations, we found that arm span could be used as proxy tool in the measurement of standing height of an individual ($p < 0.001$) which is more appropriate in case of male than female. Also, it was found that measurement

Table 1: Anthropometric parameters in male and female expressed in mean±standard deviation

Parameters	Male (n=272)	Female (n=128)	Significance
Height (cm)	159.68 ± 4.12	149.96 ± 3.04	$P < 0.001^*$
Arm span (cm)	166.30 ± 4.27	155.77 ± 3.13	$P < 0.001^*$

*Significant at 0.01 level of significance

standing height was less than the value of arm span as well as the value of mean arm span in both adult male and female [Table 1]. In both the sexes of our study subjects, the measurements of the arm span was more than their respective standing height and the variation was comparatively more in male (6.62 cm) in contrast to women (5.81 cm). The finding is in accordance with current research reported by Shahar S *et al.*^[18] from Malaysia and Sharma S *et al.*^[19] and Arlappa N *et al.*^[20] from India. On the other hand, Kwok *et al.* was observed very negligible variations in between the standing height and the length of arm span among the Chinese adult male (6.4 cm) and female (6.3 cm).^[21]

The present study shows that there is significant positive association among the arm span and standing height in male ($r = 0.988$, $P < 0.001$) and female ($r = 0.991$, $P < 0.001$) and these results are quite comparable to those found in published literatures from other studies. In a recent study published by Rai P *et al.* has shown similar high correlation between arm span and standing height with a value of $r = 0.715$ in male and $r = 0.862$ female, respectively.^[22] Similar high correlation findings have also been reported by Barwa J *et al.* ($r = 0.826$ and 0.750 in male and female respectively)^[23] and Dongare SS *et al.* ($r = 0.90$ and 0.918 in male and female, respectively).^[24] Gerver WJM *et al.* in his recent publication regarding relation between arm span and height among children of 2-17 years old has also shown similar results with a value of $r = 0.9807$ for boys and $r = 0.9819$ for girls.^[25] On a recent study published by Mumtaz SH *et al.* from Jammu and Kashmir and Srinagar (India) reported slightly higher r value for female 0.887 than the male with r value 0.766.^[26] The regression equation can be used to estimate the height from the arm span. The mean value of calculated standing height and arm span were 159.68 ± 4.12 and 166.30 ± 4.27 for the male study subjects whereas for females the corresponding measurements were 149.96 ± 3.04 and 155.77 ± 3.13 . The mean value of calculated standing height and arm span in male were comparatively larger than in female study subjects which was significant ($p < 0.001$) from statistical point of view. Hence, separate regression equation can be used in both the gender to estimate the height from their arm span. Thus, we developed separate regression equation for male and female

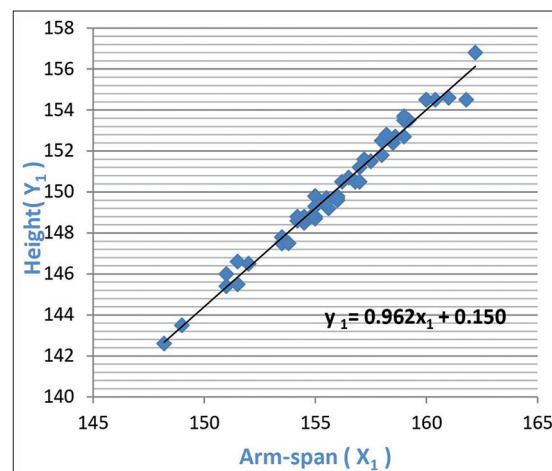
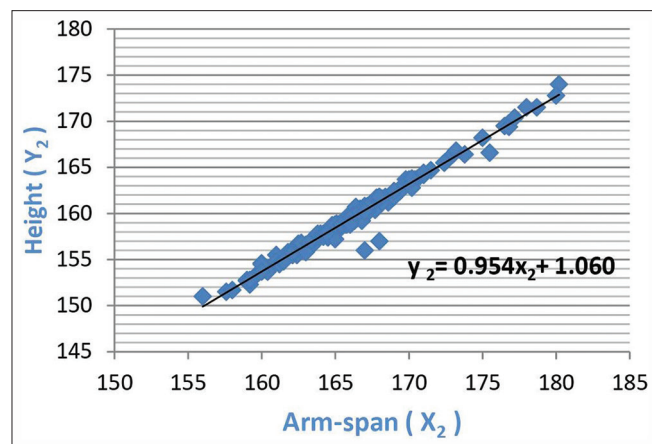


Figure 1: Linear relation of arm-span and height of female subjects

Table 2: Correlation and regression analysis between body height and arm span among the study subjects

	Male	Female
Correlation Coefficient (<i>r</i>)	0.988 (<i>P</i> <0.001*)	0.991 (<i>P</i> <0.001*)
Regression Equation	Height=1.060+0.954(Arm span); <i>R</i> ² =0.976; SEE=0.646	Height=0.150+0.962(Arm span); <i>R</i> ² =0.983; SEE=0.400

*Correlation coefficient significant at 0.01% level of significance

**Figure 2: Linear relation of arm-span and height of male subjects**

to estimate the height by their arm span. The newly formulated regression equation for our study subjects was

$$\text{Height} = 1.060 + 0.954 (\text{Arm span}) \text{ for male}$$

$$\text{Height} = 0.150 + 0.962 (\text{Arm span}) \text{ for female}$$

The regression equation has got special importance especially in situations where the exact height cannot be measured directly for various reasons like deformities of lower limb or amputated or shortening of lower limbs, in these cases if we measure arm span, height can be determined from regression equation. This measured height can also be used to calculate their basic energy requirements, standardization of measures of physical capacity, evaluation for pulmonary function test and also for adjustment of drugs dosage.

Kwok and Whitelaw accepted the arm span as one of the best proxy measurements for the estimation of the height in elderly people.^[27] In the same way, other authors also viewed that the arm span could be one of the most reliable anthropometric tool to calculate the standing height of an individual which is more trustworthy and realistic for the estimation of height estimate of height in non-ambulant bedridden elderly people.^[15,28,29]

The present study demonstrates that arm span is a reliable indirect physical measurement for estimating height. This study has developed gender specific equations to estimate height from arm span for use amongst Khasi people of Meghalaya for whom accurate measurement of standing height is not possible.

Limitation

The study was done in one ethnic group from the state of Meghalaya. Further studies involving large sample size from

different ethnic groups may provide generalized result for this state.

Conclusion

Different researchers have worked out the regression equation to estimate the standing height of an individual from arm span. Even though almost all the researchers have found a strong positive association among the measurement of arm spans and standing height, the regression equations were different for different group of population. The regression equations that we formulated are differing from the equations already used for different group of populations. This calls attention for the need of using separate regression equations for the anthropometric measurements in different group of population on the basis of their racial and ethnic differences.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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