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Anatomy

STUDY OF CORRELATION BETWEEN ARM SPAN AND STANDING HEIGHT

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ABSTRACT **INTRODUCTION :** Height is important for personal identification & determination of growth and nutritional status of individual. Estimation of inter-relationship between various body parameters and height has been an important tool in anthropometric measurements. It has been found to be of great importance in such cases where direct measurement of height is not possible. Estimation of Height can be done from incomplete skeletal and decomposing human remains where upper segment of body is available in case of accidents, natural disasters, murders etc. A wide variety of parameters are used for estimation of height including arm-span, hand length, foot length, demi span, knee height, sitting height etc.

OBJECTIVE : To formulate the regression equations to estimate Standing height from Arm span. To find the accuracy of Arm span in predicting standing height of both males and females in studied population.

METHODS : This cross sectional study was conducted among 90 medical students consisting of 59 males and 31 females in Deben Mahata Govt. Medical College & Hospital, Purulia, West Bengal. Standing Height and Arm span of each student were measured using stadiometer and calibrated steel tape respectively. The data was analysed using SPSS Version 26 & Microsoft office Excel.

OBSERVATION & RESULTS: The mean values of Arm span & Height were statistically higher in males than in females. The Arm span & Height showed strong positive correlation with each other in both sexes and the correlation was significant (p<0.0001). Mean Arm span was more than Standing Height in both sex. Regression equation has been derived for estimation of Height from the value of Arm span for male & female individuals separately and also for total population.

CONCLUSION: Arm span is a reliable tool for predicting the height of an individual and it can be used for both males & females. It can also be used for the medico-legal cases. This study will be useful for anatomist, anthropologists, forensic experts, nutritionists & physicians.

KEYWORDS : Height, Arm span, Correlation, Regression equation.

INTRODUCTION:

Standing Height is an indispensable variable when assessing pulmonary function, nutritional status, growth in childhood and body surface area estimation for drug usage & renal clearance and for other purposes. There are many conditions in which stature can't be measured accurately for example paralysis, fractures, amputation, scoliosis and pain etc. In such cases the stature estimated from Arm span is generally used to derive predicted values for pulmonary function. Measurement of the height of patients is required for determination of basic energy requirements, standardization of measures of physical capacity and for adjusting drug dosage. However in some situations exact height can't be determined directly because of deformities of the limbs or in bedridden patients. In such circumstances an estimate of the height has to be computed based on other body parameters. These estimations are also of prime importance in predicting age-related loss in stature, identifying individuals with disproportionate growth abnormalities and skeletal dysplasia or height loss during surgical procedures on the spine. These measures also have found application in normalizing pulmonary function in scoliosis[1].

Several studies have reported the effectiveness of using various body parameters in predicting body height [2,3,4] and the Arm span was found to be the most reliable[2]. However the association of Arm span and Standing Height was found to vary from race to race[4,6]. Even though several studies of this nature are available on western populations, very limited data is available on Indian subjects[5]. There are inter-racial and inter-geographical differences in measurements and their correlation with stature[8]. So there is concern regarding the accuracy of the use of population specific formula on other human populations[9]. Height is affected by genetics, environmental factors, onset of puberty, activity of person, nutritional status etc. Height varies among different sexes, different age groups, different race and different ethnic groups.

AIMS AND OBJECTIVES:

The purpose of this study is to analyze the anthropometric relationship between Arm span and Standing Height and derive regression equation to estimate Standing Height from Arm span in eastern Indian population.

MATERIALS AND METHODS:

A cross sectional study was done over a period of 1 year on 90 first year medical students of Deben Mahata Govt. Medical College & Hospital, Purulia, West Bengal, India. Standing Height and Hand length of 59 male and 31 female medical students between 18-25 years of age were recorded. Purpose of study was explained to the participants & verbal consent was taken.

INCLUSION CRITERIA- Only healthy individuals within age of 18yrs to 25yrs free from any skeletal abnormality or developmental defects were included in this study. The included individuals were ensured with ability to stand straight.

EXCLUSION CRITERIA- Any physical deformity or syndrome. Individuals with previous musculoskeletal injuries or inability to stand erect or amputation were excluded from the study[10].

Standing Height Measurement: The Standing Height was measured from the sole of the feet to the vertex of the head. Height was measured using a stadiometer with subject standing erect on horizontal resting plane bare footed having the palms of the hands turned inward and the finger pointing downward.
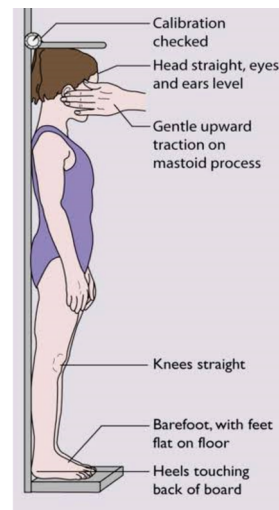
Arm span Measurement: It was measured with a calibrated steel tape from the tip of the middle finger of one arm to the tip of middle finger of

other arm with arms outstretched at right angles to the body, in bare feet on a level concrete floor with upper back, buttocks and heels against the wall.

The measurements were recorded by the same person to minimize the personal errors in methodology. Furthermore the measurements were taken at a fixed time (11am to 1pm) to eliminate discrepancies due to diurnal variation.

Results were analysed using SPSS Statistical Package (Version 26) & Microsoft Office Excel.

OBSERVATIONS AND RESULTS:
Table 1: Measurement of Standing Height and Arm span in Males

Measurements	Mean Value(cm)	Standard Deviation (cm)	Maximum Value(cm)	Minimum Value(cm)
Standing Height	168.04	5.99	179.80	151.80
Arm span	172.19	7.60	184.00	150.70

Table 1 indicates that :
a) Mean Standing Height of male individuals were 168.04cm with standard deviation of 5.99cm.
b) Mean Arm span of male individuals were 172.19cm with standard deviation of 7.60cm.

Table 2: Measurement of Standing Height and Arm span in Females

Measurements	Mean Value(cm)	Standard Deviation(cm)	Maximum Value(cm)	Minimum Value(cm)
Standing Height	154.06	7.15	180.00	143.20
Arm span	154.81	9.08	190.40	140.20

Table 2 indicates that :
C) Mean Standing Height of female individuals were 154.06cm with standard deviation of 7.15cm.
D) Mean Arm span of female individuals were 154.81cm with standard deviation of 9.08cm.

Table 3: Measurement of Standing Height and Arm span in Total population

Measurements	Mean Value(cm)	Standard Deviation(cm)	Maximum Value(cm)	Minimum Value(cm)
Standing Height	163.23	9.23	180.00	143.20
Arm span	166.21	11.59	190.40	140.20

Table 3 indicates that :
E) Mean Standing Height of total population were 163.23cm with standard deviation of 9.23cm.
F) Mean Arm span of total population were 166.21cm with standard deviation of 11.59cm.

Table 4: Regression Equation for the estimation of Height from Arm span in Males

Parameters	
Regression Equations	SH=57.680+0.641×AS
Correlation Coefficient (r)	0.813
P Value	<0.0001
Standard Error of estimate	3.52

SH = Standing Height, AS = Arm span

Table 5: Regression Equation for the estimation of Height from Arm span in Females

Parameters	
Regression Equations	SH=43.518+0.714×AS
Correlation Coefficient (r)	0.907
P Value	<0.0001
Standard Error of estimate	3.06

SH = Standing Height, AS = Arm span

Table 6: Regression Equation for the estimation of Height from Arm span in Total population

Parameters	
Regression Equations	SH=40.265+0.740×AS
Correlation Coefficient (r)	0.929
P Value	<0.0001
Standard Error of estimate	3.44

SH = Standing Height, AS = Arm span

Table 4 to 6 shows regression equations for Arm span of male and female individuals and total population. Using these regression equations Scatter Plots have been drawn below as figures 1 to 3.
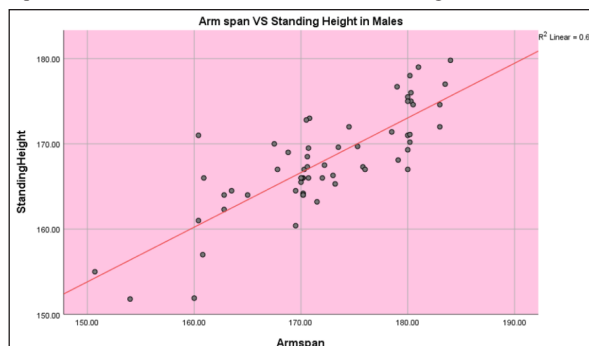
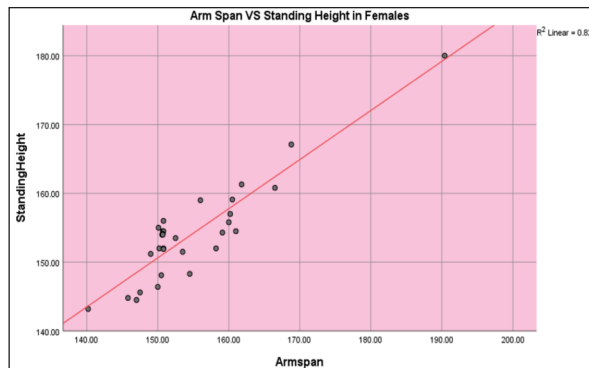**Figure 1: Regression of Standing Height on Arm span for Males**

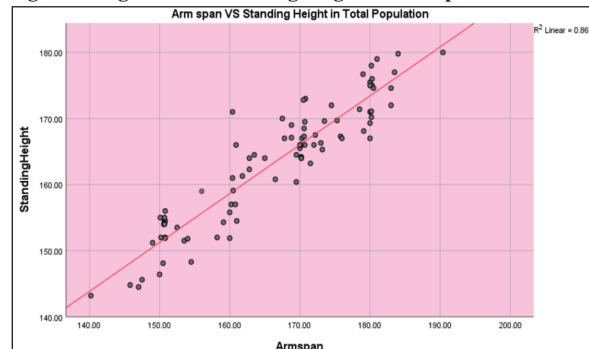**Figure 2: Regression of Standing Height on Arm span for Females**

Figure 3: Regression of Standing Height on Arm span for Total population

DISCUSSION:
In present study Standing Height ranged from 151.8cm to 179.8cm in male individuals with mean of 168.04cm±5.99cm and among female individuals Standing Height ranged from 143.2cm to 180cm with

mean of 154.06cm±7.15cm.

Arm span of male individuals ranged from 150.7cm to 184cm with mean of 172.19cm ±7.6cm. Arm span of female individuals ranged from 140.2cm to 190.4cm with mean of 154.81cm±9.08cm.

Mean Standing Height & Arm span were more in males as compared to females.

Mean Arm span was more than mean Standing Height for both males & females.
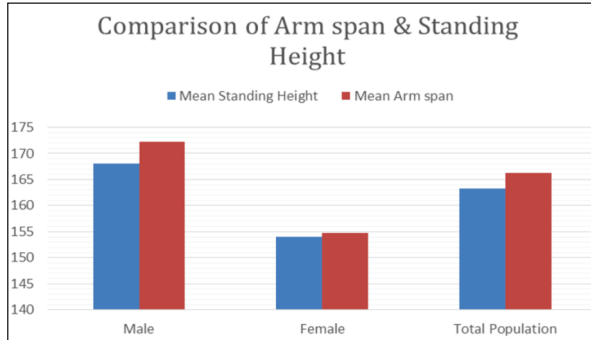

Figure 4: Multiple Bar Diagram showing comparison of Arm span & Standing Height

When the accurate measurement of stature is unobtainable, it is computed using other parameters. Arm span is the most widely used one. Estimation of stature using various physical measurements has been attempted by many authors. Present study has been compared with various previous studies in the following tables.

Table 7: Comparison of present study with previous studies done at different parts of Asia

Authors & place of study	Year of Study	Mean Height (cm)	Mean Arm span (cm)	Pearson's Correlation Coefficien®	P value	Sample size
Patel et al[12] in Bhavnagar	2012	164.59 ±9.19	167.28± 10.73	0.9080	<0.00 01	273
Shah et al[11] in Gujrat	2013	168.23 ±9.38	169.92± 10.46	0.9313	<0.00 01	150
Nadankutty[13] et al in Malaysia	2014	163.25 ±8.68	165.87± 10.91	0.9200	<0.00 01	315
Alam et al[17] in East UP	2016	167.59 ±10.38	168.67± 11.78	0.7980	<0.00 01	124
Goutam R et al[14] in North India	2018	164.86 ±8.78	169.41±10. 79	0.9222	<0.00 01	300
Present Study in West Bengal	**2021**	**163.23 ±9.23**	**166.21± 11.59**	**0.9290**	**<0.00 01**	**90**

Patel et al[12] (2012) did work on 273 subjects, showing correlation between stature and 5 parameters i.e. arm span, hand length, hand breadth, foot length & foot breadth at different degrees where arm span showed the highest correlation with stature (r = 0.908).

Shah et al [11](2013) performed a cross-sectional study on 150 MBBS students in one of the medical college of Ahmedabad. Statistical analysis of the data obtained showed strong & significant correlation of 0.9313 between height and arm span.

Nadankutty et al [13](2014) did work on 315 subjects of Malaysia and found correlation to be 0.920 between arm span and height, which was strong and positive correlation.

Alam et al [17](2016) did a study on 124 students in Uttar Pradesh, India. The correlation between stature and Arm span was positive and significant (r = 0.798, p<0.05).

Table 7 shows that Mean Height and Arm span in present study corroborate with mean height and arm span of Nadankutty et al and it is less than other previous studies.

Table 8: Comparison of Studies by various authors

Sl. No.	Authors	Year	Gender	Coefficient of correlation (r)	Regression Equation (Y) Standing Height =
1	Reeves et al[20]	1996	Afrocarribean male Asian male	Varying from 0.73 to 0.89	66.9+0.57(AS) 81.0+0.48(AS)
2	Brown et al[19]	2000	-	0.84	0.68(arm span)- 3.55(gender)- 3.81(race)- 0.02(age) + 55.34
3	Aggarwal et al[18]	2000	Total Male Female	0.8226 0.6473 0.7094	33.837+0.776(AS) 50.818+0.681(AS) 40.233+0.731(AS)
4	Zverev et al	2003	Males Females	0.871 0.815	-
5	Goon TD et al[21]	2011	Males Females	0.77 0.72	67.63+0.577(AS) 55.16+0.642(AS)
6	Chawla M et al[16]	2013	Male	0.897	44.0912+0.9987(A S)
7	Sah RP et al[23]	2013	Males Females	0.682 0.507	-
8	Alam MT et al[17]	2016	Total Male Female	0.798 0.689 0.783	48.91+0.703(AS) 36.19+0.775(AS) 60.68+0.630(AS)
9	Dongare SS et al[24]	2017	Total Male Female	0.9189 0.8443 0.9187	34.752+0.7796(AS) 50.56+0.6865(AS) 34.752+0.7796(AS)
10	Barwa J et al[15]	2019	Total Male Female	0.95 0.826 0.750	26.711+0.826(AS) 153.706+6.003(AS) 43.794+0.716(AS)
11	**Present Study**	**2021**	**Total Male Female**	**0.929 0.813 0.907**	**40.265+0.740(AS) 57.680+0.641(AS) 43.518+0.714(AS)**

AS =Arm span

A number of studies have been conducted demonstrating the positive correlation between arm span and height using regression analysis. As depicted in table 8 the high values of regression coefficient signify that arm span is reliable and significantly predicts body height in all these studies; in fact it is closest physiological measurement to standing height.

In present study by applying the regression equations Height can be estimated within error of 3.52cm, 3.06cm & 3.44cm for male, female & total population respectively.

In the present study age range of only 18 to 21years were considered and only healthy individuals were included. Hence the data may not be applicable for other age groups especially children or older people or individuals with deformities. Environmental factors, genetic factors, physical activity, nutritional status influence the size of the bones and that in turn affect the height of an individual. This can explain the difference in findings from the different parts of the country (north, south, east, west or central India) or in different race or ethnic groups.

CONCLUSION:
It was observed from the present study that there was a strong positive correlation between Standing Height & Arm span indicating a statistically significant relationship between the two parameters. In situations where exact height can't be determined directly due to deformities of lower limb, amputation or shortening as a result of fractures; Arm span can be measured and Standing Height can be easily estimated with high reliability from regression equation. This method is beneficial not only in forensic investigation but also in predicting age related loss of stature and in determining any disproportionate growth abnormalities along with calculation of basic energy requirements, standardization of measures of physical capacity and for adjusting dosages of drugs. The result of this study can be used as baseline information for further population based study in the eastern part of India. This study is useful for anthropologists, forensic experts, nutritionists and physicians for estimating the height of adult individuals of eastern part of India of either sex by using Arm span measurements.

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