Original Research Article

Estimation of stature from outstretched arm span and measurement of component/s of upper limb in the natives of Gujarat

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A R T I C L E   I N F O

A B S T R A C T

Background: The outstretched arm span and measurement of components of the upper limb are a reliable predictors of stature when fragmentary remains of the human body are found. However, this relationship can be affected by age, sex, diet, racial and geographical differences, etc. Hence, a regional database is necessary to be more accurate.

Materials and Methods: This cross-sectional, prospective analytical study included 200 students pursuing MBBS (Male = 100, Female = 100), natives of Gujarat, aged between 18 - 24 years with normal developmental history. Rich bells stature meter, Anthropometric metal rods (scaled), and Vernier caliper were used for taking measurements. SPSS software version 26 was used for statistical analysis.

Results: The findings showed a positive correlation between stature and the outstretched arm span as well as stature and various components of the upper limb. Except for the correlation between stature and the length of the shoulder to mid suprasternal notch in males, all of the results were statistically significant (p < 0.05). Regression equations were derived and verified.

Conclusion: Outstretched arm span is the most reliable indicator of stature whereas the length of the shoulder to mid suprasternal notch is the least reliable indicator of stature in both sexes in the natives of Gujarat. This study can be used as a reference in the future for medico-legal purposes.

1. Introduction

The primary characteristics of identification are sex, age, and stature and according to the Bertillon system, the dimensions of the skeleton do not change after the age of 21 years, and also that the ratio in size of different parts to one another varies considerably in different individuals.[1]

Many a time, dismembered or mutilated bodies are recovered not only from the scene of a crime but also in mass disasters like earthquakes, landslides, bomb blasts, air crashes, and building collapse, etc. When an unknown decapitated body with an amputated trunk, limbs, or only parts of the body is available, it is always necessary and crucial to determine the identity of the deceased. Stature is one of the most important factors in determining a person's

identity and its estimation from dismembered body parts can be done based on the ratio of the body part concerned with the entire body.[2] The outstretched arm span and measurement of components of the upper limb are reliable indicators of stature. However, because of differences in geographical location, age, race, sex, and dietary habits, there is a wide range of stature, and it is impossible to develop a universal formula for estimating stature based on the above parameters for people living in different parts of the world.[3,4] Hence, a population based study is required to be carried out for establishing a formula applicable to population of a particular region.

2. Objectives

1. To determine the average stature of an individual from the study group.

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2. To determine the average length of outstretched arm span of an individual and its relation with stature.
3. To determine the average length of the middle finger of an individual and its relation with stature.
4. To determine the average length of the hand of an individual and its relation with stature.
5. To determine the average length of the forearm of an individual and its relation with stature.
6. To determine the average length of the arm of an individual and its relation with stature.
7. To determine the average length of the shoulder to mid suprasternal notch of an individual and its relation with stature.
8. To compare our observation with observations of researchers from Indian Sub-continent / Foreign.
9. To create a regional database for future medico-legal references.

3. Materials and Methods

The study was conducted in the Department of Forensic Medicine at a medical college in Ahmedabad, Gujarat. The sample includes 100 females and 100 males MBBS students, natives of Gujarat in the age group of 18-24 years with normal physical development. Those students with a history of skeletal deformity, physical disability, those who were taking hormonal drugs, and non-consenting for participation were excluded. After taking approval from the Institutional Ethics committee, a study was carried out with prior informed expressed written witnesses consent from the participants. All the female subjects' measurement was taken by the female examiner/in the presence of female attendant only. All measurements were taken three times and the mean of the three readings for each factor was taken into consideration.

Stature was measured by Rich bells stature meter by asking the subject to stand barefooted with both feet in close contact with each other, trunk braced along the vertical board and head oriented in - ear - eye plane by keeping the lateral palpebral commissure and tip of the auricle of the pinna in a horizontal plane parallel to the feet. The measurement was taken by bringing the horizontal sliding bar to the vertex.

Outstretched arm span was measured by asking the subject to stand with his/her back against the wall with arms spread against the wall at shoulder level and parallel to the floor with palms facing forward. An anthropometric rod was used to measure from the tip of the middle finger on one hand, across the front of the chest at the level of suprasternal notch, and to the tip of the middle finger on the other hand.

Length of the middle finger was measured from the proximal crease to tip of middle finger with palm facing upward on a horizontal plane by Vernier caliper.

Length of the hand was measured from the proximal crease of the wrist to the tip of the middle finger when the hand was held straight and stretched by using Vernier caliper.

Length of the forearm was measured by Anthropometric rod from the tip of olecranon process to the distal margin of the head of ulna (palpable on the dorsum of the wrist) with forearm flexed and semi pronated.

Length of the arm was measured by Anthropometric rod by measuring the distance between the inferior border of the acromion process of scapula to the external superior border of the head of the radius in arm adducted and elbow in a flexed position.

Length of the shoulder to mid suprasternal notch was measured by Anthropometric rod by measuring the distance between the acromion process and mid of suprasternal notch.

All the measurements were taken in centimeters. All the data were analyzed by SPSS Software version 26, the statistical data generated was deduced to linear regression formula for estimation of the stature of an individual from the outstretched arm span and the measurement of components of upper limb in male and female subjects.
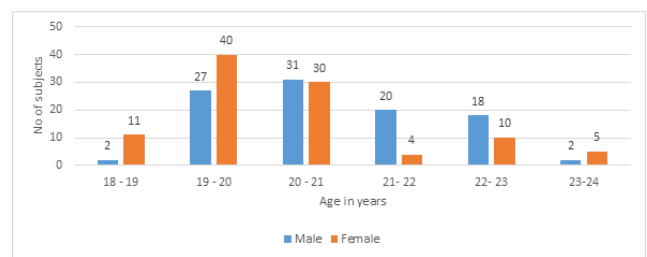
4. Results

Fig. 1: Age and sex wise distribution of subjects

The majority of the subjects in the age group of 20 - 23 years were males while the majority of the subjects in the age groups of 18 - 20 years and 23 - 24 years were females as shown in Figure 1.

Among male subjects, 64% were from urban areas, 22% from semi-urban areas and 14% from rural areas whereas 74% of female subjects were from urban areas, 21% from semi-urban areas, and 5% from rural areas. In male subjects, 82% were right-handed and 18% were left-handed whereas 85% of female subjects were right-handed and 15% were left-handed. The majority of the male subjects (53%) were on a mixed diet while the majority of the female subjects (75%) were vegetarian.

Table 1 shows that the mean stature of the male subjects was more than the mean stature of the female subjects. The mean length of the outstretched arm span, middle finger, hand, forearm, arm and shoulder to mid suprasternal notch was also more in the male subjects than in the female subjects but only a little variation between the right and the left side in both sexes.

Table 1: Comparison of various measurements in male and female

Measurement	Male			Female		
	Maximum (cm)	Mean (cm)	Minimum (cm)	Maximum (cm)	Mean (cm)	Minimum (cm)
Stature	183	169.8	158	175	156.57	145.9
Outstretched arm span	190	177.05	157.8	184.2	160.91	145
Right Middle Finger	9	8.08	7.1	8.1	7.37	6.5
Left Middle Finger	9.1	8.1	7	8.2	7.34	6.4
Right Hand	20	18.65	16.1	19.1	17.17	15.1
Left hand	20.6	18.73	16.5	19.2	17.14	15.1
Right Forearm	33.8	29.34	25.4	33.2	26.28	22.4
Left Forearm	33.7	29.16	25.3	33.2	26.24	22.4
Right Arm	41.3	36.401	29.5	37.7	33.198	26.5
Left Arm	41.6	36.4	29.4	38.3	33.28	26.4
Right Shoulder to mid suprasternal notch	22.8	18.33	15.1	21.2	16.53	13.2
Left shoulder to mid suprasternal notch	22.8	18.3	15.3	21.1	16.52	13.3

Table 2: Linear regression value of stature vs outstretched arm span in male and female

Dependent variable (stature) (y)	Independent variable (x)	
	Male outstretched arm span (xasm)	Female outstretched arm span (xasf)
Intercept (a)	52.391	65.814
Regression coefficient (b)	0.6632	0.564
Correlation coefficient (r)	0.7546	0.7563
Coefficient of determination (r^2)	0.5695	0.5724
t - value	8.5678	4.8799
SE of difference	0.846	0.889
Significance (P value)	<0.0001	<0.0001

Table 2 shows a statistically highly significant positive correlation between stature and the outstretched arms span in both sexes.
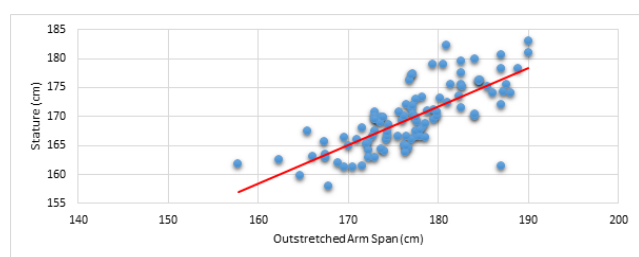

Fig. 2: Stature vs outstretched arm span in male

Fig. 3: Stature vs outstretched arm span in female

Figure 2 shows a scatter plot diagram and regression line showing a positive relationship between stature and the outstretched arm span in males.

Figure 3 shows a scatter plot diagram and regression line showing a positive relationship between stature and the outstretched arm span in females.

In males, stature and length of the shoulder to mid suprasternal notch of the right and left side have a statistically non significant positive correlation as shown in Table 3.
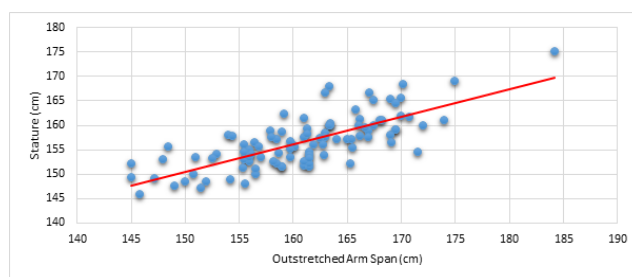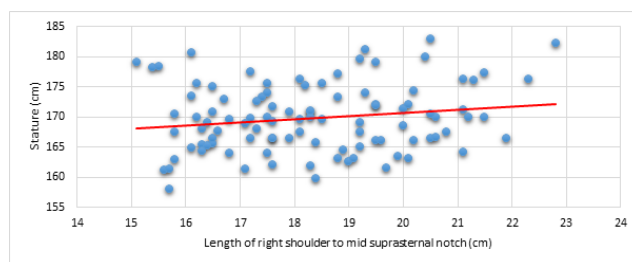

Fig. 4: Stature vs length of right shoulder to mid suprasternal notch in male

Table 3: Linear regression value of stature vs length of shoulder to mid suprasternal notch in male

Dependent variable (stature) (y)	Independent variable (x)	
	Right shoulder to mid suprasternal notch length (xSmr)	Left shoulder to mid suprasternal notch length (xSml)
Intercept (a)	160.23	160.07
Regression coefficient (b)	0.5223	0.5317
Correlation coefficient (r)	0.1712	0.1723
Coefficient of determination (r^2)	0.0293	0.0297
t - value	1.72	1.731
SE of difference	0.304	0.307
Significance (P value)	> 0.05	> 0.05

Figure 4 shows a scatter plot diagram and regression line showing a positive relationship between stature and length of the right shoulder to the mid suprasternal notch in males.
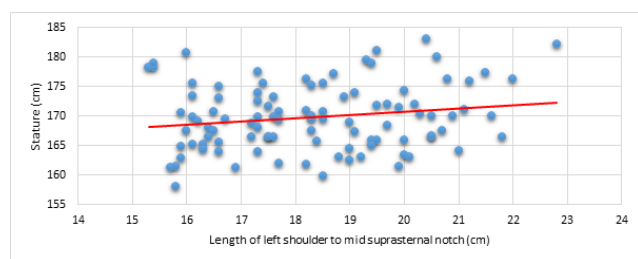

Fig. 5: Stature vs length of left shoulder to mid suprasternal notch in male

Figure 5 shows a scatter plot diagram and regression line showing a positive relationship between stature and length of the left shoulder to the mid suprasternal notch in males.

In females, stature and length of the shoulder to mid suprasternal notch of the right and left side have a statistically significant positive correlation as shown in Table 4.
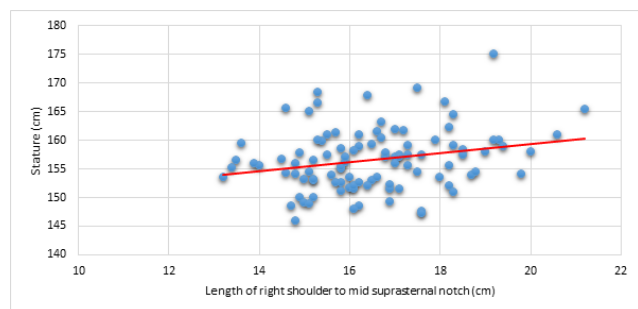

Fig. 6: Stature vs length of right shoulder to mid suprasternal notch in female.

Figure 6 shows a scatter plot diagram and regression line showing a positive relationship between stature and length of the right shoulder to the mid suprasternal notch in females.
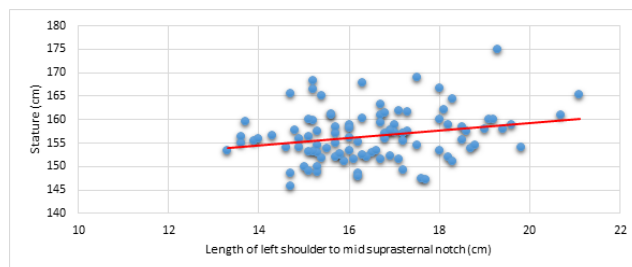

Fig. 7: Stature vs length of left shoulder to mid suprasternal notch in female

Figure 7 shows a scatter plot diagram and regression line showing a positive relationship between stature and length of the left shoulder to the mid suprasternal notch in females.

The outstretched arm span showed the highest correlation coefficient (r) with stature in which female showing a slightly higher correlation coefficient (r) than male, whereas the length of the shoulder to mid suprasternal notch showed the lowest correlation coefficient (r) with stature in which female showing a slightly higher correlation coefficient (r) than male as shown in Table 5.

Regression analysis was done and equations were derived for estimating stature from outstretched arm span and measurement of components of the upper limb for males and females as shown in Table 6.

5. Discussion

In the present study, the outstretched arm span in both sexes showed a statistically highly significant positive correlation with stature and this was similar to other studies conducted by Alam MT et al.[5] in Uttar Pradesh, Barwa J et al.[6] in Dehradun and Ter Goon D et al.[7] in Nigeria. In the present study, the female outstretched arm span showed a statistically significant positive slightly higher coefficient correlation (r = 0.7563) with stature than the male (r = 0.7546), this was consistent with a study conducted by Alam MT et al.[5] in Uttar Pradesh. But studies conducted by Barwa J et al.[6] in Dehradun and Ter Goon D et al.[7] in Nigeria showed that male outstretched arm span showed a higher

Table 4: Linear regression value of stature vs length of shoulder to mid suprasternal notch in female

Dependent variable (stature) (y)	Independent variable (x)	
	Right shoulder to mid suprasternal notch length (xSfr)	Left shoulder to mid suprasternal notch length (xSfl)
Intercept (a)	143.39	143.49
Regression coefficient (b)	0.7971	0.7916
Correlation coefficient (r)	0.2447	0.2407
Coefficient of determination (r^2)	0.0599	0.0579
t - value	2.498	2.455
SE of difference	0.319	0.322
Significance (P value)	< 0.05	< 0.05

Table 5: Comparison of correlation between the stature and various parameters in male and female

Parameters	Sex (Male/Female)	Side (Right/Left)	Correlation Coefficient (r)	P value
Outstretched Arm Span	Male		0.7546	< 0.0001
	Female		0.7563	< 0.0001
Length of Middle Finger	Male	Right	0.5528	< 0.0001
		Left	0.5786	< 0.0001
	Female	Right	0.4734	< 0.0001
		Left	0.632	< 0.0001
Length of Hand	Male	Right	0.6897	< 0.0001
		Left	0.6812	< 0.0001
	Female	Right	0.7127	< 0.0001
		Left	0.7451	< 0.0001
Length of Forearm	Male	Right	0.4995	< 0.0001
		Left	0.4997	< 0.0001
	Female	Right	0.6125	< 0.0001
		Left	0.5958	< 0.0001
Length of Arm	Male	Right	0.4682	< 0.0001
		Left	0.4853	< 0.0001
	Female	Right	0.6297	< 0.0001
		Left	0.6174	< 0.0001
Length of Shoulder to mid suprasternal notch	Male	Right	0.1712	> 0.05
		Left	0.1723	> 0.05
	Female	Right	0.2447	< 0.05
		Left	0.2407	< 0.05

Table 6: Regression equation for estimation of stature from outstretched arm span and components of upper limb

Variables	Right/Left	Male	Female
Outstretched Arm span		y = 52.391 + 0.6632 (xasm)	y = 65.814 + 0.564 (xasf)
Middle Finger	Right	y = 109.67 + 7.455 (xMFmr)	y = 107.91 + 6.6065 (xMFfr)
	Left	y = 112.04 + 7.1259 (xMFml)	y = 101.79 + 7.46 (xMFfl)
Hand	Right	y = 76.549 + 5.0006 (xHmr)	y = 74.882 + 4.7565 (xHfr)
	Left	y = 81.188 + 4.7323 (xHml)	y = 72.755 + 4.8901 (xHFl)
Forearm	Right	y = 120.63 + 1.6816 (xFmr)	y = 108.77 + 1.819 (xFfr)
	Left	y = 119.27 + 1.7326 (xFml)	y = 110.86 + 1.7417 (xFfl)
Arm	Right	y = 119.3 + 1.3875 (xAmr)	y = 104.89 + 1.5482 (xAfr)
	Left	y = 117.29 + 1.4433 (xAml)	y = 107.34 + 1.4792 (xAfl)
Shoulder to mid suprasternal notch	Right	y = 160.23 + 0.5223 (xSmr)	y = 143.39 + 0.7971 (xSfr)
	Left	y = 160.07 + 0.5317 (xSml)	y = 143.49 + 0.7916 (xSfl)

y = Stature, xasm = Outstretched arm span in male, xasf= Outstretched arm span in female, xMFmr = Right middle finger length in male, xMFml = Left middle finger length in male, xMFfr = Right middle finger length in female, xMFfl = Left middle finger length in female, xHmr = Right hand length in male, xHml = Left hand length in male, xHfr = Right hand length in female, xHfl =Left hand length in female, xFmr = Right forearm length in male, xFml = Left forearm length in male, xFfr = Right forearm length in female, xFfl = Left forearm length in female, xAmr = Right arm length in male, xAml = Left arm length in male, xAfr = Right arm length in female, xAfl = Left arm length in female, xSmr = Right shoulder to mid suprasternal notch length in male, xSml = Left shoulder to mid suprasternal notch length in male, xSfr = Right shoulder to midsuprasternal notch length in female, xSfl = Left shoulder to mid suprasternal notch length in female.

correlation coefficient (r) with stature than in the female.

In the present study, the length of the right and left middle finger in both sexes showed a statistically highly significant positive correlation with stature and this was similar to previous studies done by Uzun Ö et al.[8] in Turkey, Khan MA et al.[9] in Jammu & Kashmir and Kuppast N et al.[10] in Karnataka. The present study showed that the left middle finger of a male has a slightly higher correlation coefficient (r = 0.5786) with stature than the right middle finger (r = 0.5528), this was inconsistent with studies done by Uzun Ö et al.,[8] Khan MA et al.[9] and Kuppast N et al.[10] The left middle finger of female showed a higher correlation coefficient (r = 0.532) with stature than the right middle finger (r = 0.4734) in the present study, this was consistent with studies conducted by Uzun Ö et al.[8] among the Turkish population and Khan MA et al.[9] in the population of Jammu & Kashmir but not with Kuppast N et al.[10] in the population of Karnataka.

The length of the right and left hand in both sexes showed a statistically highly significant positive correlation with stature in the present study and this was similar to previous studies done by Uzun Ö et al.[8] in Turkey and Wakode NS et al.[11] in Maharastra. The length of the right hand in males showed a slightly higher correlation coefficient (r = 0.6897) with stature than the left hand (r = 0.6812) in the present study and this was similar to the study done by Wakode NS et al.[11] but not with Uzun Ö et al.[8] In female, the length of the left hand showed a slightly higher correlation coefficient (r = 0. 7451) with stature than the right hand (r = 0.7127) in the present study and this was inconsistent with studies conducted by Uzun Ö et al.[8] in Turkey and Wakode NS et al.[11] in Maharastra in which right hand showed a higher correlation coefficient (r) value with stature than the left side.

In the present study, the length of the right and left forearm in both sexes showed a statistically highly significant positive correlation with stature and this was similar to a study done by Uzun Ö et al.[8] in Turkey. Potdar AB et al.[12] also showed a statistically highly significant positive correlation of the length of left forearm with stature in both sexes in Maharastra. In the present study, the length of the right forearm in males showed a slightly higher correlation coefficient (r = 0.4995) with stature than the left forearm (r = 0.4977), this was similar to a study conducted by Uzun Ö et al.[8] among the Turkish population. The length of the right forearm in females showed a higher correlation coefficient (r = 0.6125) with stature than the left forearm (r = 0.5958) in the present study, this was similar to a study conducted by Uzun Ö et al.[8] In the present study, the length of the left forearm in females showed a higher correlation coefficient (r = 0.5958) with stature than the left forearm of males (r = 0.4977), this was inconsistent with a study conducted by Potdar AB et al.[12] in Maharastra.

In the present study, the length of the right and left arm in both sexes showed a statistically highly significant positive correlation with stature and this was similar to other studies conducted by Uzun Ö et al.[8] in Turkey and Airan N et al.[13] in Uttarakhand. In the present study, the length of the left arm in male showed a slightly higher correlation coefficient (r = 0.4853) with stature than the right side (r = 0.4682), this was similar to study conducted by Uzun Ö et al.[8] but not with Airan N et al.[13] In the present study, the length of the right arm showed a slightly higher correlation coefficient (r = 0.6297) with stature than the left arm (r= 0.6174) in females and this was similar to studies conducted by Uzun Ö et al.[8] and Airan N et al.[13]

To the best of our knowledge, there was no previous study on estimation of stature from the length of the shoulder to mid suprasternal notch. In the present study, the length of the left shoulder to the mid suprasternal notch in males showed a statistically non significant slightly higher positive correlation coefficient (r = 0.1723) with stature than the right side (r = 0.1712). In females, the length of the right shoulder to mid suprasternal notch showed a statistically significant slightly higher positive correlation coefficient (r = 0.2447) with stature than the left side (r = 0.2407).

6. Conclusion

It can be concluded that the mean values of stature, outstretched arm span, length of the middle finger, length of the hand, length of the forearm, length of the arm, and length of the shoulder to mid suprasternal notch were higher in males than in females and there is a definite correlation between stature and outstretched arm span and components of the upper limb. The outstretched arm span is the most reliable predictor of stature in both sexes whereas the length of the shoulder to mid suprasternal notch is the least reliable predictor of stature in both sexes. The regression formulas derived from this study can be used as a reference in the future for estimation of stature from outstretched arm span and measurement of component/s of upper limb in the natives of Gujarat for medico-legal purposes.

7. Source of Funding

None.

8. Conflict of Interest

The authors declare that there is no conflict of interest.

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