

The use of arm span as a predictor of height: A study of South Indian women

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ABSTRACT

This study was undertaken to find out the relationship between various body parameters to identify the measurement that correlates most closely to stature. Sitting height, standing height, arm span and leg lengths of 505 healthy women between the ages of 20 and 29 were measured. The relationship between the parameters was determined by computing correlation coefficients and 95% confidence intervals. The correlation between sitting height, arm span and leg length were poor ($r=0.56$ and 0.29 respectively), while the correlation of arm span and leg length with standing height were good ($r=0.82$ and 0.84 respectively). These estimations can be of use in quantifying the age related loss in stature and in identifying individuals with disproportionate growth abnormalities and skeletal dysplasias. It can also be useful to find out the alterations in the height of an individual that may occur due to progressive deformities of the spine. The adequacy of the correction of spinal deformities may also be facilitated by computing the ratio of arm span to standing height.

Key words: *standing height prediction, arm span, anthropometric measurements, leg length, stature*

INTRODUCTION

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 the exact height cannot be determined directly because of deformities of the limbs or in patients who have undergone amputations. 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 measurements also have found application in normalizing pulmonary function in scoliosis.²

Several studies have reported the effectiveness of using various body parameters in predicting body height^{3,4,8} and the arm span was found to be the most reliable.³ However the association of arm span and height was found to vary from race to race.^{5,7} Even though several studies of this nature are available on western populations, very limited data is available on Indian subjects.⁶ To our knowledge no such study has been reported for the South Indian population.

The aims of this study were to find out the relationship between different anthropometric measurements and the standing height of South Indian women and to identify the measurement that correlates most closely to standing height in such women.

MATERIALS AND METHODS

The subjects for this study were 505 apparently healthy women in the age group of 20–29. These subjects were selected randomly from colleges of Udupi district in Karnataka State of South India. This age group was selected because by this age the growth of the individual ceases. Girls were preferred because the investigators wanted to extend this study to patients with idiopathic scoliosis which is predominantly seen in girls.

The sitting height, standing height, arm span and leg length were measured for all individuals. Standing height was measured with the individual standing barefoot on the platform of the stadiometer with the upper back buttock and heels pressed against the upright position of the instrument. The subject's head was positioned in the Frankfort horizontal plane, and the head plate was brought into firm contact with the vertex. Sitting height was taken sitting on a stool kept on the platform of the stadiometer so that the head was in the Frankfort plane, the shoulders relaxed, the back straight, upper surface of the thighs horizontal, the feet supported and the back of the knee joint clear of the stool. The difference between sitting height and standing height was taken as leg length. 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 her back to the wall with both arms abducted to 90°, the elbows and wrists extended and the palms facing directly forward. Readings were taken to the nearest 0.1 cm. Each subject was measured twice. When the two measurements for each parameter agreed within 0.4 cm, their average was taken as the best estimate for the true value. When the two initial measures did not satisfy the 0.4 cm criterion, two additional determinations were made and the mean of the closest records was used as the best estimate. To rule out intra-observer error, 40 subjects were measured again for all the three parameters after three weeks. These measurements were compared with initial measurements of the same subjects using the paired t-test and found to be statistically not significant.

Statistical Analysis

The inter-relationships between sitting height, standing height, arm span and leg length were determined using simple correlation coefficient and their 95% confidence interval. Then linear and multiple regression analyses were performed to derive the estimate of sitting and standing height in terms of arm span and leg length. Finally these relationships were plotted as scatter diagrams and regression lines. A p-value less than 0.05 was considered as significant.

RESULTS

A summary of the various physical measurements determined on 505 women is shown in Table 1. The average age of the subjects was 20.7 years. The mean sitting height was 79.35 cm (SD=3.29 cm), which was on average 2 cm more than leg length. The mean arm span was 159.14 cm (SD=7.06), which was also on average 2 cm more than standing height.

Table 2 presents the correlation between the different physical measurements. The correlation of sitting height with arm span and leg length was poor ($r=0.561$, 0.294 respectively). The correlation of arm span and leg length with standing height was very good ($r=0.816$ and 0.842 respectively).

The results of linear regression analysis are shown in Table 3. Initially, models were derived by including age as a covariate. However, the contribution of age was found to be insignificant. Hence age was dropped and estimates were derived as univariate analysis. The estimated regression lines for different parameters were obtained as:

$$\text{Sitting height (cm)} = 37.68 + 0.2618 \text{ Arm span (cm)}$$

$$\text{Standing height (cm)} = 49.57 + 0.674 \text{ Arm span (cm)}$$

$$\text{Sitting height (cm)} = 60.35 + 0.245 \text{ leg length (cm)}$$

$$\text{Standing height (cm)} = 60.35 + 1.245 \text{ leg length (cm)}$$

The coefficients of determination of the above models were 31.5%, 66.6%, 8.6% and 70.9% respectively. These models are graphically represented in Figures 1 to 4.

Table 1
Various physical measurements of the women in the study (n=505)

| Physical measurements | Mean | Standard deviation | Range |
|-----------------------|--------|--------------------|-------------|
| Age (Years) | 29.66 | 1.22 | 20–29 |
| Sitting height (cm) | 79.35 | 3.29 | 69.9–88.4 |
| Standing height (cm) | 156.88 | 5.83 | 138.6–174.6 |
| Leg length (cm) | 77.53 | 3.94 | 65.1–89.5 |
| Arm span (cm) | 159.14 | 7.06 | 135.6–176.0 |

Table 2
Correlation between various physical measurements of the study subjects (n=505)

| Physical measurements | Correlation Coefficient | 95% confidence interval | Significance p-value |
|--------------------------------|-------------------------|-------------------------|----------------------|
| Sitting height and arm span | 0.561 | 0.501–0.620 | <0.0001 |
| Standing height and arm span | 0.816 | 0.787–0.845 | <0.0001 |
| Sitting height and leg length | 0.294 | 0.214–0.374 | <0.001 |
| Standing height and leg length | 0.842 | 0.817–0.867 | <0.0001 |

Table 3
Results of linear regression analysis of various physical measurements as predictors of sitting height and standing height (n=505)

| Variables | Regression Coefficient | Standard Error (SE) | R-square (%) | T-value | p-value |
|---------------------------------|------------------------|---------------------|--------------|---------|----------|
| Sitting height with arm span | 0.2618 | 0.0172 | 31.5 | 15.21 | <0.00001 |
| Standing height with arm span | 0.6743 | 0.0213 | 66.6 | 31.65 | <0.00001 |
| Sitting height with leg length | 0.2450 | 0.0355 | 8.6 | 6.89 | <0.0001 |
| Standing height with leg length | 1.2451 | 0.0355 | 70.9 | 35.01 | <0.00001 |

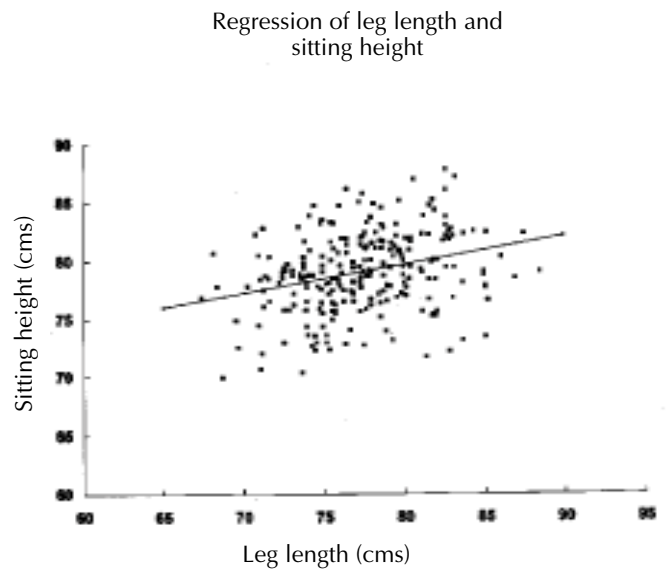
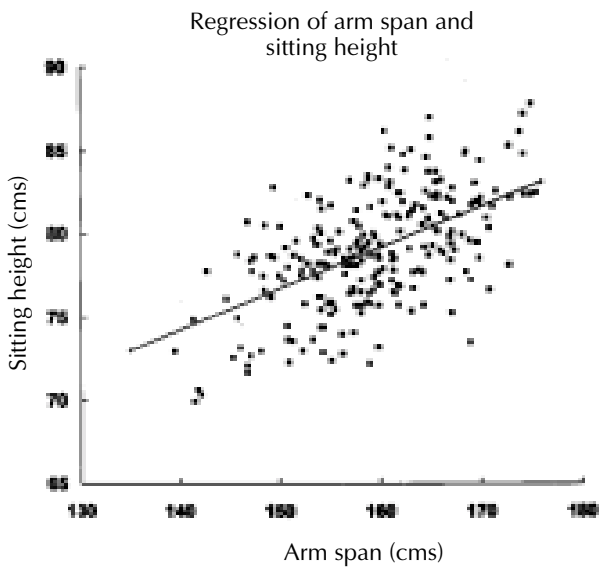


Figure 1 Scatter diagram and regression line showing relationship between arm span and sitting height.

Figure 2 Scatter diagram and regression line showing relationship between leg length and sitting height

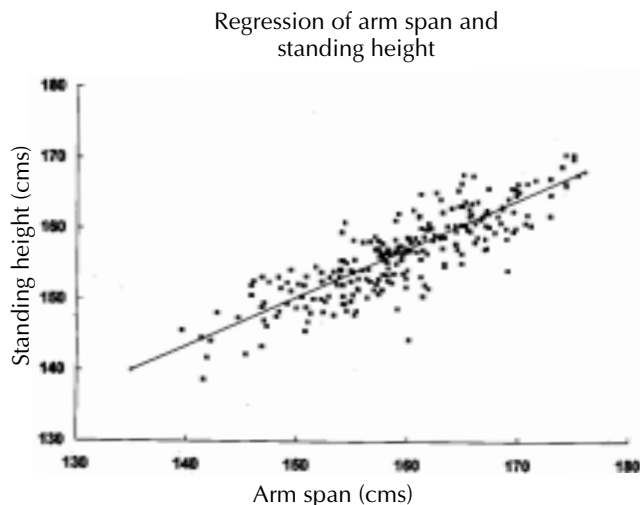


Figure 3 Scatter diagram and regression line showing relationship between arm span and standing height

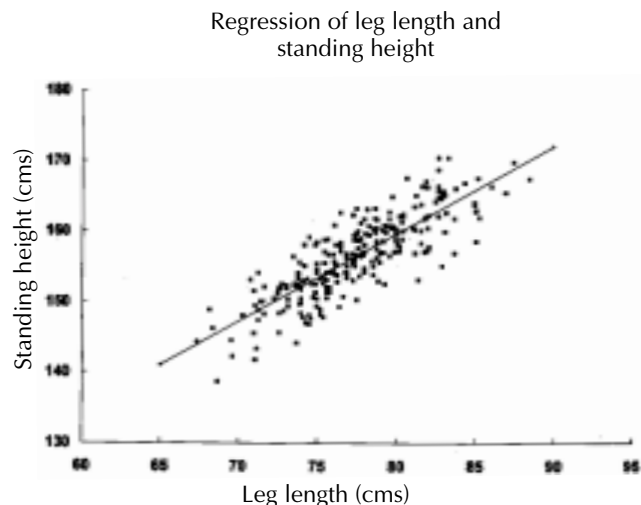


Figure 4 Scatter diagram and regression line showing relationship between leg length and standing height

DISCUSSION

Estimation of height using various physical measurements has been attempted by many authors. Chumlea¹ estimated stature from knee height, while Mitchel⁴ correlated arm length with height. The one variable that proved to be consistently reliable in estimating height was the arm span. Steele and Chenier⁷, in a study on black and white women in the age group 35–89, reported correlations of arm span and height of 0.852 and 0.903 for black and white women respectively. In a similar study of blacks of both sexes in the age group 22–49, a correlation of 0.87 was observed between arm span and height. These results are similar to the correlation obtained in the present study ($r=0.816$).

In Steel and Chenier's study, arm span was nearly 8.3 cm more than height for blacks, whereas for whites, this difference was only 3.3 cm.⁷ In the present study also we noted that the arm span was nearly 2.5 cm more than height, which is similar to that noted in the white population. Even though these relations are similar, the estimation equations which we obtained are clearly different from those of other populations. This emphasizes the need for developing separate models for each population on account of racial and ethnic differences in anthropometric measurements.

As reported by earlier authors, our study also

failed to demonstrate a meaningful correlation of other physical measurements with height other than arm span and leg length. Though leg length was significantly correlated with height, we do not recommend its use for estimating stature for two reasons: (i) leg length contributing to an individual's height may be the cause of a very high correlation; (ii) deformities or amputations may preclude its use. We contend that arm span is the most reliable indirect physical measurement for estimating height. Since the estimating equation varies from race to race, similar studies for different races and regions are recommended.

CONCLUSION

Arm span is the most reliable body parameter for predicting the height of an individual. It is useful in predicting age-related loss in stature and in identifying individuals with disproportionate growth abnormalities and skeletal dysplasias. It can also be of use in finding out the alterations in the height of an individual that may occur due to progressive deformities of the spine and following surgical correction of spinal deformities.

REFERENCES

1. **Chumlea WC, Roche AE and Steinbearagh ML.** Estimating stature from knee height for persons 60 to 90 years of age. *J Amer Geri Soc* 1985, 33:116–20.
2. **Hepper NGG, Black LF, Fowler WS.** Relationships of lung volume to height and arm-span in normal subjects and in patients with spinal deformity. *Am Rev Resp Dis* 1965, 91:356.
3. **Jalzem PF, Gledhill RB.** Predicting height from arm measurements. *J Pediatr Orthop* 1993, 13(6):761–65.
4. **Mitchell CO, Lipschitz DA.** Arm length measurement as an alternative to height in nutritional assessment of the elderly. *J Parenter and Enteral Nutr* 1982, 6:226.
5. **Reeves SL, Varakamin C, Henry CJ.** The relationship between arm-span measurement and height with special reference to gender and ethnicity. *Eur J Clin Nutr* 1996, 50(6):398–400.
6. **Sathyavathi K, Agarwal KN, Rao NSN, Reddy PR.** Arm-span and height measurement during adolescence. *Ind Pediatr* 1979, 14(10):839–47.
7. **Steele MF, Chenier TC.** Arm-span, height, and age in black and white women. *Ann Hum Biol* 1990, 17(6):533–41.
8. **Yun DJ, Yun DK, Chang YY, Lim SW, Lee MK, Kim SY.** Correlations among height, leg length and arm span in growing Korean children. *Ann Hum Biol* 1995, 22(5):443–58.