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Evaluating Arm Span as a Surrogate Marker for Height: A Cross-Sectional Observational Study among Medical Students of a North Indian Medical College

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ABSTRACT

Background: Accurate height measurement is essential in clinical, forensic, and sports science applications. However, direct height assessment may not always be feasible, such as in patients with musculoskeletal deformities or amputations. In such cases, arm span may serve as a practical surrogate marker.

Methods: A cross-sectional observational study was conducted among healthy medical students aged 18–25 years at a North Indian medical college. Arm span and height were measured using standardized protocols. Pearson's correlation and linear regression analyses were used to explore associations and predict height.

Results: The study included 142 participants, comprising 85 males and 57 females. Mean height and arm span were (171.78±5.98) cm and (177.03±7.41) cm in males; (156.13±5.96) cm and (159.44±6.90) cm in females, respectively. A strong positive correlation was observed between arm span and height: males ($r=0.742$, $p<0.001$) and females ($r=0.881$, $p<0.001$). Regression models confirmed arm span as a significant predictor of height in both sexes.

Conclusion: Arm span demonstrates a strong, statistically significant correlation with height in both males and females. It can be a reliable alternative for height estimation when direct measurement is impractical.

Key-words: Anthropometry, Anthropometric parameter, Arm span, Correlation, Height

INTRODUCTION

Height is a key anthropometric parameter with wide applications in medicine, nutrition, and scientific research. It plays an essential role in growth assessment, drug dosage calculations, and the evaluation of nutritional and health status.

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Despite its importance, accurately measuring height is not always feasible. Conditions such as spinal deformities, lower-limb amputations, immobility, or postmortem examinations may render direct assessment impractical, necessitating the use of alternative anthropometric indicators.

Arm span—the distance between the tips of the middle fingers with both arms fully extended horizontally—has emerged as one of the most reliable substitutes for height. Numerous studies have demonstrated a strong association between arm span and stature, although the strength of this relationship can vary with sex, age, ethnicity, and genetic background. Mohanty *et al.*[1] reported a significant correlation in South Indian women, while Hickson and Frost [2] observed stronger associations in European females. Aggarwal *et al.* [3] highlighted the utility of arm span in North Indian patients with physical disabilities, reinforcing its value when direct height measurement is not possible.

More recent investigations further corroborate this relationship. Sultana *et al.* [4] reported near-perfect correlations in Bangladeshi medical students, while Laldingliana *et al.* [5] documented similar findings among the Khasi tribal population of Northeast India. Shah *et al.* [6] and Thomas *et al.* [7] demonstrated strong associations and derived predictive regression equations in student populations from Ahmedabad and Kerala, respectively. Additionally, Rani *et al.* [8] in North India and Sahoo *et al.* [9] in Eastern India, confirmed robust correlations (r=0.87 to 0.90) and proposed population-specific regression models for accurate height estimation. Alshamrani *et al.* [10] extended these findings to Saudi adults, indicating that the arm span–height relationship is consistently strong across diverse populations, while slope and intercept values may vary regionally.

Evidence from prior Indian studies (Alam *et al.* [11], Mishra *et al.* [12], Singh *et al.* [13], Patel *et al.* [14], Sharma *et al.* [15], Rahul *et al.* [16]) consistently demonstrates that arm span explains a substantial proportion of height variability, often exceeding two-thirds, underscoring its potential as a reliable surrogate. Taken together, these data emphasize the importance of population-specific predictive models, as regional differences in body proportions influence both correlation strength and regression parameters.

Against this backdrop, the present study investigates the relationship between arm span and height among medical students in a North Indian medical college, deriving sex-specific regression equations and assessing whether arm span can serve as a reliable predictor of stature for clinical, forensic, and sports-related applications.

MATERIALS AND METHODS

Research Design- This cross-sectional observational study was conducted in the Department of Anatomy at a North Indian medical college. The study aimed to evaluate the correlation between height and arm span in healthy medical students, and the study population consisted of healthy medical students aged 18–25 years.

Inclusion Criteria

- Healthy medical students aged 18–25 years
- Willing to provide written informed consent

Exclusion Criteria

- Any congenital/ acquired musculoskeletal deformity
- Limb amputation
- History of chronic illness or injury affecting limb or trunk length

Sample Size- A total of 142 students were included in the study. Participants were selected using a simple random sampling technique from the list of eligible students who consented to participate.

Data Collection- Height and arm span were measured using standardized instruments and procedures. A stadiometer (calibrated before each measurement session) was used to measure standing height, while a non-stretchable measuring tape was used to measure arm span. Height was recorded with participants standing erect on a flat surface, barefoot, with heels together and head positioned in the Frankfurt plane. Arm span was measured as the distance between the tips of the middle fingers of both hands with arms fully extended horizontally. All measurements were taken by a single trained observer to minimize inter-observer variation, and instruments were calibrated before each use.

Statistical Analysis- Data were analyzed using Microsoft Excel and Jamovi version 2.6.44. Descriptive statistics (mean and standard deviation) were calculated for height and arm span. Pearson's correlation coefficient was used to assess the relationship between height and arm span. At the same time, linear regression analysis was applied to derive the predictive equation for estimating height from arm span. All tests were two-tailed, and p<0.05 was considered statistically significant. Ninety-five percent confidence intervals (CI) were calculated for correlation and regression coefficients.

Ethical Considerations- Ethical clearance was obtained from the Institutional Ethics Committee before commencement of the study. Written informed consent was obtained from all participants. Privacy and confidentiality were strictly maintained, and no personal identifiers were used in data analysis.

RESULTS

A total of 142 medical students participated, including 85 males and 57 females. Among males, the mean height was 171.78±5.98 cm, and the mean arm span was 177.03±7.41 cm. The range of height varied from 158 cm to 185 cm, while arm span ranged from 160 cm to 191 cm (Table 1).

Table 1: Height and Arm Span in Males

Variables	N	Mean	SD	Minimum	Maximum	Ranges
Height (cm)	85	171.78	5.98	158	185	27
Arm Span(cm)	85	177.03	7.41	160	191	31

Among females, the mean height was 156.13±5.96 cm, and the mean arm span was 159.44±6.90 cm. The height ranged from 143 cm to 171.2 cm, and arm span ranged from 144 cm to 179.4 cm (Table 2).

Table 2: Height and Arm Span in Females

Variables	N	Mean	SD	Minimum	Maximum	Ranges
Height (cm)	57	156.13	5.96	143	171.2	28.2
Arm Span (cm)	57	159.44	6.90	144	179.4	35.4

A strong positive correlation was observed between height and arm span in both males and females (Table 3). In males, the Pearson correlation coefficient (r) was 0.742 ($p<0.001$, 95% CI), indicating a statistically significant linear relationship. In females, the correlation was even stronger ($r=0.88$, $p<0.001$, 95% CI). Simple linear regression analysis was performed to develop predictive equations for estimating height from arm span. The details of correlation coefficients, regression equations, and R^2 values are summarized in Table 3.

For males:

Regression equation: Height (cm) =52.47 + 0.67 × Arm Span (cm)

Coefficient of determination (R^2) =0.55, indicating that 55% of the variability in height could be explained by arm span.

For females:

Regression equation: Height (cm) =31.85 + 0.78 × Arm Span (cm)

R^2 =0.77, showing that 77% of the variation in height was explained by arm span.

Thus, arm span demonstrated a strong predictive value for height estimation, particularly among female participants.

Table 3: Correlation and Regression Analysis

Groups	r (Pearson Correlation Coefficient)	p-value	R^2	Regression Equation (Height=a + b × Arm Span)
Males	0.74	<0.001	0.55	Height=52.47 + 0.67 × Arm Span
Females	0.88	<0.001	0.77	Height=31.85 + 0.78 × Arm Span

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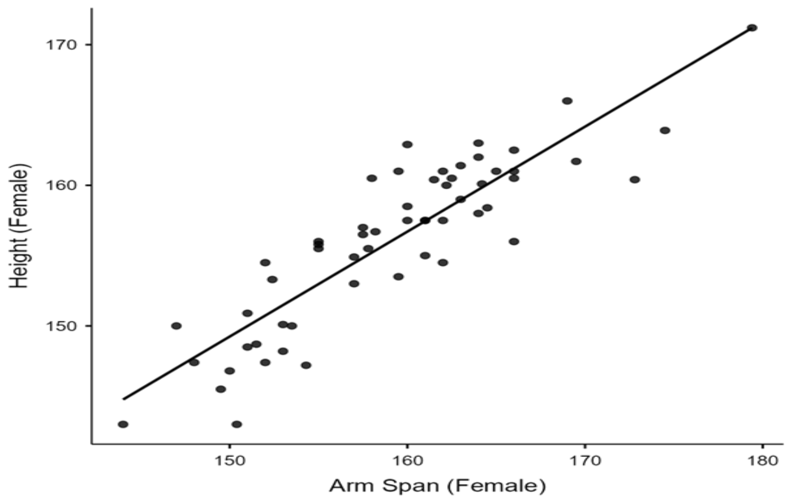

Fig. 1: Scatter plot showing correlation between height and arm span among male participants (n=85)

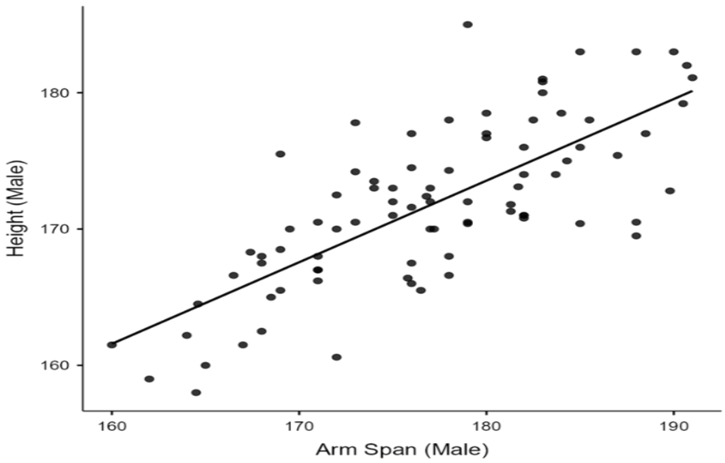

Fig. 2: Scatter plot showing correlation between height and arm span among female participants (n=57)

DISCUSSION

The findings of the present study demonstrate a strong positive correlation between arm span and height in both sexes (males: r=0.74, p<0.001; females: r=0.88, p<0.001). Regression analysis further confirmed this association, yielding predictive equations—Height (cm)=52.47 + 0.67 × Arm Span (cm) for males and Height (cm)=31.85 + 0.78 × Arm Span (cm) for females — with coefficients of determination (R^2) of 0.55 and 0.77, respectively. These values indicate that arm span accounts for 55% of height variability in males and 77% in females. The stronger correlation and higher R^2 in females suggest more consistent body proportions and reduced biological variability, possibly influenced by hormonal and growth pattern differences.

The present study's correlation results (males: r=0.742; females: r=0.88; both p<0.001) and the derived regression equations—Height (cm)=52.47 + 0.67 × Arm Span (cm) for males (R^2 = 0.55) and Height (cm) = 31.85 + 0.78×Arm Span (cm) for females (R^2=0.77)—are concordant with the general body of literature showing a strong positive relationship between arm span and stature. Earlier Indian and international studies have reported comparable correlation coefficients and predictive models (Mohanty *et al.* [1], Aggarwal *et al.* [3], Shah *et al.* [6], Thomas *et al.* [7]). For example, Mohanty *et al.* [1] and Shah *et al.* [6] reported strong correlations in student populations, supporting the use of arm span as a practical surrogate for height. Recent regional work also aligns with our findings: Rani *et al.* [8] reported slopes close to ours (b ≈ 0.68 in males and b ≈ 0.77 in females), and Sahoo *et al.* [9] found similarly high correlations (r=0.87 males, r=0.90 females), reinforcing regional consistency. Internationally, Alshamrani *et al.* [10] reported correlation strengths and regression coefficients in the same range (r ≈ 0.85–0.90; b values near 0.70–0.80), indicating that the arm span–height relationship is broadly stable across populations while allowing for population-specific calibration.

Some reports show substantially higher correlations (Sultana *et al.* [4]; Khasi tribal study [5]) with r values approaching 0.99. These near-perfect correlations are likely reflective of more homogeneous populations (tribal cohorts or large, demographically uniform samples) or much larger sample sizes that reduce sampling variability. Differences between our results and those extreme values can plausibly be explained by: (i) sample size and sampling frame (our n=142 vs. much larger cohorts in some recent studies such as Sultana *et al.* [4]); (ii) population heterogeneity—urban mixed cohorts (like ours) often show greater anthropometric variability compared with homogenous tribal or single-ethnicity groups; (iii) methodological differences—variation in instrument calibration, exact measurement landmarks, observer training, and whether single- or multi-observer measurements were used can influence intercept (a) and slope (b) estimates; and (iv) age range and nutrition/anthropometric secular trends — studies including wider age ranges or different nutritional backgrounds may demonstrate altered limb-to-height proportions. Numerically, our slopes (b = 0.67 in males, 0.78 in females) are very close to those reported by Rani *et al.* [8] and fall within the range of slopes reported across Indian and international studies (typically 0.65–0.95), suggesting that the slopes are broadly consistent. Still, the intercept (a) can shift with population mean stature and arm span.

Importantly, the coefficient of determination in our work (R^2=0.55 males; 0.77 females) indicates that while arm span is a strong predictor—especially in females—other anthropometric variables (e.g., sitting height, leg length) and population-specific factors still account for residual variance. This underlines the value of locally derived regression models (as provided here) rather than universal equations, particularly for forensic and clinical use, where small systematic prediction errors may have practical consequences [3,8].

The regression equations derived in this study provide a population-specific model for predicting stature from arm span in young North Indian adults. Such models are highly valuable in forensic investigations, particularly for stature estimation from skeletal or decomposed remains, fragmented bodies, or in mass disaster scenarios where complete measurement is not possible [3,7]. Clinically, these equations can be applied to patients who are unable to stand upright, such as those with spinal deformities, amputations, or paralysis [1,8]. In sports medicine and nutrition, arm span can serve as a reliable substitute for height in anthropometric assessments, improving accuracy in monitoring growth, fitness, and body composition [6,9,]. Using locally validated regression equations enhances the applicability and precision of these measurements in regional populations [8,9].

LIMITATIONS

This study has several limitations. The study was conducted at a single institution with a relatively small sample size, which may limit the generalizability of the results to the broader North Indian population. The age group was limited to 18–25 years, representing only young adults; therefore, the regression equations may not apply to children, adolescents, or older individuals whose body proportions differ due to growth or degenerative changes. Additionally, although efforts were made to minimize observer bias through standardized protocols, minor intra-observer variation cannot be ruled out. The study also did not include other anthropometric parameters, such as sitting height, leg length, or arm length, which could complement arm span in improving stature prediction models.

CONCLUSIONS

Arm span can be used as a reliable predictor of height among young North Indian adults. The regression equations derived in this study may serve as practical tools for clinical, nutritional, and forensic applications. These models are particularly useful in situations where direct height measurement is not feasible, such as in patients with deformities, immobility, or amputations in postmortem assessments. However, these regression models require validation in larger, multi-centric cohorts to ensure accuracy and generalizability across diverse populations.

Future research should aim to conduct larger, multi-centric studies encompassing diverse age groups and ethnic backgrounds to validate and refine these regression equations. Incorporating multiple anthropometric predictors may further enhance model accuracy. Longitudinal studies could also investigate how age, gender, and nutritional factors impact the arm span–height relationship across various life stages.

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