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A cross-sectional study on the relationship between arm span and height among adolescents: An anthropometric approach.

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Abstract
Background
Height measurement is essential in adolescent health assessment, yet it becomes challenging when individuals present with postural abnormalities, trauma, disability, or acute illness. This study evaluated the relationship between arm span and height using a standardized anthropometric approach.

Objective
To determine the association between arm span and height among adolescents and to develop regression equations for height estimation.

Methods
A cross-sectional study involving 100 adolescents aged 13–18 years was conducted. Height and arm span were measured following standard anthropometric protocols. Sex-wise comparisons were analyzed using independent t-tests. Pearson's correlation assessed the strength of association between the two parameters. Linear regression equations were constructed for the total sample and stratified by sex to estimate height from arm span.

Results
The mean age was 15.6 ± 1.7 years, and males constituted 52% of the sample. Overall mean height was 159.8 ± 8.2 cm, while mean arm span measured 161.4 ± 8.7 cm. Both parameters were significantly higher in males ($p < 0.001$). Most participants demonstrated arm span values exceeding their height. A strong correlation existed between arm span and height in the total group ($r = 0.89$, $p < 0.001$), with similarly high correlations in males ($r = 0.91$) and females ($r = 0.87$). The primary regression model for the sample was: *Height = 24.3 + 0.84 × Arm Span* ($R^2 = 0.79$). Sex-specific models showed R^2 values of 0.82 and 0.76 for males and females, respectively.

Conclusion
Arm span is a reliable predictor of height among adolescents and demonstrates strong validity across sexes. The developed regression equations can assist in clinical, field, and resource-limited settings where height cannot be directly measured.

Recommendations
Routine inclusion of arm span measurement is encouraged in adolescent anthropometric assessments. Larger multicentric studies are recommended to enhance the external validity of the predictive equations.

Keywords: *Arm span; Height estimation; Adolescents; Anthropometry; Regression equation; Stature prediction.*
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INTRODUCTION
Accurate anthropometric evaluation is fundamental to adolescent health assessment, nutritional monitoring, growth surveillance, and clinical decision-making. Among all anthropometric parameters, standing height remains a key indicator, forming the basis for growth chart

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interpretation, medication adjustment, and physiological assessment. However, obtaining a reliable height measurement is not always feasible in adolescents with spinal deformities, lower-limb injuries, neuromuscular limitations, or acute illness that prevents erect posture [1-2]. In such conditions, alternative body measurements become necessary substitutes.

Arm span has consistently been identified as one of the most dependable surrogate markers of stature due to its strong biological linkage with skeletal growth and upper-body longitudinal development. Studies conducted in different populations, including rural African children and Asian adolescents, have reported significant correlations between arm span and height, underscoring its value as a robust predictor [3–4]. Beyond its practicality, arm span measurement requires minimal equipment and can be performed even in individuals unable to stand, making it particularly useful in clinical and community settings [2].

Despite this established relationship, proportional differences in limb length and trunk growth vary across ethnicities, age groups, and nutritional backgrounds. Research among adolescents in Ethiopia, Indonesia, and other global cohorts demonstrates that growth patterns during puberty influence the strength and slope of the arm span–height association, highlighting the need for population-specific data [3,5,6]. Adolescence represents a period of rapid and uneven skeletal development; therefore, region-appropriate regression models are essential to ensure accuracy.

India's adolescent population is diverse, and anthropometric norms from one region may not apply uniformly. Limited studies exploring arm span as a surrogate for height in Indian adolescents reinforce the need for localized references. Furthermore, emerging evidence from functional studies in children, such as the predictive role of arm span in physical performance, supports the broader utility of this measurement in paediatric assessment [7].

The present study investigates the relationship between arm span and height among adolescents in Jogulamba Gadwal and formulates sex-specific regression equations. By quantifying the strength of association and comparing differences between boys and girls, the study aims to provide reliable, population-based tools for height estimation in clinical, educational, and field environments.

METHODOLOGY

Study Design and Setting

This cross-sectional anthropometric study was conducted in the Department of Anatomy, Government Medical College (GMC), Jogulamba Gadwal, an institution that caters to a mixed rural and semi-urban population in Telangana. The setting provided an appropriate environment for obtaining representative adolescent measurements. Data collection was carried out over one year, from August 2024 to July 2025.

Study Population and Sample Size

A total of 100 adolescents aged 13–18 years were included in the study. Participants were selected using a convenience sampling technique from local schools and college health check-up camps organized in the field practice area of GMC Jogulamba Gadwal. Both males and females who provided assent and whose parents/legal guardians consented were eligible for inclusion.

Inclusion Criteria

Adolescents aged 13–18 years.
Individuals without deformities of the upper limb or spine.
Participants were able to cooperate with standard anthropometric measurement procedures.

Exclusion Criteria

History of musculoskeletal disorders affecting posture or limb proportion.
Chronic illnesses are known to influence growth (e.g., endocrine disorders).
Recent fractures or injuries involving the upper limbs or lower limbs.

Anthropometric Measurements

All measurements were obtained following standardized anatomical and anthropometric protocols.

Height: Measured using a stadiometer with the participant standing upright, barefoot, heels together, and Frankfurt plane horizontal. Values were recorded to the nearest 0.1 cm.

Arm Span: Measured as the distance between the tips of the middle fingers with both arms fully extended horizontally at shoulder level. A non-stretchable measuring tape was used, and readings were taken to the nearest 0.1 cm.

Each measurement was taken twice by the same observer, and the average value was used for analysis to minimize observer error.

Bias and Quality Control

Potential sources of bias were addressed at multiple stages of the study. Selection bias was minimized by including all eligible adolescents who met the predefined inclusion and exclusion criteria during the study period. Measurement bias was reduced by using standardized anthropometric

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protocols for both height and arm span assessment, with all measurements performed by the same trained observer using calibrated instruments. Each measurement was recorded twice, and the average value was used for analysis to limit intra-observer variability. Analytical bias was minimized by applying uniform statistical methods for all participants and by predefining the significance level before analysis.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee of GMC Jogulamba Gadwal. Written informed consent from parents/guardians and assent from adolescents were secured before enrolment.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS (Version 25.0). Descriptive statistics (mean, standard deviation, frequency, and percentages) were used to summarize variables. Sex-wise comparisons were performed using the independent t-test. Pearson's correlation coefficient assessed the relationship between arm span and height. Simple linear regression models were developed for the total sample and separately for males and females. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 100 adolescents were examined for the study, representing a nearly even distribution of males (52%) and females (48%). The mean age of the participants was 15.6 ± 1.7 years. Baseline anthropometric characteristics are presented in Table 1. Overall mean height measured 159.8 ± 8.2 cm, while the mean arm span was slightly higher at 161.4 ± 8.7 cm. Both parameters demonstrated higher values among males when compared with females.

Table 1. Demographic and Anthropometric Profile of Study Participants (N = 100)

Parameter	Category / Unit	n (%)	Mean ± SD
Age (years)	–	100 (100%)	**15.6 ± 1.7**
Sex	Male	52 (52%)	–
	Female	48 (48%)	–
Height (cm)	Overall	100 (100%)	**159.8 ± 8.2**
	Male	52 (52%)	**163.2 ± 7.5**
	Female	48 (48%)	**156.1 ± 7.2**
Arm Span (cm)	Overall	100 (100%)	**161.4 ± 8.7**
	Male	52 (52%)	**165.1 ± 8.1**
	Female	48 (48%)	**157.5 ± 7.8**

Sex-wise Comparison

The comparative assessment of males and females revealed statistically significant differences in both height and arm span (p < 0.001). Males exhibited greater mean height (163.2 ± 7.5 cm) and arm span (165.1 ± 8.1 cm) than females (156.1 ± 7.2 cm and 157.5 ± 7.8 cm, respectively). The mean difference between arm span and height also varied slightly by sex, with males showing a wider gap (1.9 ± 1.6 cm) than females (1.4 ± 1.3 cm), as depicted in Table 2.

Table 2. Sex-wise Comparison of Anthropometric Measurements (N = 100)

Parameter	Male (n = 52) Mean ± SD	Female (n = 48) Mean ± SD	Total (N = 100) Mean ± SD	p-value
Height (cm)	163.2 ± 7.5	156.1 ± 7.2	159.8 ± 8.2	< 0.001
Arm Span (cm)	165.1 ± 8.1	157.5 ± 7.8	161.4 ± 8.7	< 0.001
Arm Span – Height (cm)	1.9 ± 1.6	1.4 ± 1.3	1.6 ± 1.5	0.04

Correlation Analysis

A strong linear association between arm span and height was evident across the study population. The total sample demonstrated a correlation coefficient of r = 0.89 (p < 0.001), indicating a robust positive relationship. Sex-stratified analysis confirmed similarly high correlations, with r = 0.91

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among males and r = 0.87 among females. Details of the correlation analysis are summarized in Table 3.

Table 3. Correlation Between Height and Arm Span

Group	Sample Size (n)	Correlation Coefficient (r)	p-value	Interpretation
Total Sample	100	0.89	< 0.001	Strong positive correlation
Male	52	0.91	< 0.001	Strong positive correlation
Female	48	0.87	< 0.001	Strong positive correlation

Regression Analysis

Simple linear regression was employed to predict height using arm span as the independent variable. For the total sample, the derived equation—Height = 24.3 + 0.84 × Arm Span explained 79% of the variance in height ($R^2 = 0.79$). Sex-specific equations demonstrated slightly higher predictive power among males ($R^2 = 0.82$) compared with females ($R^2 = 0.76$). The complete set of regression models is presented in Table 4.

Table 4. Regression Models for Predicting Height from Arm Span

Group	Sample Size (n)	Regression Equation	R^2	Interpretation
Total Sample	100	Height = 24.3 + 0.84 × Arm Span	0.79	79% of height variability is explained by arm span
Male	52	Height = 18.7 + 0.87 × Arm Span	0.82	Excellent predictive ability
Female	48	Height = 29.1 + 0.81 × Arm Span	0.76	Good predictive ability

DISCUSSION

The present study explored the association between arm span and standing height among adolescents aged 13–18 years in Jogulamba Gadwal. A consistent relationship was observed between the two parameters, reaffirming the usefulness of arm span as a dependable surrogate for stature when direct height measurement is limited. The mean anthropometric values in this study reflect patterns described in previous adolescent research across different populations, where proportional growth of the upper body often continues into late adolescence [8,9].

A notable finding was that arm span exceeded height in most participants, a trend frequently documented in studies of adolescent growth dynamics. Research on idiopathic scoliosis and peri-pubertal growth has also shown elongated upper-limb proportions relative to stature during specific developmental phases, supporting the biological plausibility of this observation [8,14]. Similar proportional relationships have been reported among tribal and ethnic subgroups, such as the Khasi population, indicating that these trends are widespread and not confined to a single demographic [9].

The strong positive correlation identified between arm span and height (r = 0.89) aligns with findings from hospitalized paediatric cohorts and community-based adolescent studies, which consistently highlight arm span as one of the most reliable indicators for estimating stature in the absence of direct measurement [10,11]. Sex-stratified analysis in this study revealed minimal differences in correlation strength between boys and girls, echoing earlier reports where sex had limited influence on the predictive consistency of upper-limb dimensions [12].

Regression analysis in the present study resulted in equations with high predictive accuracy, explaining 79% of height variability in the total sample. Comparable predictive models have been described in athletic and physically active youth, where body composition and limb proportions

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significantly influence functional performance, further validating the anthropometric relationship [13]. The higher R^2 value observed among males is consistent with earlier findings that suggest a slightly more stable proportionality index in boys during adolescence [12–14].

The practical implications of these results are substantial. Arm span offers a reliable alternative for height estimation in adolescents with spinal deformities, lower-limb impairments, musculoskeletal injuries, or clinical conditions that hinder upright posture. It remains equally valuable in field surveys, school health assessments, and sports evaluations where stadiometers may be unavailable.

Generalizability

The findings of this study offer valuable insights into the relationship between arm span and height among adolescents in the Jogulamba Gadwal region. However, the generalizability of the results should be interpreted with caution. The study sample was drawn from a mixed rural–semi-urban population, which provides a useful representation of the local adolescent demographic, yet may not fully capture the diversity of growth patterns seen across different geographic, ethnic, and socioeconomic groups in India. Variations in nutrition, genetic background, lifestyle, and pubertal development could influence anthropometric proportions, potentially altering the strength or slope of the arm span–height relationship in other populations.

Despite these considerations, the strong correlation and consistent regression trends observed in both sexes suggest that the derived models may apply to adolescents in similar settings with comparable demographic characteristics. Broader applicability to urban, tribal, or multi-ethnic adolescent groups would require validation through larger multicentric studies.

Conclusion

This study demonstrated a strong and consistent relationship between arm span and height among adolescents aged 13–18 years in the Jogulamba Gadwal region. Arm span measurements exceeded height in most individuals and showed high predictive accuracy across both sexes. Regression equations developed from the sample provided reliable estimates of stature, particularly in situations where direct height measurement is not feasible due to physical limitations or resource constraints. These findings highlight the value of arm span as a practical surrogate for height in clinical practice, school health programmes, sports assessments, and community surveys. Broader validation in diverse adolescent populations is recommended.

Limitations

The study was limited by its modest sample size and single-centre design, which does not reflect wider regional variability. Convenience sampling may have introduced selection bias. Nutritional status, pubertal staging, and ethnic variation were not assessed, all of which could influence anthropometric proportions and predictive accuracy.

Recommendations

Routine inclusion of arm span measurement is advised in adolescent health assessments, especially in settings where accurate height recording is difficult or equipment is limited. Clinicians, school health teams, and community screening programmes may use the regression equations derived from this study to estimate stature reliably. Incorporating arm span into growth monitoring protocols can improve assessment accuracy for children with mobility restrictions or postural deformities. Future research should validate these predictive models across larger, multi-regional adolescent cohorts and explore the influence of nutritional status, pubertal stage, and ethnic diversity. Developing region-specific anthropometric references will further enhance applicability and clinical precision. Future research incorporating wider age ranges and additional anthropometric markers would further strengthen the external validity of the height prediction equations developed in this study.

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Abbreviations

BMI – Body Mass Index
cm – Centimetre
SD – Standard Deviation
SPSS – Statistical Package for the Social Sciences
R^2 – Coefficient of Determination
r – Pearson's Correlation Coefficient

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The Author declares no conflict of interest.

Author's contribution
PRK-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript.

Data Availability
Data Available on request

Author Biography
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