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Original Research Article

Title: Age and Gender-Based Correlation between Arm-Span and Stature in Western Region of Uttar Pradesh

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Abstract:

Background: Anthropometry, a branch of anthropology, involves the systematic measurement of the human body's dimensions, including height, weight, and proportions. In this context, stature refers to the quantitative measurement of a person's height. The present study was used to assess the correlation between the arm-span and the stature among males and females in different age group in Western region of Uttar Pradesh

Materials and Methods: In this observational cross-sectional study, 324 patients were included. The participants belonged to the medical, paramedical students, and staff of our college, and were aged between 18-50 years. According to the standard anthropometric methods of the International Society for the Advancement of Kin anthropometry. Stature and arm span were measured in all the participants. The data collected was compiled, tabulated, analyzed and applied statistical tests. **Results:** A positive linear relationship was found between arm span and height in both males and females. The strength of this relationship varied by age group, with R-squared values indicating that 41.2% of arm span variation is explained by height in males, 32.8% of arm span variation is explained by height in females and 45.6-47.0% of arm span variation is explained by height across different age groups (20-30, 30-40, and >40 years).

Conclusion: Arm span is the most consistent body parameter for estimating an individual's height. Its strong correlation with height makes it a recommended tool for distinguishing age-related stature loss, uneven growth patterns, and skeletal dysplasia.

Keywords: arm span, stature, correlation.

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Introduction:

Physical anthropology focuses on the study of human behavior across different times and spaces. Anthropometry servesas a fundamental tool within this field, encompassing the examination of the human body and skeleton, which is crucial for forensic science in medico-legal cases. This discipline is also divided into social and cultural units, as it addresses human interactions and conduct within communities. Every individual has the inherent right to identity.

In cases of missing persons, external features and body parts play a critical role in recognition. In instances of mass casualties due to natural disasters, available body remnants become vital for medico-legal investigations. The stature of an individual is a key variable that aids in identification post-mortem. Height can be correlated with various measurements, such as hand length, foot length, and arm span, enhancing the accuracy of identification efforts (1). Stature and arm span are critical anthropometric measurements that have significant implications in various fields, including forensic science, medicine, and anthropology. In the Indian adult population, studies have shown a statistically significant positive correlation between these two parameters. The Indian population structure is characterized by its division into various levels, including castes, tribes, and religions, within specific geographical areas. Each of these categories is further divided into subunits, such as sub-castes or sub-tribes. The ongoing processes of subdivision and/or amalgamation of different populations across various regions of India are explained in literature through two models: fusion and fission (2). The correlation between two parameters varies significantly across different age groups and genders, as evidenced by multiple studies. Generally, a strong positive correlation exists, particularly in males, while females exhibit a weaker correlation. This relationship is crucial for anthropometric assessments and can serve as a reliable alternative measurement for height. This correlation is particularly useful for estimating stature in situations where direct measurement is not possible, such as in forensic cases involving damaged bodies. Assessing stature and weight is essential for measuring the growth and nutritional status of children. Both stature and arm span rise with age in children and are influenced by gender. In adults, these measurements decline with age, with stature decreasing at a faster rate than arm span. Research indicates that the age-related decline in height is less pronounced in the white population compared to the black population. For bed-

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bound patients, arm span serves as a useful measure for estimating stature. In forensic studies, arm span is significant for estimating stature in disabled athletes for identification purposes. Measurements of arm span and stature are also utilized to normalize pulmonary function in patients with scoliosis. By measuring standing height, one can estimate longitudinal growth, body fatness, and energy requirements, which are crucial for adjusting medication dosages. Estimating stature becomes challenging in children who are unable to stand (1). The aim of the present study was to find out the correlation between the arm-span and the stature among males and females in different age group in Western region of Uttar Pradesh.

Material and Methods:

After obtaining institutional ethical clearance and informed consent from all subjects, a total of 324 subjects (162 males and 162 females) with an age range of 18 to 50 years were examined for this study. These subjects, belonging to the medical, paramedical students, and staff of Uttar Pradesh University of Medical Sciences, Saifai, Etawah, UP, India, were all from the Western U.P. region. All subjects were apparently healthy, without any physical deformity. Simple random sampling was used for data collection. The inclusion criteria were healthy adult males and females who could stand erect for standing height measurement and had no spinal or skeletal deformities of the limbs. Subjects who were unwilling to give consent to participate in the study were excluded. The equipment used for measuring various parameters included a stadiometer capable of measuring to the nearest 0.1cm, a flexible steel measuring tape, and a digital camera. According to the standard anthropometric methods of the International Society for the Advancement of Kin anthropometry (3). Stature and arm span were measured in all the participants

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Measurement of stature of arm span:

Stature is defined as the vertical distance from the vertex to the floor. It was measured to the nearest 0.1 cm in bare feet, with participants standing upright against a stadiometer (Figure 1). The respondent's head was positioned in the Frankfort horizontal plane, achieved by ensuring the lower edge of the eye socket was horizontal with the tragion. The vertex was identified as the highest point on the head. If necessary, respondents were asked to adjust their chin to align their head properly with the Frankfort horizontal plane. Participants were instructed to stand erect with heels together and backs straight, ensuring their heels, buttocks, shoulders, and head touched the stadiometer rod. Arms were hung freely by their sides. After taking a deep breath and holding it, a reading was taken from the stadiometer scale at the vertex point. Participants were then asked to breathe and step away from the stadiometer.

Arm span was measured as the anthropometric length from the tip of the middle fingers of the left and right hands when raised parallel to the ground at shoulder height, forming a 180-degree angle. Measurements were taken using a calibrated steel tape to the nearest 0.1 cm in bare feet on a level concrete floor. Participants stood with their upper backs, buttocks, and heels against the wall for support. (Figure 2) Their head was positioned in the Frankfort horizontal plane, and arms were outstretched at right angles to the body with palms facing forwards. Measurements were taken from one middle fingertip to the other, with the tape passing in front of the clavicles, while two field workers supported the elbow (3). The measurements were taken twice, and an average of the two readings was calculated.

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Figure 1: Procedure of measuring the Stature

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Figure 2: Procedure of measuring the Arm span

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Statistical Analysis:

The collected data were coded and entered into an excel software (Microsoft office Excel 2010) database. Data were analyzed using Statistical Package for Social Sciences, version 16.0 (SPSS, Inc., Chicago, IL, USA). All tests were carried out at the 5% level of significance. Independent t test was used to test the comparison between continuous variables (Arm Span (cm) and Stature (cm)) according to age groups & gender. Pearson Correlations coefficients (r) tests was used to find relation and using Scatter plot for trend between Arm Span (cm) and Stature (cm) in gender & age groups separately.

Results

Table 1: Comparison of Stature (cm) in different age groups between male and female participants

Age group (in years)		Gender	N	Mean	Std. Deviation	Std. Error Mean	p-value
20-30	Stature (cm)	Male	81	171.34	6.46	0.71	<0.001
		Female	87	166.70	6.38	0.68	
30-40	Stature (cm)	Male	41	171.08	7.57	1.18	0.004
		Female	48	167.03	5.14	0.74	
>40	Stature (cm)	Male	40	173.92	5.66	0.89	<0.001
		Female	27	168.57	5.00	0.96	

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Table 1 shows a significant difference in Stature between male and female participants across all age groups. Notably, males were consistently taller than females, with a significant difference observed in the 20-30 age group, where males averaged 171.34 cm and females averaged 166.70 cm ($p < 0.001$). This trend continued in the 30-40 age group, with males averaging 171.08 cm and females averaging 167.03 cm ($p = 0.004$), and was also evident in the >40 age group, where males averaged 173.92 cm and females averaged 168.57 cm ($p < 0.001$). Overall, the findings indicate that males tend to be taller than females across different age groups.

Table 2: Comparison of Arm Span(cm) in different age groups between male and female participants

Age group (in years)		**Gender**	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**p-value**
20-30	Arm Span(cm)	Male	81	177.06	6.21	.69	<0.001
		Female	87	172.35	6.01	.64	
30-40	Arm Span(cm)	Male	41	176.84	5.86	.91	<0.001
		Female	48	171.52	4.90	.71	
>40	Arm Span(cm)	Male	40	178.41	5.40	.85	<0.001
		Female	27	172.37	6.58	1.26	

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Table 2 shows a significant difference in arm span between male and female participants across all age groups. Males consistently had a larger arm span than females. Specifically, in the 20-30 age group, males averaged 177.06 cm, while females averaged 172.35 cm ($p < 0.001$). This trend continued in the 30-40 age group, with males averaging 176.84 cm and females averaging 171.52 cm ($p < 0.001$), and was also evident in the >40 age group, where males averaged 178.41 cm and females averaged 172.37 cm ($p < 0.001$). Overall, the findings indicate that males tend to have a larger arm span than females across different age groups.

Table 3: Pearson Correlations coefficients between Arm Span (cm) and Stature (cm) in different age groups separately.

Age group (in years)			Stature (cm)
	20-30	Pearson Correlation (r)	0.675
		p-value	<0.001
Arm	30-40	Pearson Correlation (r)	0.623
Span		p-value	<0.001
(cm)	>40	Pearson Correlation (r)	0.685
		p-value	<0.001

Table 3 shows a strong positive correlation between arm span and Stature across all age groups. The Pearson correlation coefficients (r) were 0.675 ($p < 0.001$) for the 20-30 age group, 0.623 ($p < 0.001$) for the 30-40 age group, and 0.685 ($p < 0.001$) for the >40 age group. This indicates that as Stature increases, arm span also tends to increase, and vice versa, across all age groups. The strong correlation suggests a consistent relationship between these two anthropometric measures.

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Table 4: Pearson Correlations coefficients between Arm Span (cm) and Stature (cm) in male & female groups separately.

Gender			Stature (cm)
Arm	Male	Pearson Correlation (r)	0.641
Span		p-value	<0.001
(cm)	Female	Pearson Correlation (r)	0.573
		p-value	<0.001

Table 4 shows a strong positive correlation between arm span and Stature in both male and female groups. For males, the Pearson correlation coefficient (r) was 0.641 ($p < 0.001$), indicating a strong relationship between arm span and Stature. Similarly, for females, the correlation coefficient (r) was 0.573 ($p < 0.001$), also indicating a strong positive relationship. This suggests that, regardless of gender, arm span tends to increase with Stature.

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Figure 1(a): Scatter plot showing trend between Arm Span (cm) and Height (cm) in male.

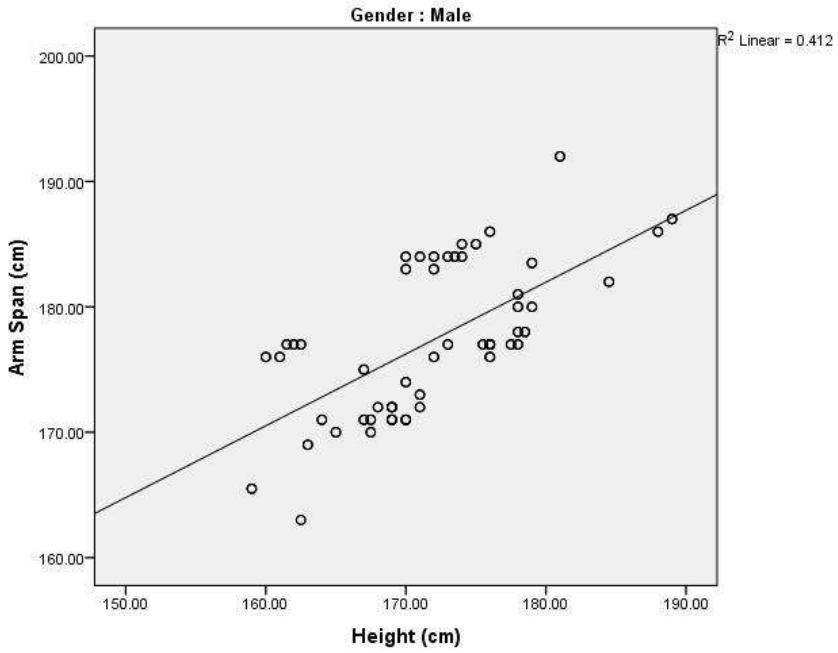
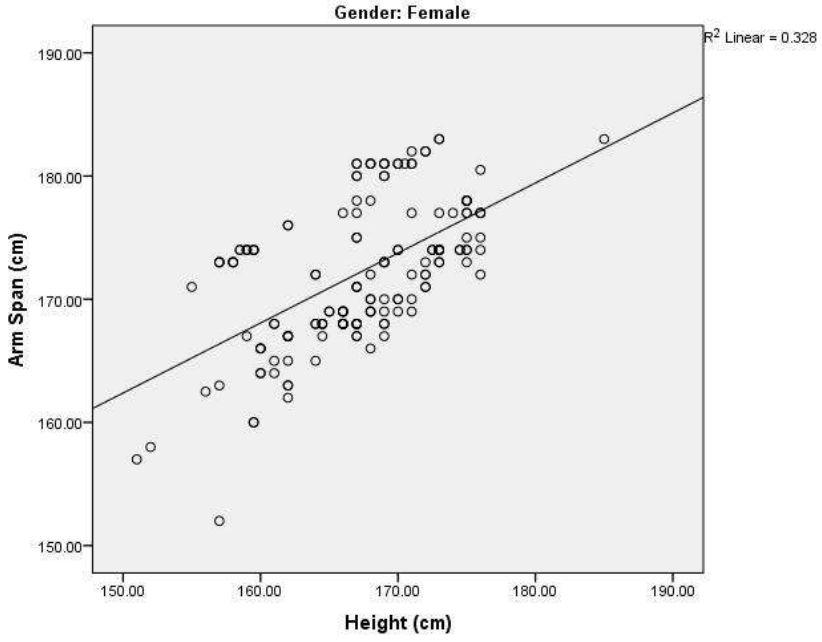


Figure 1(b): Scatter plot showing trend between Arm Span (cm) and Height (cm) in female.



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The scatter plots in Figure 1(a) and 1(b) illustrate a positive linear relationship between arm span and height in both males and females. The R-squared values indicate that approximately 41.2% of the variation in arm span can be explained by height in males, and 32.8% of the variation in arm span can be explained by height in females.

Figure 2(a): Scatter plot showing trend between Arm Span (cm) and Height (cm) in 20 to 30 years age group.

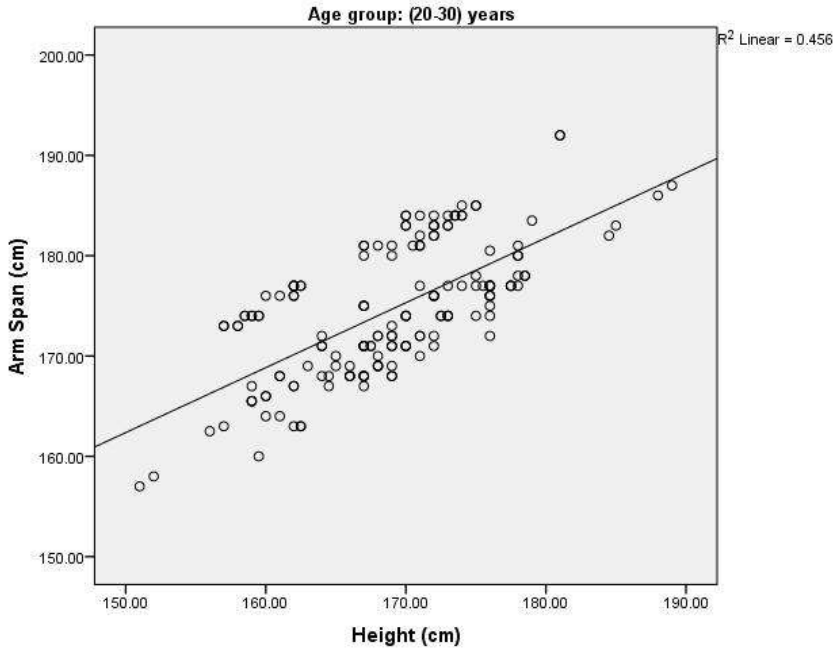

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Figure 2(b): Scatter plot showing trend between Arm Span (cm) and Height (cm) in 30 to 40 years age group.

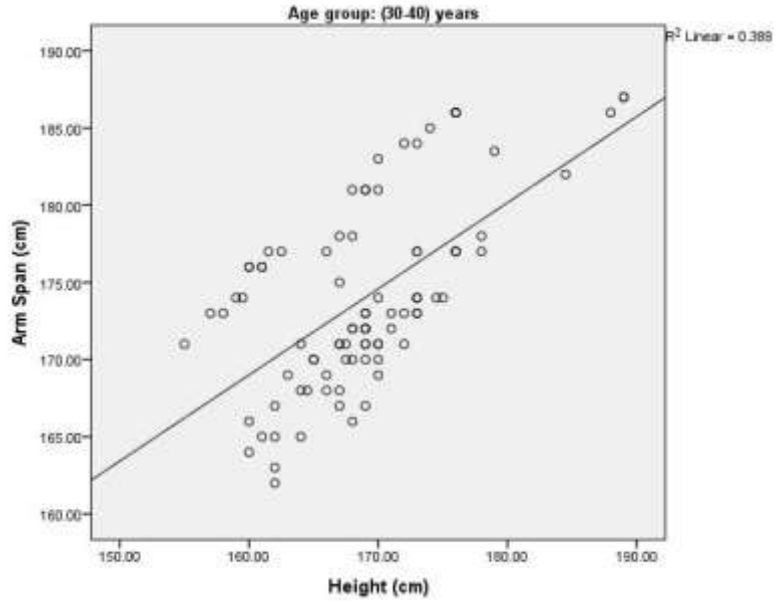
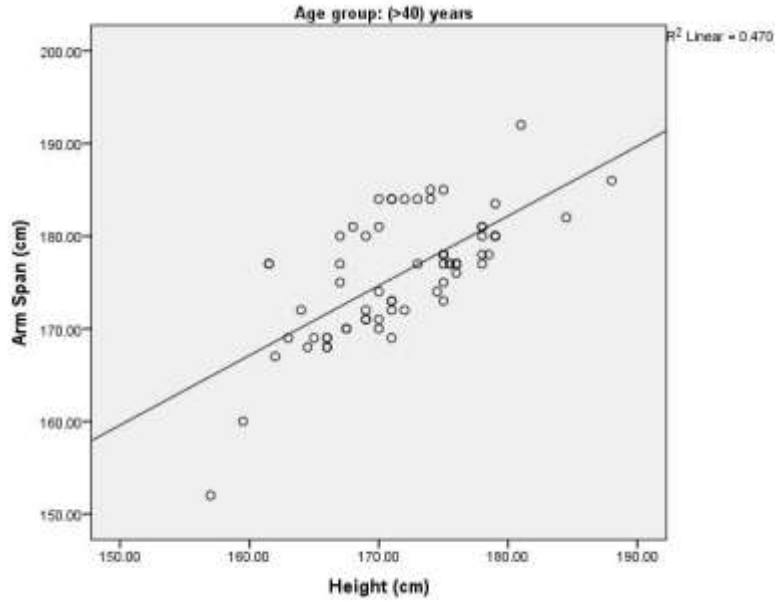


Figure 2(c): Scatter plot showing trend between Arm Span (cm) and Height (cm) in greater than 40 years age group.



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The scatter plots in Figure 2(a), 2(b), and 2(c) illustrate a positive linear relationship between arm span and height across three different age groups. The R-squared values indicate that the relationship is moderate to strong, with 45.6% of the variation in arm span explained by height in the 20-30 years age group, 38.8% in the 30-40 years age group, and 47.0% in the >40 years age group. This suggests that arm span tends to increase with height, and this relationship is consistent across different age groups.

Discussion:

The most consistent body parameter for foreseeing the height of an individual is Arm span. It is helpful in envisaging age-related loss in stature and identifying individuals with uneven growth oddity and skeletal dysplasia. Alterations in the height of an individual that may occur due to progressive deformities of the spine and surgical correction of spinal deformities has become very easy as arm spam plays very crucial role in this regard. Medico-legally it is a significant parameter where determining height of subject is a major step in recognition of a deceased subject when only parts of the body are obtainable. This should persuade others in taking up advance research in the area. The comparison of height and arm span between male and female participants across various age groups reveals consistent trends that align with existing literature on anthropometric measurements. Furthermore, mean stature of male population observed by Ritesh et al. is 175.95 (cm) in Gujarat population,(4) by Sah et al., in Nepal region is 167.39 (cm), and the mean stature in female were observed by Ritesh et.al is 161.1(cm) and by Sah et al.,(5). Similar results in the present study in U.P region observed that males are consistently taller than females across all age groups, in the 20-30 age group, males averaged 171.34 cm while females averaged 166.70 cm. This trend continues in the 30-40 age group, where males averaged 171.08 cm and females 167.03 cm, and in the >40 age group, males averaged 173.92 cm compared to females at 168.57 cm.

These findings are supported by other studies that report similar height differences, with males generally being taller than females by approximately 5-7 cm across various populations (6-8)

In terms of arm span, males also exhibit larger measurements than females across all age groups. Specifically, in the 20-30 age group, males averaged 177.06 cm while females averaged 172.35

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cm . This pattern persists in the 30-40 age group (males: 176.84 cm, females: 171.52 cm, and in the >40 age group (males: 178.41 cm, females: 172.37 cm. Previous studies reported that the mean arm span in male observed by Ritesh et al., is 178.18 (cm), by Sah et al., the mean of arm span of male is 168.01 (cm) (4,5). These results are consistent with previous research indicating that males typically have a greater arm span than females, with studies showing average male arm spans exceeding female arm spans by about 4-6 cm. (7,9,10). Studies have compared anthropometric measurements such as knee height, sitting height, arm span, with height, particularly in conditions where its measurement is difficult or unreliable such as in kyphotic individuals, of all the measurements, arm span was found to be associated most strongly with height. In present study, the correlation between height and arm span is notably strong across all age groups. This suggests that as height increases, arm span tends to increase as well, which is corroborated by other studies that report similar correlation coefficients ranging from 0.6 to 0.8 in various populations (7,10). When examining the correlation separately by gender, indicates a strong positive relationship between arm span and height for both genders, although the correlation is slightly stronger in males. The scatter plots illustrate a positive linear relationship, with R-squared values indicating that approximately 41.2% of the variation in arm span can be explained by height in males, and 32.8% in females. This aligns with findings from other studies that demonstrate a consistent relationship between these two anthropometric measures across different populations and age groups (6, 11). Research has consistently shown a strong correlation between height and various body measurements, including arm span, demispan, hand length, knee length, and foot length. Studies by Rai P et al. and others have specifically demonstrated a reliable link between arm span and height across different age groups, with young adults aged 20-25 years showing a particularly strong correlation (9,12). Previous studies suggested that arm span can be a useful predictor of height, and may even help detect changes in height due to skeletal disorders.

Conclusion:

In conclusion, arm span is the most reliable body parameter for predicting an individual's height. Its strong correlation with height makes it a valuable tool for detecting age-related stature loss, uneven growth patterns, and skeletal dysplasia. This study's findings align with previous research, demonstrating a consistent positive relationship between arm span and height across various populations and age groups. Furthermore, arm span measurement can serve as a useful predictor of height in medicolegal cases.

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