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Estimation of Stature Based on Lower Limbs: A Study Among the Male Children from Uttar Pradesh's Chandauli - Mirzapur Districts

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Abstract*: The goal of this study is to estimate stature or height from lower-limbs in male-children from the Uttar Pradesh (UP) districts of Chandauli and Mirzapur (India). 501 children aged eight (8) to fourteen years (14) old volunteered to take part in the research during the school year 2014-2015, and data was collected using multistage random sampling. On the right-side of each participant, four anthropometric measurements were taken: height, trochanterion length (TL), tibiale-laterale length (TLL), and biepicondylar femur breadth (BFB) (ISAK recommendation). The data was analysed, and an attempt was made to create a regression model based on the link between stature (dependent variable) and TL, TLL, and BFB (estimates). At P<0.05, all culled estimates showed a significant correlation. To compare authentic and estimated stature, an independent t-test was used, and all three segments were obtained after that. The constructed regression models worked well for estimating stature, and the Trochanterion length is a very reliable predictor of stature. Because regression models for stature prediction from the above-mentioned body segments were used in this work, the findings could be beneficial in establishing biological profiles during forensic investigations and disaster victim identification

***Keywords*: Biepicondylar Femur Breadth, Lower Limbs, Medico-Licit Autopsies, Regression Model, Stature Estimations**

I. INTRODUCTION

Anthropometry was first used in forensic-science and medicine in the year 1882. Alphonse Bertillon, a French-police-expert, established a criminal identification system based on anthropometric measurements. Anthropometry has since been used in forensic studies of unidentified commingled human remains [1]. In the anthropometric investigation, individual stature is the most critical factor.

It's the measurement from the top of the head (vertex) to the bottom of the feet. It is a significant physical identity [2]. An individual's stature, which is made up of the lengths of several bones and appendages, reflects a definite relationship with the shape of proportions in the full stature. Both in the anthropological study and the identification procedure required by medico-legal professionals, it plays a critical role [3]. Establishing the personal identity of the victims is frequently essential in medico-legal autopsies. In forensic exams, estimating stature from extremities and their components is critical for identifying the dead. As a result, the ability to reconstruct stature from fragmentary skeletal remains or disfigured or fragmented human remains has a prominent role in personal identification [4 5 1 6 7]. Knee height is one of the reliable quantifications that can prognosticate Height by mathematical techniques due to its high cognition[8 9].

The stature estimated by Biepicondylar Femur and Trochanterion length has been very constrained. It has also been established that anthropometric traits change amongst populations due to differences in nutrition, physical activity, and genetics [10 11 12 13]. Overall, we may say that skeletal identification standards vary amongst people and that one population's bar may not apply to another. The anatomical approach, also known as the 'Full Skeleton methods,' entails measuring stature/height based on the total of the vertical-measures of all bones that contribute to height/ stature, as well as a rectification of the soft tissue factor [14 15 16]. And another way is an indirect estimation of stature is a mathematical method that is derived from different body segments which are utilized two methods; Multiplication factor (MF) and Regression analysis: These tactics are based on a mathematical link between body segments and height (correlation) (i.e., People who are taller tend to have longer body segments than those who are shorter). The lengths of single or numerous long bones in skeletal remains, Long bones in the legs and arms are frequently at their full length, represent these segments. The most precise procedures use the measurements of entire limb bones (rather than partial or non-limb bones). The femur is the most precise, followed by the lower-leg and arm-bones, because it contributes the most to stature. When allometric discrepancies are greater, estimates based on several bone measures are frequently more accurate than those based on a single skeletal measurement [17]. Regression analysis, on the other hand, has been proved in multiple studies to be a more reliable and efficient way of determining stature than multiplication factors [1,18,19]. Using both techniques, none of the studies have found any variation in estimated and authentic stature. This is the first study to use leg length (LL), trochanterion length (TL), and biepicondylar femur length (BFL) to determine stature in the Chandauli-Mirzapur districts, Uttar Pradesh. The current study employs regression analysis to show the disparity between estimated and true stature.

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II. METERIALS AND METHODS

A. Participants

A cross-sectional sample of 501 healthy male children with no postural abnormalities were used in this investigation. The data accumulated from October to January in the academic year 2014-2015. The information was gathered using a multistage sampling technique with inclusion and exclusion criteria for primary and secondary schools in rural areas of Chandauli and Mirzapur, Uttar Parades (India). According to their ages, the subjects were divided into seven categories: eight (8), nine (9), ten (10), eleven (11), twelve (12), thirteen (13), and fourteen years (14) (Table 1). The head teachers /principals of the affected schools and the boys' parents who took part in the study gave their approval. The methods for the testing were thoroughly explained to all of the lads. They took part in this research project voluntarily and cheerfully, with no pressure or force in the data collection. After thoroughly describing the study's aims and objectives to all of the respondents, their parents, and the school's significant officials, oral and written consents were obtained from all of them and those of their parents and the school's leading authorities. Before beginning data collecting for the project, the Doctoral Committee of Pondicherry University's Department of Physical Education and Sports provided proper ethical clearance.

B. Including/excluding:

The following criteria were used to conduct the research:
1. Male children ranged in age from 8 to 14 years old.
2. Government schools were the only ones considered.
3. The study excluded participants with a history of significant leg injuries or fractures, Achondroplasia (ACH), or any other congenital or inherited bone illness.
4. Children's postural abnormalities were omitted, including “kyphosis, round-shoulder, lordosis, knock-knee, and bowleg deformities”. The researcher also analyzed postural abnormalities subjectively.

Table 1 Subjects are Distributed Based On Their Age And District.

S.No.	Age (years)	Children of Chandauli District		Children of Mirzapur District		Total	
		No.	%	No.	%	No.	%
1	8	35	13.94	35	14.00	70	13.97
2	9	31	12.35	31	12.40	62	
3	10	33	13.15	32	12.80	65	
4	11	27	10.76	28	11.20	55	
5	12	38	15.14	37	17.80	75	
6	13	39	15.54	38	15.20	77	
7	14	48	19.12	49	19.60	97	
Total		251	100.0	250	100.0	501	

C. Anthropometry Protocol

Four anthropometric measurements were taken from each subject's right side: stature (St), TL, TLL, and BFB. According to the guidelines, all measures were taken in cm using a cross-hand technique with a 1 mm graduation 20.

1. Stature

The distance between the transverse plane of the vertex of the head and the bottom of the feet, measured perpendicularly. It was also measured using an Anthropometric rod. The individual was asked to stand with his feet together and his heels, buttocks, and upper back contacting the anthropometric rod against the wall. The maximum distance measured from the apex point of the head to the bottom of the feet immediately before the patient exhaled was measured in the Frankfort plane (the lower borders of the eye sockets were in the same horizontal-plane). The height i.e stature was measured to the nearest 0.1 cm, with a 5 mm error allowed by the ISAK.

2. Trochanterion Length:

The minimum distance between the trochanterion to the bottom of the right leg. And it was measured through an anthropometric rod. Method: With the examiner standing on his right side, the subject was told to stand in a comfortable stance with his feet together or apart by 10 cm and his arms folded across his thorax. One end of the rod was put on the surface, and the other end was on the point of the trochanterion site through the sliding technique. Scoring: The perpendicular distance was recorded to the nearest 0.1cm.

3. Tibiale-Laterale Length:

The vertical distance from the standing surface's tibiale-laterale location. It was also measured using an Anthropometric rod. Method: The participant was asked to stand in a relaxed stance with his feet 10 cm apart or together, arms crossed across his torso and the examiner on his right side. One end of the rod was put on the surface, and the other end was on the point of the tibiale-laterale length. Scoring: The perpendicular distance was recorded to the nearest 0.1 cm.

4. Biepicondylar Femur Breadth:

The linear distance between the lateral femoral epicondyle's most lateral aspects and the medial femoral epicondyle's most medial aspects. It was also measured using a small sliding calliper. Method: The subject took a seated position with his hands away from the knee regions. The knees and thighs were kept perpendicular to each other. The distance between the medial and lateral epicondyles of the femur was measured horizontally. The tester used his middle finger to palpate the epicondyles beginning proximally and then circled to locate his sites. The caliper faces were resting on the epicondyles, and the value was read by applying firm pressure with the index fingers. The measurement was taken to the nearest 0.1 cm, and the ISAK accepted a 2 mm mistake.

D. Measurement Error

The accuracy of the measurements employed determines the validity of the predictive-regression-models. The following two metrics of validity were used to assess measurement-inaccuracy in this study: (a) Measuring or technical error of measurement (technical error) (TEM), The corrections were done as proposed21,(b) Intra-correlation correlation coefficient (ICC); ICC for Trocantorian length is (0.96*), for Tibiale-laterale length is (0.94*) and for Biepicondylar femur breadth is (0.95*) were obtained.

E. Data quality control

Before collecting the data researcher was a good verse about equipment handling and took enough training given by Dr Anup Adhikari, Criterion Photoscopic Somatotype Rater, Exercise Physiologist, Level-4 Anthropometrist (ISAK), and tester is completed the Level-1 certificate course (ISAK) also training was given by Department of Anthropology, Pondicherry University. The tester itself took all of the measurements. Data collecting materials that were developed correctly were prepared. Before data collection, the tester conducted a pilot study to ensure that the data was complete and consistent.

F. Statistical-Analysis

The data's descriptive properties, such as mean, standard deviation (SD), and Min and Max values, were acquired to analyse the study's findings. At the P0.05 and P0.01 levels of significance, the product-moment correlation coefficients were utilised to find a link between stature and the dependent variables TL, TLL, and BFL. The coefficient of determination (R2) was calculated to see how much of the variation in the dependent-variable can be explained by the other-variables?. The research group's stature was estimated using the regression equations derived for each variable. At the $P < 0.05$ and $P < 0.01$ level of significance, the independent "t" was used to quantify the difference between actual and estimated stature. The Statistical-Package for the Social-Sciences was used to conduct all statistical analyses (SPSS).

III. RESULTS

Table 2: Anthropometric parameters of the current subject: descriptive statistics (N = 501)

Variables (cm)	Minimum	Maximum	Mean	SD
Stature	111.10	168.20	137.96	11.89
Trochanterion length	54.50	87.30	70.19	6.98
Tibiale-laterale length	26.30	53.50	36.63	4.16
Biepicondylar femur breadth	6.60	10.00	8.15	0.68

In the case of stature and Trochanterion length among male-children of Districts Chandauli-Mirzapur, UP, the Mean and standard deviation were found to be 137.961±1.89 cm and 70.19±6.98 cm, respectively. In contrast, the Mean and standard deviation of Tibiale-laterale length and Biepicondylar femur breadth were 36.63±4.16cm and 8.15±0.68cm, respectively.

Table 3 Correlation between independent variables and dependent variable (stature)

Independent variables (estimates)	Dependent variable (stature) (r)
Trochanterion length	0.960**
Tibiale-laterale length	0.899**
Biepicondylar femur breadth	0.824**

**P < 0.01

Table 3 depicts the correlation between independent factors and the dependent variable (stature). As can be seen, all estimations are highly and positively linked with stature (0.960** to 0.824**). All predictor factors substantially correlate with the dependant (stature) variable.

Table 4 For Male Children, Linear Regression Estimates Their Stature.

Vari.	R	R^2	B	t	Sig	Durbin – Watson	Estimate formula Stature (S)
TL	0.96**	0.922	23.37 (1.63)	15.46	0.00	1.951	S= 23.375 + 1.633 (TL)
TLL	0.89**	0.809	43.82 (2.57)	21.25	0.00	1.534	S= 43.846 + 2.569 (TLL)
BFB	0.82**	0.680	21.62 (14.27)	6.02	0.00	1.573	S=21.623 +14.275 (BFL)

**P < 0.01

The Durbin- Watson test is performed to see if residual terms are uncorrelated (autocorrelation checking). "The Durbin – Watson statistic has a range of values from 0 to 4. As a general rule, the Durbin–Watson statistic is about 2 if the residuals are uncorrelated. All Durbin–Watson values in this study ranged from 1.59 to 1.87. (Table 5). The value of R2 indicates how much of the variance in this analysis is explained by estimates (degree of determination). From Table 5, R2 = 0.921, which is approximately 92.1% variance of stature, which is defined by Trocantorian length; R2 = 0.809, which is about 80.9% variance of stature, which is explained by Tibiale-laterale length; R2 = 0.680, which is approximately 68.0% variance of stature, which is explained by Biepicondylar femur breadth.

Table 5 Comparison of Actual Stature and Regression Analysis-Estimated Stature

Variables	Min.	Max.	Mean	SD	t	Sig.
Actual stature	111.10	168.20	137.95	11.89	0.018	0.986
Estimated stature from TL	112.37	165.94	137.94	11.41		
Estimated stature from TLL	111.41	181.29	137.96	10.69	0.002	0.999
Estimated stature from BFB	115.84	164.37	137.96	9.80	0.001	0.999

**P < 0.01

IV. DISCUSSION

Quantifications of various body components can be used to determine stature. It is directly proportionate to many body components and has a clear biological and genetic sodality. Due to natural disasters or other physical disasters. Ergo, identifying skeletal remains and mutilated bodies is essential for both licit and humanitarian reasons. Many anthropologists, anatomists, and forensic scientists study the stature of living individuals from skeletal remains [19, 22, 23, 24] utilizing different percutaneous quantifications. In the cases of natural disasters and other calamities, disjointed human remains are often found, which need to be identified. With all of this in mind, the researcher devised the current study's aims to estimate children's stature using the Trochanterion, Tibiale-laterale, and Biepicondylar femur breadth criteria. The analysis utilised the product-moment correlation coefficient to obtain a cognation between dependent and independent variables. The estimation was obtained using the Linear Regression model.

The Multiplication factor was additionally utilized to estimate the stature, but it is a very crowded estimation1 [19, 22, 25, 26]. According to Trotter and Gleser, the world population is growing taller. As a result, the relationship between height and the length of long bones is shifting, necessitating a new formula for each generation. As a result, they set out to find a new regression model for the populations mentioned above.

Kindred research studies have been conducted on sundry other ethnic groups, age groups, gender groups, and withal in other geographical conditions respectively [22, 25, 27, 28, 29, 30, 31, 32, 33]. According to the study's findings, the connection between stature and all prognosticators is positive (+) and statistically-significant at $P < 0.01$. The correlation-coefficients obtained as follows: between stature and Trochanterion length, r = .960** ($P < 0.01$; R2 = 92.2%), between stature and Tibiale-laterale length, r = .899** ($P < 0.01$; R2 = .809%), between stature and Biepicondylar femur breadth, r = .824** ($P < 0.01$; R2 = 68. %). All the estimates were robust to presage the stature. Moreover, the highest correlation obtained between Trochanterion length and stature signifies the long segment. The longest body segment (bone), which contributes the most to stature, is generally accurate, followed by lower-leg bones and arm-bones.

This research is consistent with 17. Moreover, linear regression models were evolved to estimate the children's stature; from Table 6, the authentic mean of stature is 137.95 and calculated stature from; Trochanterion length, 137.94; from Tibiale-laterale length, it is 137.9606; and from Biepicondylar femur, breadth is 137.96. The independent t-test showed insignificant results obtained between actual stature and estimated stature at $P < 0.01$ for all estimations. Data in the above table betokened that the mean values of estimates were virtually kindred up to the first decimal value. The developed regression modes were very robust for estimating the stature.

However, mean values were almost identical, but their ranges (min. and max.) varied. Of course, this variation may be due to age differences. However, if data are taken from the same age groups, this deviation in range will be minimized, and estimated regression will become more robust. Various factors such as age, gender, race and ethnicity, and alimental status influence humans' magnification and development, so different equations are needed for use with sundry populations [27 34].

In contrast, the estimation equation differs among sundry races and ethnic groups13. The norms for calculating stature from TL, TLL, and BFB for the population of school-aged children in the districts of Chandauli-Mirzapur, are documented for the first time in this study. The formulas are valid for the age group of 8–14 years. Notwithstanding that the stature progressively decreases with age due to the shrinking of the spinal cord, it is desirable to conduct homogeneous studies on different age groups to complement and validate the results obtained from the present study [34]. The proposed regression models will be very utilizable in anthropological and archaeological studies and clinical and medico-legal practices. The subject's stature under investigation can be calculated from the parameters above.

V. CONCLUSION

The current findings suggest that TL (Trochanterion length), TLL (Tibiale-laterale length), and BFB (Biepicondylar femur breadth) can be used to estimate stature in forensic exams with high accuracy. Furthermore, Trochanterion length is more reliable for estimating stature than TLL and BFB among the three segments. As a result, once the Trochanterion length is recovered in forensic contexts in the Uttar Pradesh districts of Chandauli and Mirzapur, it is recommended that the Trochanterion length be used to estimate stature (Lone segment is more preferable than short segment).

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AUTHOR CONTRIBUTIONS

Ashish Kumar Singh was involved in the study's design and data collecting, analysis, and interpretation. Ajeet Jaiswal, on the other hand, was involved in the study for examination, performance, and drafting of the research paper, as well as critical revision of the article. The article's final version has been read and approved by all authors, and the authors' order of presentation has been agreed upon.

COMPETING INTERESTS

There are no competing interests declared by the authors.

CONFLICT OF INTEREST

There is no conflict of interest

ETHICS-APPROVAL AND CONSENT

Following a detailed explanation of the study's goals and objectives to all participants, as well as their parents and the school's leading authorities, oral and written consents were obtained from all of them, as well as their parents and the school's leading leaders. Before beginning data collecting for the project, the Doctoral Committee of Pondicherry University's Department of Physical Education and Sports obtained proper ethical clearance. The methods for the testing were thoroughly explained to all of the lads. They took part in this research project voluntarily and cheerfully, with no pressure or force in the data collection. The research timetable was written in both English and the local language, such as Hindi, to ensure no misunderstandings.

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Professional Qualification

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6. Qualified **UGC NET Exam** December (2012) in Physical education. Roll No: 77470067.
7. Qualified **UGC NET Exam** (December 2013) in Physical education. Roll No: 77470079.

TEACHINH EXPERIENCE

1. Working as an Assistant Professor in the Department of Physical Education and Sports. Hemvati Nandan Bahubuna Garhwal University Srinagar, Uttrakhanad. Joining from 24th August 2016 to 09th November 2017.
2. Working as an Assistant Professor in the Department of Physical Education. Aryavart Institute of Higher Education, Lucknow. Joining from 11th November 2017 to till continue.

I have published 13 research papers in **National Seminars and conferences** and also 2 International Conferences

I have published 12 international research papers along with **2 National papers.**

I have participated in international Congress

Participated in an International workshop on "**ISAK ACCREDITATION COURSE LEVEL – 1".**

NATIONAL WORKSHOP

1. Attended three days National Workshop on "**Data analysis in management**" using SPSS and AMOSE from April 24-26, 2015.
2. Attended four day National Workshop on "**Research Techniques and Data Analysis**" from September 19-22, 2013.
3. **Participated 21 days Interaction programme for Ph.D Scholar held in Pondicherry University from October 9-29, 2013, and obtained grade "A".**
4. Participated in the National Workshop on present trends in cricket officiated by the Department of Physical education and sports, Pondicherry University from March 27-29, 2012.

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