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Estimation of Stature from Anthropometric Measurements of the Sternum in Nepalese Population at the Tertiary Health Care Hospital

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ABSTRACT

Introduction: Stature estimation is crucial for identifying human remains in forensic and anthropological contexts, aiding in mass casualties, criminal investigations, and archaeological studies. Traditionally using long bones, alternative methods are necessary when these bones are unavailable or fragmented.

Objectives: The main purpose of this study was to access the morphometric measurements of the study population and compare the findings between the two sexes.

Method: A study of 100 medico-legal autopsies at Department of Forensic Medicine, Maharajgunj Medical Campus, Nepal investigated stature estimation from sternal lengths. During autopsies, cadaver length was measured using a steel tape. An incision was made from the suprasternal notch to the pubis, the sternum was removed, and the combined manubrium and mesosternum length was measured with sliding callipers.

Results: The study included 67 male and 33 female cadavers, with a mean age of 37.46 years. The mean length of the manubrium was 43.34 ± 6.88 mm (44.58 ± 7.15 mm for males, 40.81 ± 5.59 mm for females). The mesosternum averaged 101.85 ± 15.65 mm (104.40 ± 16.68 mm for males, 96.66 ± 11.92 mm for females). The combined sternal length was 146.12 ± 16.64 mm. Body length correlated weakly but significantly with manubrium, mesosternum, and combined sternal lengths (r = 0.242, 0.206, 0.320 respectively).

Conclusion: Stature estimation from sternal length is valuable for identifying mass casualty victims, with males showing greater measurements. Combined manubrium and mesosternum lengths are better stature estimators.

Keywords: Autopsy; manubrium; mesosternum; morphometric measurements; stature.

INTRODUCTION

Human identification, a fundamental aspect of forensic investigations, becomes particularly challenging when bodies lack external physical clues. In such scenarios, determining age, sex, and stature through anthropological measures is essential to narrow down potential matches. Stature estimation, a key factor in identifying unknown or mutilated bodies, is based on the

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relationship between skeletal elements and height.[1]

Nepal faces significant challenges in identifying human remains found in mass graves or isolated locations. The lack of ante-mortem medical and dental records complicates the identification process.[2] In developed countries, advanced techniques such as DNA analysis, facial reconstruction, and superimposition are standard, but these resources are often unavailable in Nepal. Anthropometric parameters, which include somatometric, radiological, and osteological examinations, become paramount.[3, 4] Worldwide studies have shown that different populations require specific formulas for accurate anthropometric measurements due to inherent genetic and environmental differences.

Therefore, establishing a comprehensive anthropometric database for the Nepalese population is imperative.[5] By enhancing forensic capabilities, Nepal can better address the challenges posed by unidentified remains, providing closure to affected families and supporting the judicial system.[6] This research underscores the critical role of anthropometric data, especially in Nepal, where recent political unrest and natural disasters have led to numerous unidentified remains.

METHODS

This study adopted a comparative and analytical design. Formal approval was obtained from the Institutional Review Board of the Maharajgunj Medical Campus, Nepal (IRC approval number: 108/6-11-E/2/071/073). The research was conducted at the Department of Forensic Medicine, Maharajgunj Medical Campus, Nepal. Measurements were gathered during the execution of 100 medico-legal autopsies.

The sampling method for this study was a convenience sample technique (non-probability sampling method). All deceased individuals, aged between 16 and 70 years, who were registered for routine medico-legal autopsies at the Department of Forensic Medicine were considered the total population. A total of 100 medico-legal autopsies were selected for the sample.

This study included people aged 16 to 70 with sternums free of chest traumas, visually discernible diseases, deformities, and inherited or acquired anomalies. The exclusion criteria of the study were unidentified body; deceased foreign nationals; Any individual less than 16 years of age and above 70 years of age; any injuries/fracture to the chest resulting in deformation of the contour of the sternum; any congenital or acquired anomalies altering the shape of the chest or crown-heel length of the deceased an individual; cases where the exact length of the deceased an individual cannot be established like cases of heat stiffening (pugilistic attitude), advanced stage of decomposition, amputation of any of the lower limbs, any diseases related to the vertebral column, etc.

The morphometric measurements were length of manubrium (MN); length of mesosternum (MS); and midline combined length of manubrium and mesosternum (T).

The materials used for the measurements were sliding vernier's calliper (Scienceware® Digi-Max™ slide calliper, Sigma-Aldrich, accuracy: ± 0.1 mm); scalpel (Henry Schein®); rib shearer (Surtex instruments); water.

Using the routine medico-legal autopsy, the body was placed in supine position on a flat, hard surface of autopsy table, with the knee and hip joints extended, and the neck and feet in neutral position. The cadaveric length (stature) was measured between the vertex of the head and the heel using a steel measuring tape.

Incision was made from the suprasternal notch inferiorly along the sternum, extending further inferiorly along the anterior abdominal wall to the pubis. Following the incision with the rib shearer, the costal cartilages were cut inferiorly by sliding the lower blade of the shears beneath the cartilage close to its bony attachment to the rib and shearing through the firm tissue as cleanly as possible before cutting the cartilage just medial to the rib.

The sternum was released by grasping the lower end and lifting it while horizontal cuts were made upwards into the deep surface of the sternum to separate from the adjacent anterior mediastinal soft tissue. The cuts were made through the sternoclavicular joints, and the clavicle reflected the midline combined length of the manubrium, and the mesosternum was measured in the mid-sagittal plane from the incisura jugularis (central suprasternal notch) to the mesoxiphoid junction using sliding callipers to the nearest millimetre.

In sternums with an ossified proximal end of the xiphoid process, the lower end of the two-lateral articular demi facets for the seventh costal cartilage along the lateral margins of the mesosternum was used as a landmark to distinguish it from the xiphoid process. During the routine autopsies, the thoracic cavity of the dead bodies had to be opened for the removal and subsequent examination of the lungs and heart. For this study, following the removal of the thoracic cavity, the soft tissues that surrounded the sternum were removed by meticulous dissection, and the sternal dimensions were measured.[7]

For the statistical analysis, Statistical Program for Social Science (SPSS) v 16 was used. Descriptive analysis was done by calculating the frequency, mean, and standard deviation (SD). Corelation between the dependent and independent variable were evaluated by corelation coefficient value. $P<0.05$ was considered as statistically significant.

RESULTS

Demographic analysis

The study was conducted on a sample population of 100 autopsies carried out at the Department of Forensic Medicine, Maharajgunj Medical Campus, Nepal. The study sample consisted of 67 male and 33 female cadavers. The mean age of the total population was 37.46 years with standard deviation (SD) of 14.76. The age distribution of the sample population was between 16 years to 70 years. The mean age and the standard deviation for the males were 38.14 and 13.67 years, respectively. The mean age and the standard deviation for the females were 36 years and 16.88 years, respectively as shown in Table 1.

Table 1: Descriptive statistics of the age for entire sample population.

Gender	Mean of age	Total number	SD	Mean age ± SD
Male	38.149	67	13.686	38.149±13.686
Female	36.060	33	16.879	36.060±16.879
Total	37.46	100	14.763	37.46±14.763

Statistical analysis of manubrium, mesosternum, and combined length

The descriptive statistics showed that the mean length of manubrium of the entire sample population was 43.34 ± 6.883 mm. Similarly, the descriptive statistics showed that the mean length of mesosternum of the entire sample population was 102.85 ± 12.627 mm. The mean combined length of mesosternum and manubrium of the entire sample population was 146.12 ± 16.643 mm (Table 2).

Table 2: Descriptive statistics of manubrium, mesosternum, and combined length measurements.

SN	Parameters	Mean	SD	Mean ± SD
1.	Manubrium Length (mm)	43.34	6.883	43.34±6.883
2.	Mesosternum Length (mm)	102.85	12.627	102.85±12.627
3.	Combined Length (mm)	146.12	16.643	146.12±16.643

Gender wise statistical analysis of sternal measurements

The mean length of manubrium for the sexes were 44.58 ± 7.15 mm and 40.81± 5.59 mm for males and females, respectively. The mean length of manubrium for the sexes are 104.403 ± 16.68 mm and 96.66.81 ± 11.92 mm for males and females, respectively. The mean length of manubrium for the sexes were 150.97 ± 15.23 mm and 137.48 ± 16.23 mm for males and females, respectively. The mean body length of the entire sample was 162.67 ± 8.15 cm. The mean length of manubrium for the sexes were 166.65 ± 6.79 cm and 155.18 ± 6.79 cm for males and females, respectively (Table 3).

Table 3: Descriptive statistics of different sternal measurements in male and female.

Parameters	Male	Female	p-value
Manubrium Length (mm) ± SD	44.58 ± 7.15	40.81 ± 5.59	0.009
Mesosternum Length (mm) ± SD	104.4 ± 16.6	96.66 ± 11.9	0.019
Combined Length (mm) ± SD	150.37 ± 15.2	137.48 ± 16.23	0.001
Body Length (cm) ± SD	166.35 ± 15.23	155.18 ± 4.8	0.001

<u>Statistical analysis of manubrium, mesosternum, combined length with age and gender</u>

The data revealed the mean lengths and standard deviations for the manubrium, mesosternum, combined sternal length, and body length across different age groups in male. The manubrium length increases with age, peaking at 48.85 mm for the 50–60 years group (p=0.19). Mesosternum length shows significant variation, highest in the 50–60 years group at 121 mm (p=0.02). Combined sternal length also increases with age, reaching 171 mm in the 50–60 years group. Body length varies less across age groups, showing no significant difference (p=0.409) (Table 4). These findings suggest age-related changes in sternal lengths, particularly for the mesosternum and combined sternal lengths.

Table 4: Descriptive statistics of different age groups in male.

Parameters	< 20 Years	20 – 30 Years	30 – 40 Years	40 – 50 Years	50 – 60 Years	> 60 Years	p-value
Manubrium Length (mm)	38.5 ± 2.12	42.1 ± 5.8	45.37 ± 7.77	46.71 ± 10.16	48.85 ± 5.81	44.28 ± 7.15	0.19
Mesosternum Length (mm)	87 ± 4.24	99.45 ± 22.39	106.54 ± 10.05	97.42 ± 9.08	121 ± 17.17	106.57 ± 11.04	0.02
Combined Length (mm)	125.5 ± 6.36	146.3 ± 8.4	151.5 ± 14.04	144.14 ± 14.5	171 ± 20.12	150.85 ± 11.95	0.001
Body Length (cm)	165 ± 0.01	168.8 ± 5.0	165.91 ± 8.09	170.57 ± 8.9	166.5 ± 4.72	162.57 ± 5.88	0.409

The table 5 showed the mean lengths and standard deviations of various parameters for females across different age groups. The manubrium length significantly varies with age, peaking at 47.25 mm in the 50–60 years group (p=0.003). Mesosternum length shows no significant variation (p=0.259). Combined sternal length slightly increases with age, with the highest at 149.5 mm in the 50–60 years group, but the variation is not significant (p=0.075). Body length remains relatively consistent across age groups with no significant differences (p=0.475). These results suggest notable age-related changes in manubrium length.

Table 5: Descriptive statistics of different age groups in female.

Parameters	< 20 Years	20 – 30 Years	30 – 40 Years	40 – 50 Years	50 – 60 Years	> 60 Years	p-value
Manubrium Length (mm)	41.0 ± 2.6	42.36 ± 3.9	34.71 ± 3.4	42.33 ± 3.78	47.25 ± 5.85	39.0 ± 8.54	0.003
Mesosternum Length (mm)	101.6 ± 14.84	96.45 ± 10.14	88.42 ± 10.54	104.33 ± 12.42	102.25 ± 9.42	93.33 ± 15.27	0.259
Combined Length (mm)	142.6 ± 16.37	138.81 ± 13.06	123.14 ± 12.99	146.66 ± 16.16	149.5 ± 13.07	132.33 ± 23.58	0.075
Body Length (cm)	151.8 ± 4.76	155.63 ± 4.08	154.14 ± 2.26	159.33 ± 10.69	156.25 ± 4.23	156.0 ± 1.73	0.475

Corelation of independent variables

Following the descriptive analysis of the data, the independent variables, i.e. length of mesosternum, length of manubrium and the combined length were analyzed for correlation using SPSS. The r-value of manubrium, mesosternal, and combined length were 0.242, 0.289, and 0.32, respectively (Table 6).

Table 6: Table of correlation of different sternal measurements for the entire population.

Body length	Co-relation coefficient (r)	P-value
Manubrium length	0.242	0.015
Mesosternal length	0.289	0.004
Combined length	0.32	0.001

DISCUSSION

Forensic anthropology is vital in medico-legal investigations of unidentified human remains, focusing on determining sex, age, stature, and ancestry to create a biological profile. With changing population demographics, generating population-specific regression equations is crucial. Early methods of stature estimation involved measuring the total length of a re-articulated skeleton, which is challenging with incomplete or poorly preserved remains. Proper management of mass disaster victims relies on accurate biological profiling to categorize remains, aiding identification efforts. Establishing databases that correlate body parts with stature enhances the evaluation of remains in mass disasters.[8,9]

In mass graves, where remains are often commingled, regression equations for various body parts are essential. These functions increase the examiner's ability to match remains, facilitating victim identification and aiding criminal investigations. Traditionally, stature estimation in forensic anthropology relies on long bones like the femur and tibia. However, this becomes challenging when these bones are missing or damaged in mass fatalities. Thus, exploring the use of other bones for stature prediction is necessary. Since stature formulas are population-specific, applying them across different populations can lead to errors. Additionally, males are generally taller than females due to later puberty onset, influencing stature estimations across populations.[10,11]

Goldine C. Gleser and Mildred Trotter in their studies of 545 military white males found that the correlations between the length of long bones of the upper and lower extremities and stature were statistically significant. They reported these correlations to vary from 0.870 between the right tibia and the length to 0.720 between the right radius and the stature. They also went on to formulate regression equations for estimating stature from measurements of other long bones. These functions laid the foundations of estimating stature in skeletal remains in forensic anthropology throughout the world. Since then, many other studies have shown, reiterated that long bones are the best predictors of the height and show the most significant correlation with stature. Justifiably, all these are still being used to estimate stature in various parts of the world where other anthropometric data for the population in question are not available.[12,13]

In recent years, linear regression equations to estimate stature from various parameters like the hand dimensions, middle finger length, vertebral column length and coronal sutures have been studied. Rastogi et. al.[14] did this from the hand dimension, Nagesh and Kumar from the vertebral column[15] and Rao et. al.[16] from the length of the coronal sutures, all in South Indian males. Menezes et. al. studied both South Indian male and female subjects to estimate stature from the dry sternum.[17] Our study assessed the correlation between the length of sternum and the body length in Nepalese subjects brought to the Kathmandu autopsy center for a medico-legal investigation. A linear relation was established for stature estimation with the sternal length as the independent variable.

There have also been studies to determine sex from sternum measurements in different populations of the world. The mean body length or stature, in this study sample, was 162.67±8.15141 cm, with a mean of 166.35±6.7 cm for the males and a mean of 155.181±4.88 cm for the female group, with a minimal length of 147 cm and a maximum of 184 cm for the whole sample. The body length in this study was significantly different from that of caucasians (167.9 cm ± 6.9 cm), as reported by Marinho et. al.[18] Menezes et. al. reported the mean female body length to be 155.58±5.27 cm[17], whereas Nagesh and Kumar reported the mean female body length to be 153.51±5.83 cm.[15] These findings are very similar to the mean female body length of 155.181±4.88 cm found in our study.

Studies in the past have shown some degree of correlation between the sternal length and the body length Menezes et.al. [17], Marinho et.al. [18], and Nagesh and Kumar.[15] The association between these two variables focused on the measurement of the sternum within the first few hours of death at the time of postmortem examination. The correlation between the length of the sternum and stature in a different sample population was higher when compared to the Nepalese population. The correlation co-efficient in our study was $r = 0.32$, $p \leq 0.001$ while Singh et al. reported a correlation coefficient of 0.318 in his study of a North Indian population.[19] Likewise, Marinho et.al.[18] in his pilot study to determine whether the length of sternum is reliable to estimate the stature in a Portuguese population showed a correlation of 0.329, which is almost the same as in our study.

Torimitsu et.al.[20] conducted a study to estimate the stature from measurements of sternal medullary cavity using multi detector computed tomography images in a Japanese population. The main finding of that study was the sternal medullary cavity have a significant positive correlation with stature in both sexes. In particular, there were stronger positive correlations between stature and the length of a rising diagonal stroke from the bottom left to the top right of the sternal medullary cavity (RS) and the length of a falling diagonal stroke from the top left to the bottom right of the sternal medullary cavity (FS) in males than among females. These results may be due to decreased bone metabolism, which is predominantly caused by postmenopausal osteoporosis in women. During menopause, the oestrogen levels of women dramatically decrease, leading to increased osteoclast formation, enhanced bone resorption, and both cancellous and cortical bone loss. Previous studies using images obtained from patients with osteoporosis revealed increased trabecular spacing and anisotropy.

Rastogi et al. reported correlation coefficients of 0.594 and 0.592 for estimating stature from right- and left-hand breadth in South Indian males.[14] Rao et al. found coefficients of 0.363 and 0.090 for coronal and sagittal suture lengths, respectively.[16] Hand length and middle finger length showed better correlations than sternal length, with Rastogi et al. reporting coefficients of 0.705 to 0.734 for hand length, and 0.696 and 0.679 for right and left middle finger lengths.[14] Vertebral column segments also showed better correlations, with Nagesh and Kumar reporting coefficients ranging from 0.649 to 0.776.[15] These variations are likely due to differences in ethnic, environmental, socio-economic, and nutritional factors between the Nepalese and other populations.

Linear regression equations from parameters like hand and foot dimensions, middle finger length, facial measurements, cephalo-facial anthropometric measurements, footprints, stride length, etc., have been used for stature estimation in North Indians in the recent past.[21] But no study was available for direct comparisons with the present study results, except studies by Menezes et. al., Singh et.al., and Marinho et.al. on South Indian, North Indian and Portuguese populations that use a single sternal length, i.e., the combined length of the manubrium and mesosternum.

In the recent past, linear regression equations to estimate the stature from parameters like the vertebral column length, hand length, middle finger length, foot length, leg length and the arm span have been studied in the South Indian male and female populations. Nagesh and Kumar estimated the stature of South Indian females from the various segments of the vertebral column, and Rastogi et. al. also estimated stature of South Indian females from the hand length and the middle finger length. Nachiket et. al. did this from the foot length and Mohanty et. al.[22] estimated the same from the leg length and the arm span. The importance of the present study lies in the fact that this is the first study to report a linear regression equation for stature estimation from the length of the sternum in a Nepalese population.

Stature estimation methods are not universally applicable; models developed for one population may be unreliable for another due to differences in body proportions influenced by environmental conditions during growth. For example, stunted individuals have proportionally shorter legs compared to their normal counterparts. Consequently, body proportions vary between developed and developing nations. Our small sample size prevents us from conclusively determining if Menezes et al.'s, Marinho et al.'s, and Singh et al.'s formulae are accurate for the Nepalese population.

Limitation of this study was less sample size which may not give the proper answer to the research questions. The research results cannot be generalized for the world populations. Furthermore, our results suggest these formulae do not significantly overestimate or underestimate true stature. Since regression equations may be specific to populations with similar body proportions, further research on Nepalese samples using Indian population equations would be insightful.

CONCLUSIONS

Stature estimation from sternal length is a valuable supplementary tool for identifying victims of mass casualties. Males had greater measurements than females, corroborating previous studies. Sternal lengths were positively correlated with stature, more significantly in males. The combined length of the manubrium and mesosternum and the length of the manubrium in males were better estimators of stature. Linear regression equations were reliable, but results should be population-specific. Further studies on larger samples are needed.

Conflict of interest: None

NJHS

REFERENCES

1. Hughes C, Yim A Di, Juarez C, Servello J, Thomas R, Passalacqua N, et al. Investigating identification disparities in forensic anthropology casework. Vol. 18, PLoS ONE. 2023. 1–32 p. [PubMed].
2. Dahal S, Chaudhary GK, Maharjan MR, Walung ED. A dental perspective on the successes and limitations of the disaster victim identification response to the Nepal earthquake. Forensic Sci Res. 2022;7(3):366–70. [PubMed].
3. Baral P, Lobo SW, Menezes RG, Kanchan T, Krishan K, Bhattacharya S, et al. An anthropometric study of facial height among four endogamous communities in the Sunsari district of Nepal. Singapore Med J. 2010;51(3):212–5. [PubMed].
4. Tesfa NA, Dessie AM, Anley DT, Zemene MA, Gebeyehu NA, Adella GA, et al. Anthropometric Measurements of Singleton Live Full-Term Newborns in Comparison to Who Standard at University of Gondar Comprehensive Specialised Hospital, Ethiopia. J Mother Child. 2023;27(1):198–208. [PubMed].
5. Malla K, Mall T, Rao S, Gauchan E, Basnet S, Koirala DP. Antropometric measurements in different ethnic groups of Nepalese new borns. J Nepal Paediatr Soc. 2012;32(1):1–8. [DOI].
6. de Boer HH, Blau S, Delabarde T, Hackman L. The role of forensic anthropology in disaster victim identification (DVI): recent developments and future prospects. Forensic Sci Res. 2019;4(4):303–15. [PubMed].
7. Verzeletti V, Cannone G, Hirtler L, Bonis A, Lloret Madrid A, Marino MC, et al. Step-by-Step Dissection of the Mediastinum: A Training Protocol. Surgeries (Switzerland). 2023;4(3):471–82. [DOI].
8. Spradley MK. Metric Methods for the Biological Profile in Forensic Anthropology: Sex, Ancestry, and Stature. Acad Forensic Pathol. 2016;6(3):391–9. [PubMed].
9. Austin D, King RE. The Biological Profile of Unidentified Human Remains in a Forensic Context. Acad Forensic Pathol. 2016;6(3):370–90. [PubMed].
10. Šlaus M, Strinović D, Petrovečki V, Vyroubal V. Contribution of forensic anthropology to identification process in Croatia: Examples of victims recovered in wells. Croat Med J. 2007;48(4):503–12. [PubMed].
11. Dahal A, McNevin D, Chikhani M, Ward J. An interdisciplinary forensic approach for human remains identification and missing persons investigations. WIREs Forensic Sci. 2023;5(4):1–34. [DOI].
12. Trotter M, Gleser GC. Estimation of stature from long bones of American Whites and Negroes. Am J Phys Anthropol. 1952 Dec 7;10(4):463–514. [DOI].
13. Trotter M, Gleser GC. Estimation of stature from long bones of American Whites and Negroes. Am J Phys Anthropol. 1952 Dec 7;10(4):463–514. [DOI].
14. Rastogi P, Nagesh KR, Yoganarasimha K. Estimation of stature from hand dimensions of north and south Indians. Leg Med. 2008 Jul;10(4):185–9. [PubMed].
15. Nagesh KR, Pradeep Kumar G. Estimation of stature from vertebral column length in South Indians. Leg Med. 2006 Oct;8(5):269–72. [PubMed].
16. Jagadish Rao PP, Sowmya J, Yoganarasimha K, Menezes RG, Kanchan T, Aswinidutt R. Estimation of stature from cranial sutures in a South Indian male population. Int J Legal Med. 2009 May 13;123(3):271–6. [PubMed].
17. Menezes RG, Kanchan T, Kumar GP, Rao PPJ, Lobo SW, Uysal S, et al. Stature estimation from the length of the sternum in South Indian males: A preliminary study. J Forensic Leg Med. 2009 Nov;16(8):441–3. [PubMed].
18. Marinho L, Almeida D, Santos A, Cardoso HFV. Is the length of the sternum reliable for estimating adult stature? A pilot study using fresh sterna and a test of two methods using dry sterna. Forensic Sci Int. 2012 Jul 5;220(1–3):292.e1-292.e4. [PubMed].
19. Singh J, Pathak RK, Chavali KH. Skeletal height estimation from regression analysis of sternal lengths in a Northwest Indian population of Chandigarh region: A postmortem study. Forensic Sci Int. 2011 Mar;206(1–3):211.e1-211.e8. [PubMed].
20. Torimitsu S, Makino Y, Saitoh H, Sakuma A, Ishii N, Hayakawa M, et al. Stature estimation based on measurements of the sternal medullary cavity using multidetector computed tomography images of Japanese cadavers. Forensic Sci Int. 2014 Sep;242:299.e1-299.e5. [PubMed].
21. Nachiket S, Sujatha N, Priya R, Raveendranath V, Rema D, Roopa R. Reliability of inter-anterior superior iliac spinous distance as compared to foot length for stature estimation in South Indians. J Forensic Leg Med. 2010 Aug;17(6):352–4. [PubMed].
22. Mohanty SP, Babu SS, Nair NS. The use of arm span as a predictor of height: A study of South Indian women. J Orthop Surg. 2001;9(1):19–23. [PubMed].