Research Article

Stature Estimation Of Geographically Varied Population In India Using Head Length And Head Breadth: a Forensic Somatometric Co-Relative Study

Dr. Urvashi A. Shetty[1], Dr. Manisha Rai[2*], Dr. Priyanka K. Shetty[3]

[1] Head of the Department, Department of Oral and Maxillofacial Pathology, A. B. Shetty Memorial Institute of Dental Sciences. Email ID: urvashishetty10@gmail.com. ORCID ID: 0000-0003-3523-407X
[2*]Senior Lecturer, Department of Conservative Dentistry and Endodontics, KVG Dental College and Hospital, Email ID: manisharaik2@gmail.com, ORCID ID: 0009-0001-8384-1459
[3]Assistant Professor, Department of Oral Pathology and Microbiology, A. J. Institute of Dental Sciences, Email ID: drpshetty77@gmail.com, ORCID ID: 0000-0002-4808-2549

***Corresponding Author**: Dr. Manisha Rai, Email ID: manisharaik2@gmail.com, ORCID ID: 0009-0001-8384-1459

Abstract

Stature estimation is important in forensic identification of unknown or fragmented human remains. This study evaluated the relationship between cephalometric index and stature in two South Indian populations. A cross-sectional study was conducted on 100 participants aged 18–24 years, including equal numbers of males and females. Stature was measured using an anthropometric rod. Head length and head breadth were recorded using standard landmarks and a spreading caliper, and cephalometric index was calculated. Data were analyzed using SPSS version 22. Mean and standard deviation were calculated. Independent samples t-test compared group means, and Pearson correlation assessed the relationship between cephalometric index and stature, with significance set at $p < 0.05$. The mean cephalometric index was higher in the Karnataka group compared to the Kerala group, while mean stature values were similar between groups. No statistically significant difference was observed between the two populations for cephalometric index or height. Correlation analysis showed a weak negative and non-significant relationship between cephalometric index and stature in both groups and in the overall sample. These findings indicate that cephalometric index derived from head length and head breadth is not a reliable parameter for stature estimation in the studied populations. Further studies with larger sample size and inclusion of individual cranial parameters with regression analysis are required to improve accuracy in forensic applications.

Keywords: Anthropometry, Cephalometric index, Craniofacial measurements, Frankfurt plane, Glabella, Morphometry, Opisthocranion, Somatometry

INTRODUCTION

Stature estimation is an important component of forensic anthropological investigation, particularly for identification of unknown, decomposed, or mutilated human remains [1,2]. In medico-legal examinations, reconstruction of biological profile parameters such as age, sex, ancestry, and stature provides investigative leads and helps in narrowing missing person identification [3]. The long bones are commonly used for stature estimation but may be unavailable in mass disasters, dismemberment, or severe trauma [1,4]. In such cases, craniofacial measurements serve as an alternative [5,6]. The use of standardized methods, with Frankfurt horizontal plane orientation and caliper-based measurements, improves consistency and reduces observer variation [3,7]. Anthropometric studies show a relationship between stature and craniofacial dimensions [8,9], though these vary with genetic factors, nutrition, climate, and ethnicity across populations [10,11]. The Indian population shows wide geographic and ethnic variation in cranial and somatometric traits. Regression equations developed for one population may not be applicable to another, requiring population-specific validation [1,12]. Head length shows stronger association with stature in North Indians, while South Indians show different cephalometric patterns [11,13].

Maxillofacial anthropometry, including maximum head length and head breadth, is used for stature estimation in South Asian populations [14,15]. Studies in North India report strong positive correlation, with head length values between 0.732 and 0.775 [2,15]. Central Indian groups also show significant association, higher in males than females [6]. The standard error of estimate ranges from ±4.0 to ±6.5 cm when long bones are unavailable [1,6]. The head breadth shows weak or non-significant correlation, especially in males [1,12]. The South Indian populations show variation in cephalometric index patterns, which indicates the need for separate evaluation in different regions [11,13]. The information on the relationship between cranial dimensions and stature in Kerala and Karnataka populations is limited. The present study evaluates cephalometric index calculated from head length and head breadth and its association with stature in these two South Indian populations. The study assesses the correlation between cephalometric index and stature and compares values between the two groups. The study also examines whether any statistically significant association exists between cephalometric index and stature in the study population.

MATERIALS AND METHOD

Study Design and Population: This cross-sectional anthropometric study was conducted among students from the corresponding college representing Kerala and Karnataka. A total of 100 participants aged 18–24 years were included, with 50 males and 50 females, allowing comparison between sexes and regional groups. This age group was selected as stature is considered stable after 18 years. Participation was voluntary. All procedures were non-invasive and conducted with confidentiality.

Inclusion and Exclusion Criteria: Students aged 18–24 years who consented were included. Individuals with congenital or acquired deformities of the spine, extremities, or head were excluded to avoid measurement bias.

Anthropometric Measurements: Measurements were recorded using standard anthropometric methods with participants in standing position and head oriented in the Frankfurt horizontal plane. Stature was measured from vertex to floor using an anthropometric rod. Head length was measured as the distance from glabella to opisthocranion along the mid-sagittal plane. Head breadth was recorded as the maximum transverse diameter between bilateral euryon points using a spreading caliper. Cephalic index was calculated from head length and head breadth for analysis.

Data Collection Procedure: All measurements were taken by trained personnel to maintain consistency. Each parameter was measured carefully, and repeat readings were taken when required. Data were recorded in a structured datasheet.

Statistical Analysis: Data were analyzed using IBM SPSS Statistics. Mean and standard deviation were calculated. Independent samples t-test was used to compare groups. Pearson correlation assessed the relationship between cephalic index and stature. A p-value <0.05 was considered statistically significant. Inter-observer reliability was assessed using kappa statistics (0.88).

RESULTS

Table 1 shows that the mean cephalometric index was higher in the Karnataka population (84.584 ± 13.4073) than in the Kerala population (78.816 ± 5.9224). Mean stature values were comparable, with 165.616 ± 12.1777 cm in Karnataka and 166.140 ± 10.3527 cm in Kerala. These findings indicate regional variation in cranial measurements, while stature was similar. Table 2 shows no statistically significant difference for cephalometric index ($t = -1.968$, $p = 0.055$) or stature ($t = 0.164$, $p = 0.870$). In the Kerala population, Pearson correlation analysis (Table 3) demonstrated a weak negative correlation between cephalometric index and height ($r = -0.316$), which was not statistically significant ($p = 0.123$). In the Karnataka population, a weak negative correlation was also observed between cephalometric index and height ($r = -0.218$), with a p-value of 0.295, indicating lack of statistical significance (Table 4). When both populations were analyzed together, the overall correlation remained weak and negative ($r = -0.232$) with a p-value of 0.105 (Table 5), confirming that cephalometric index does not show a statistically significant relationship with stature in the study sample.

Table 1. Group Statistics for Cephalometric Index and Height in Kerala and Karnataka Populations

Variable	Group	N	Mean	Standard Deviation
Cephalometric Index	Kerala	50	78.816	5.9224
	Karnataka	50	84.584	13.4073
Height (cm)	Kerala	50	166.140	10.3527
	Karnataka	50	165.616	12.1777

Table 2. Independent Samples t-test for Comparison Between Kerala and Karnataka Populations

Variable	t-value	p-value	Mean Difference	95% CI Lower	95% CI Upper
Cephalometric Index	-1.968	0.055	-5.7680	-11.6620	0.1260
Height (cm)	0.164	0.870	0.5240	-5.9034	6.9514

Table 3. Correlation Between Cephalometric Index and Height in Kerala Population

Variable Pair	Pearson Correlation (r)	p-value	N
Cephalometric Index vs Height	-0.316	0.123	50

Table 4. Correlation Between Cephalometric Index and Height in Karnataka Population

Variable Pair	Pearson Correlation (r)	p-value	N
Cephalometric Index vs Height	-0.218	0.295	50

Table 5. Overall Correlation Between Cephalometric Index and Height

Variable Pair	Pearson Correlation (r)	p-value	N
Cephalometric Index vs Height	-0.232	0.105	100

DISCUSSION

The present investigation evaluated the relationship between cephalometric index calculated from head length and head breadth and stature in two South Indian populations from Kerala and Karnataka. The main finding was the absence of a statistically significant correlation between cephalometric index and stature in both groups (Kerala: r = -0.316, p = 0.123; Karnataka: r = -0.218, p = 0.295) and in the combined sample (r = -0.232, p = 0.105). These findings show that cephalometric index does not provide a dependable measure for stature estimation in the studied populations [3,10]. Stature is not a fixed biological parameter and shows diurnal variation due to compression of intervertebral discs and joint cartilages during upright posture [8,16]. Stature may decrease by 1–2 cm during routine daily activities and up to 10 cm under heavy load conditions [8]. Age-related reduction of about 6 mm per decade after 30 years has been reported [17]. The study included participants aged 18–24 years, as skeletal growth is complete in this period and age-related reduction is minimal; this age group also provides stable stature measurements with minimal biological variation [1,18].

The relationship between body segments and total stature has been studied in anatomy and forensic science [9,14]. Body segments show proportional measurements with overall height, and these proportions vary with age, sex, and population characteristics [7,11]. Long bones are commonly used for stature estimation due to their strong association with height [19,20]. When these bones are not available, craniofacial measurements can be used as an alternative [1,9]. Cranial parameters show variation between populations, which affects their use in stature

estimation and requires population-specific evaluation [10,21].

The findings of non-significant correlation between cephalometric index and stature are not in agreement with previous studies that reported positive associations between cranial dimensions and height. Krishan et al. [2] reported a strong correlation for maximum head length (r = 0.775) in a North Indian population, indicating its use in stature estimation. Keche et al. [6] also reported significant correlations for head length in a Central Indian population, with higher values in males (r = 0.775) than females (r = 0.604). Wankhede et al. [1] reported similar observations with variation between sexes. The use of cephalometric index in the present study, instead of individual linear measurements, may explain the findings, as head length has shown stronger association with stature than head breadth in earlier studies [1,2,6]. Regional variation in cranial morphology between South Indian and North or Central Indian populations is also reported [12,13]. The smaller sample size in the present study can be considered while interpreting the results.

Geographic and ethnic variation in craniofacial morphology is reported in South Asian populations, with differences observed between regions [11,15]. Studies from North India show stronger association between head length and stature compared to South Indian groups. Sahni et al. [16] reported moderate correlation for facial measurements in a Northwest Indian population. Reddy et al. [5] reported higher correlation for horizontal head circumference, which indicates that linear cranial measurements may show better association with stature than composite or limited parameters. In South Indian populations, Shah et al. [13] reported low predictive value for head dimensions, while Dinakaran et al. [22] reported better association with nasal height than head measurements. These findings indicate that different cranial parameters show variable association with stature in different populations, and selection of measurement plays an important role in stature estimation [4,23].

The cephalometric index is a composite parameter and differs from individual linear measurements in stature estimation. Head length shows stronger association with stature in several Indian studies, while head breadth often shows weak or non-significant association, especially in males [6,12,24]. The use of cephalometric index in the present study may explain the findings, as combining head length and breadth into a ratio can reduce the strength of linear association with stature. This observation shows that individual measurements have stronger correlation than derived indices. Males show higher correlation with cranial dimensions, while females show variable patterns depending on the parameter studied [2,11,15]. Standardized methods, with Frankfurt horizontal plane and precise landmark identification, reduce measurement variation [3,7]. The study followed these methods and showed high inter-observer agreement (kappa = 0.88). The absence of significant correlation indicates variation between populations [10,21]. The regression analysis is used for stature estimation and provides better accuracy than simple methods [2,19]. The present study used correlation analysis of cephalometric index and did not include regression equations, which limits its use in direct estimation of stature. Studies from other populations show variable results. Ilayperuma et al. [7] reported moderate to strong correlation between cranial length and stature in a Sri Lankan group. Ryan et al. [25] reported moderate correlation for skull measurements in a South African population. Agnihotri et al. [4] reported low correlation for craniofacial measurements in an Indo-Mauritian population. These findings show that cranial measurements do not show similar association with stature in all populations [26].

The findings have forensic relevance in the study population. Cephalometric index does not provide accurate estimation of stature in Kerala and Karnataka groups. The higher mean cephalometric index in Karnataka (84.584 ± 13.4073) compared to Kerala (78.816 ± 5.9224) shows regional variation in cranial morphology [11,21]. Mean stature values were similar between groups (Kerala: 166.14 ± 10.35 cm; Karnataka: 165.62 ± 12.18 cm), which indicates that cranial proportions do not show a direct relationship with body height [10,17]. Other anthropometric parameters such as knee height, nasal dimensions, and hand measurements have shown better association with stature in different populations, which indicates that selection of parameter plays an important role in estimation [27-29]. Cranial suture measurements have also been studied with variable results, which further supports variation in cranial parameters used for stature estimation [30]. The present study shows that cephalometric index calculated from head length and head breadth does not have a statistically significant correlation with stature in Kerala and Karnataka populations. Cranial proportions do not show a direct relationship with body height in these groups. Stature estimation varies between populations due to differences in cranial morphology. Cranial measurements can be used when long bones are not available, but accuracy is limited. Further studies with larger samples and use of individual cranial parameters with regression methods are required for better estimation.

Strengths and Limitations: Standardized anthropometric methods with defined landmarks and trained observers

ensured measurement consistency and reduced error. Equal representation of males and females enabled comparison between groups. The sample size of 100 may reduce detection of small correlations. The use of cephalic index instead of individual measurements reduces association strength. Absence of regression analysis prevents direct stature estimation; selected age group does not represent others.

CONCLUSION

The study shows that cephalic index derived from head length and head breadth is not suitable for stature estimation in the study groups. Cranial proportions do not show a strong relationship with body height. The selection of appropriate anthropometric parameters improves accuracy, while composite indices reduce predictive value in estimation Future studies should include larger samples across regions. The evaluation of individual cranial measurements with regression methods can improve accuracy and support forensic identification in diverse populations.

REFERENCES:

1. Wankhede KP, Anjankar VP, Parchand MP, Kamdi NY, Patil ST. Estimation of stature from head length and head breadth in Central Indian population: an anthropometric study. Int J Anat Res. 2015 Mar 31;3(1):954-7.
2. Krishan K. Estimation of stature from cephalo-facial anthropometry in north Indian population. Forensic Sci Int. 2008 Oct 25;181(1-3):52.e1-6. doi: 10.1016/j.forsciint.2008.08.001. Epub 2008 Sep 16. PMID: 18799276.
3. Krishan K, Kanchan T, Menezes RG, Ghosh A. Forensic anthropology casework-essential methodological considerations in stature estimation. J Forensic Nurs. 2012 Mar;8(1):45-50. doi: 10.1111/j.1939-3938.2011.01122.x. Epub 2012 Jan 6. PMID: 22372398.
4. Agnihotri AK, Kachhwaha S, Googoolye K, Allock A. Estimation of stature from cephalo-facial dimensions by regression analysis in Indo-Mauritian population. Journal of forensic and legal medicine. 2011 May 1;18(4):167-72.
5. Reddy M, Reddy V, Wadhwan V, Venkatesh A. Correlation and estimation of stature from cephalofacial measurements: A study on Western Uttar Pradesh population. Journal of forensic dental sciences. 2018 May 1;10(2):101-6.
6. Keche AS, Keche HA. Estimation of stature by head length in central India. Journal of Research in Medical and Dental Science. 2022;10(1):393-6.
7. Ilayperuma I. On the prediction of personal stature from cranial dimensions. Int J Morphol. 2010 Dec;28(4):1135-40.
8. Hansi B, Ashish B. An Estimation of Correlation between the Head length and the Stature of the Children aged between 6-10 Years. J Forensic Sci. 2013;1(2):1-5.
9. Singh R. Estimation of stature and age from head dimensions in Indian population. Int J Morphol. 2013 Dec 1;31(4):1185-90.
10. Mittal M, Gupta P, Kalra S, Bantwal G, Garg MK. Short stature: understanding the stature of ethnicity in height determination. Indian Journal of Endocrinology and Metabolism. 2021 Sep 1;25(5):381-8.
11. Lc P, S B, As D, H M, Rh T, Ks S. Facial indices of north and South Indian adults: reliability in stature estimation and sexual dimorphism. J Clin Diagn Res. 2013 Aug;7(8):1540-2. doi: 10.7860/JCDR/2013/5497.3204. Epub 2013 Aug 1. PMID: 24086833; PMCID: PMC3782890.
12. Prasa AK, Prakash Hiwarkar M, Kuma A, Taywade OK. Stature estimation from head length and breadth by regression analysis in Madhya Pradesh population. Age. 2019;19(1.18):17-25.
13. Shah P, Thangavelu L. Estimation Of Stature From Head Length and Head Breadth-A Cross Sectional Study. International Journal of Dentistry and Oral Science. 2021 Mar 19;8(3):2052-5.
14. HR J. Determination of personal height from the length of head in Gujarat region. J Anat Soc India. 2004;53(1):20-1.
15. Krishan K, Kumar R. Determination of stature from cephalo-facial dimensions in a North Indian population. Legal medicine. 2007 May 1;9(3):128-33.
16. Sahni D, Sanjeev, Sharma P, Harjeet, Kaur G, Aggarwal A. Estimation of stature from facial measurements in northwest Indians. Leg Med (Tokyo). 2010 Jan;12(1):23-7. doi: 10.1016/j.legalmed.2009.10.002. Epub 2009 Dec 11.

PMID: 20005144.
17.Siwach R. Anthropometric study of proximal femur geometry and its clinical application. Annals of the National Academy of Medical Sciences (India). 2018 Oct;54(04):203-15.
18.Manandhar B, Shrestha R. Estimation of Body Height from Head Length among Dental Students of a Dental College. JNMA J Nepal Med Assoc. 2018 Sep-Oct;56(213):861-865. doi: 10.31729/jnma.3751. Erratum in: JNMA J Nepal Med Assoc. 2019 Apr;57(216):149. PMID: 31065121; PMCID: PMC8959364.
19.Kanchan T, Menezes RG, Moudgil R, Kaur R, Kotian MS, Garg RK. Stature estimation from foot dimensions. Forensic Science International. 2008 Aug 6;179(2-3):241-e1.
20.Kalia S, Shetty SK, Patil K, Mahima VG. Stature estimation using odontometry and skull anthropometry. Indian J Dent Res. 2008 Apr-Jun;19(2):150-4. doi: 10.4103/0970-9290.40471. PMID: 18445934.
21.Nagar N, Singi Y, Dabhi D, Rathore R. Cephalic Index Variation in the Indigenous Population of Tribal Districts in Himachal Pradesh. Cureus. 2024 Aug 28;16(8):e68018. doi: 10.7759/cureus.68018. PMID: 39347171; PMCID: PMC11430408.
22.Dinakaran J, Hariganesgh P, Shamala S, Dhivya K, Saranya V, Saranya M. Stature Estimation of an Individual Using Nasal, Facial, and Palatal Height among Tamil Nadu Population. J Pharm Bioallied Sci. 2021 Jun;13(Suppl 1):S751-S756. doi: 10.4103/jpbs.JPBS_595_20. Epub 2021 Jun 5. PMID: 34447195; PMCID: PMC8375831.
23.Nayyar K, Parmar P. Stature Estimation from Regression Analysis of Craniofacial Anthropometry in an Indian Population. Journal of Forensic Science and Research. 2025 Sep 24;9(2):179-83.
24.Kamal R, Yadav PK. Estimation of stature from different anthropometric measurements in Kori population of North India. Egyptian journal of Forensic sciences. 2016 Dec 1;6(4):468-77.
25.Ryan I, Bidmos MA. Skeletal height reconstruction from measurements of the skull in indigenous South Africans. Forensic Sci Int. 2007 Mar 22;167(1):16-21. doi: 10.1016/j.forsciint.2006.06.003. Epub 2006 Jul 12. PMID: 16842949.
26.Pelin C, Zağyapan R, Yazici C, Kürkçüoğlu A. Body height estimation from head and face dimensions: a different method. J Forensic Sci. 2010 Sep;55(5):1326-30. doi: 10.1111/j.1556-4029.2010.01429.x. PMID: 20487169.
27.Özer BK, Gültekin T, Sağir M. Estimation of stature in Turkish adults usinig knee height. Anthropologischer Anzeiger. 2007 Jun 1:213-22.
28.Kamdar RS, Babu YK. Estimation of stature from nasal height, breadth and depth. Research Journal of Pharmacy and Technology. 2016 Dec 1;9(12):2124.
29.Rastogi P, Nagesh KR, Yoganarasimha K. Estimation of stature from hand dimensions of north and south Indians. Legal medicine. 2008 Jul 1;10(4):185-9.
30.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;123(3):271-6. doi: 10.1007/s00414-008-0316-5. Epub 2009 Jan 13. PMID: 19139914.