

Validity of Carrea's index in stature estimation among two racial populations in India

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Abstract

Background: Stature is considered to be one of the “big fours” in forensic anthropology. Though Carrea's Index was published as early as 1920 it has not been validated in any other population apart from the Brazilians. **Aim:** The present study was conducted to validate Carrea's index in stature estimation in two different racial populations in India. **Materials and Methods:** The study was carried out in a sample of 100 persons comprising of 25 Aryan males, 25 Aryan females, 25 Dravidian males, and 25 Dravidian females in the age group of 18–30 years. The maximum and minimum stature of all individuals was estimated by Carrea's Index. The actual stature was measured by an anthropometer. The estimated stature was compared with the actual stature and percentage of success was calculated. **Results:** The Carrea's Index was found to be valid in predicting the stature of 80% Dravidian and 84% Aryan males, the difference being statistically insignificant (Fisher Exact test=0.16; $P = 0.99$). The stature of 76% of females in both Aryan and Dravidian races was successfully predicted by Carrea's index. Regression analysis showed that the minimum estimated height was more valid in estimating the stature of Aryan and Dravidian population. **Conclusion:** The validity to use Carrea's index in Aryan and Dravidian population was evaluated and found to be valid.


Key words: Aryan, carrea's index, dravidian, forensic anthropology, height, stature estimation

Introduction

The aim of forensic science is to establish individuality or to approach it as closely as scientific methods allow.^[1] It is an essential and often indispensable aid in medicolegal cases involving person identification.^[2] Forensic anthropology, a branch of forensic medicine, involves the application of physical anthropology in legal issues. Stature estimation is an

imperative component of forensic anthropology as it greatly helps in narrowing the search for a person's identification.^[3-5]

Stature refers to the total height of a person in upright position. For forensic identifications, often the long bones like femur, tibia, and humerus as well as short bones are used for stature estimation.^[3,6-10] However, in the present day context, wherein road traffic accidents, terrorism, mass disasters and crime rates are increasing at an alarming rate, fragments of long bones or short bones including skull and mandible may be obtained as the sole fragmentary evidence.^[1,11] In such a scenario, stature estimation using dental tissues can be an easy and viable option. Further, the human dentition is credited to be a highly durable tissue as it can withstand postmortem changes, even after other tissues succumb to destruction and hence is considered ideal for person identification in these situations.^[3,12,13]

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Literature review showed sparse work in stature estimation through odontometric measurements. Carrea has proposed an index to estimate the stature of an individual based on the measurements made from mandibular anterior teeth.^[14] A study conducted among Brazilian population reported that the Carrea's index was almost 100% valid in estimating the stature of an individual.^[15] Further, Lima *et al.*, found 81.5% success rate for predicting the stature of males and 76.0% in females.^[3]

Although the Carrea's index was published in 1920, it has not been validated in other populations apart from the Brazilians and hence demands further investigation. Race, along with age and sex are considered to be an important factor in determining the stature of an individual.^[16,17] Hence, the present study was contemplated to assess the validity of Carrea's index in stature estimation among the two major racial subgroups of India, namely the Aryans and the Dravidians.

Materials and Methods

Ethical clearance to conduct the study was obtained from the Institutional Review Board of Ragas Dental College and Hospital, Chennai. Subjects were informed about the purpose of the study before obtaining their written voluntary informed consent. The study was conducted among a convenient sample of 100 subjects comprising of 25 Aryan males, 25 Aryan females, 25 Dravidian males, and 25 Dravidian females. Subjects were either dental students or subjects attending the outpatient ward of the teaching institution where the study was carried out.

The race of the subjects was determined based on their linguistic orientation, physical characteristics, place of ancestral origin, and familial history for past two generations. Fair complexion, tall stature, narrow nose, thin lips are some of the physical characteristics of Aryans with ancestral origin in north western parts of India [Figure 1]. Dark complexion, short stature, broad nose, dark eyes, thick lips, dense black hair, are some characteristic features of Dravidians who are considered to be the aboriginals of India and ancestral origin in the

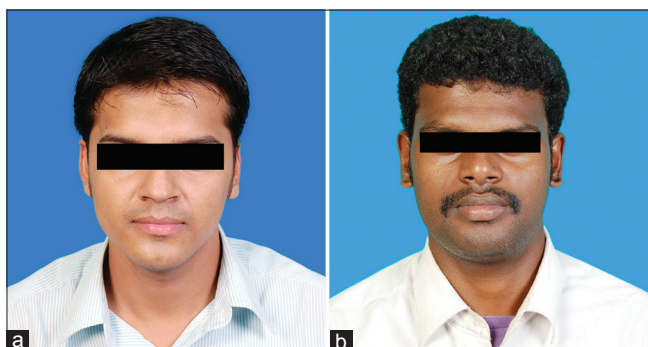


Figure 1: (a) Aryan male, (b) - Dravidian male

southern parts of India^[18-21] [Figure 2]. Subjects who satisfied the following inclusion criteria were recruited: Those who were between 18–30 years of age and those who had fully erupted, periodontally healthy, non-carious, intact, mandibular anterior dentition, no history or clinical features suggestive of endocrinal disorders, metabolic disorders, and developmental disorders. Subjects were excluded if they have crown restoration in mandibular anterior teeth; have undergone orthodontic treatment or orthognathic surgery; or gave history of trauma involving the anterior mandible as well as subjects under any hormonal therapy.

The stature of the subjects was measured with an anthropometer (Samsco Company, New Delhi) which had a precision of up to one millimeter. The stature was measured in centimeters by making the subject to stand erect on the horizontal plane, barefooted, in inspiratory apnea, aligning the posterior surface of heels, pelvic girdle, scapular girdle, and occipital region to the vertical plane.^[3,6] The stature was measured with the rod of the anthropometer in contact with the vertex. All measurements were performed by a single investigator.

Clinical impressions of the mandibular dentition were made in Alginate impression material (Tropicalgin, Zhermack Company, Italy) and poured immediately with dental stone (Kalastone, Kalabai Company, India). The casts were stabilized by fabricating a base with dental plaster so that the measurements required in Carrea's index can be recorded properly. The maximum and minimum statures of an individual were estimated according to Carrea's index as follows:

$$\text{Maximum stature} = \frac{\text{arch (mm)} \times 6 \times 3.1416 \times 100}{2}$$

$$\text{Minimum stature} = \frac{\text{chord (mm)} \times 6 \times 3.1416 \times 100}{2}$$

The measurements of each hemi arch were performed as described by Carrea.^[3]

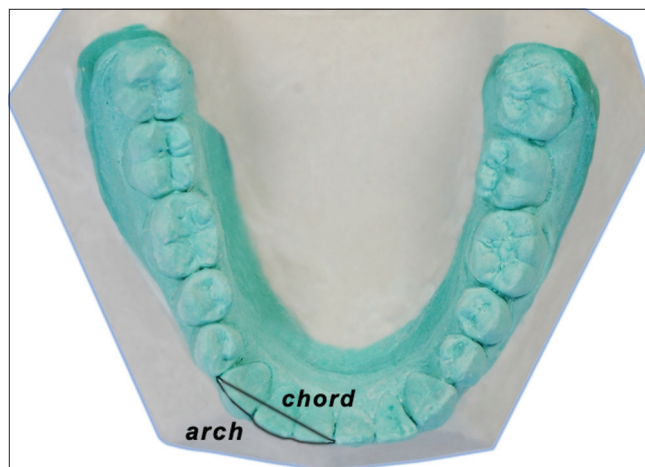


Figure 2: Cast showing arch and chord measurement

Arch dimension

The sum of the mesiodistal diameters of right mandibular central incisor, lateral incisor, and canine measured on the labial surface.

Chord dimension

The linear distance between the ends of the arch, represented by the mesial edge of the right central incisor and the distal edge of right canine, measured on the lingual surface.

The estimated statures in millimeters were converted to centimeters for direct comparison with the actual stature. The validity of Carrea's index was expressed as percentage of subjects whose actual stature was within the range of estimated maximum and minimum statures. The difference in the validity of Carrea's index in stature estimation between Aryans and Dravidians was tested for statistical significance using Fischer exact test. Further, simple linear regression models were created, with actual stature as the outcome variable (y) and estimated stature as the predictor variable (x). Regression lines were constructed as $y = a + bx$ wherein the regression coefficients, a and b were obtained from the regression models. Separate regression equations were constructed for maximum and minimum estimated statures which were gender and race specific. Data analysis was performed using Statistical package for Social Sciences (SPSS version 19; IBM). For all statistical tests, P value of < 0.05 was considered to be statistically significant.

Results

The mean estimated minimum and maximum statures as well as the actual stature of the study subjects according to their race and gender are shown in [Table 1]. The Carrea's index was valid in predicting the stature of 80% Dravidian and 84% Aryan males, the difference being statistically insignificant (Fisher Exact test = 0.16; $P = 0.99$). The stature of 76% of females in both Aryan and Dravidian races was successfully predicted by Carrea's index. Regression analyses showed that minimum estimated stature was found to predict the actual stature of males and females belonging to both races [Table 2]. However, the maximum estimated stature could not predict the actual stature of the Aryan and Dravidian females [Table 3].

Discussion

In this study we found that the actual stature of 80% of Dravidian males, 84% of the Aryan males and 76% of Dravidian and Aryan females could be determined using Carrea's Index. Stature is considered to be one of the "big fours" of forensic anthropology along with age, sex, and ancestry for the identification of an individual.^[14] In addition, given the estimated stature, race and sex of an

Table 1: Mean estimated statures and actual stature of the subjects belonging to Aryan and Dravidian population

Group	Mean actual stature \pm SD (cms)	Mean minimum estimated stature \pm SD (cms)	Mean maximum estimated stature \pm SD (cms)
Aryan male	172.22 \pm 6.37	164.37 \pm 6.72	178.31 \pm 2.63
Aryan female	159.78 \pm 6	156.45 \pm 7.2	171.16 \pm 5.88
Dravidian male	169.42 \pm 7.40	162.86 \pm 5.79	177.56 \pm 7.03
Dravidian female	156.56 \pm 5.76	154.19 \pm 7.2	170.03 \pm 5.76

SD: Standard deviation

Table 2: Prediction of actual stature through minimum estimate stature as obtained using Carrea's index

Group	a	b	F	P
Aryan	39.094	0.791	51.229	0.001
Aryan male	84.017	0.537	10.829	0.003
Aryan female	78.194	0.521	14.821	0.001
Dravidian	18.378	0.912	45.075	0.001
Dravidian male	75.667	0.576	5.841	0.02
Dravidian female	75.473	0.526	7.229	0.01

Table 3: Prediction of actual stature through maximum estimated stature as obtained using Carrea's index

Group	a	b	F	P
Aryan	-1.504	0.959	31.834	0.001
Aryan male	-20.951	1.083	5.739	0.02
Aryan female	102.747	0.333	2.754	0.11
Dravidian	29.069	0.771	29.754	0.001
Dravidian male	86.688	0.466	5.604	0.02
Dravidian female	90.252	0.39*	4.122	0.06

individual, the actual stature can be predicted using the regression equations modeled in this study. Thus in this study, a relation has been established between three out of "big four factors" in forensic anthropology. Such a link would reduce the ambiguity in person identification and perhaps may take us closer to establishing individuality.

In this study, a modified method was adopted for recording the arch and chord dimension using caliper and ruler. With this modified method Cavalcanti *et al.*, 1997 obtained 100% success in estimating the stature of males and 93.3% for females, whereas with the conventional method of using a millimeter tape he obtained a success rate of only 35% for males and 36% for females.^[14] Lima *et al.*, had proved that any side of the arch can be used for stature estimation as there was no statistically significant difference between them.^[3] According to the "Principle of Bilateral symmetry" given by Carrea, any hemi arch can be used for stature estimation by accepting small variations as physiological asymmetries.^[14] Hence in the present study, the arch and the chord dimensions were measured on the right side in all the casts.

This study noted that the minimum estimated stature was closer to the actual stature for most of the subjects. Similar

results were obtained by Silva *et al.*, and Lima *et al.*^[3,14] However, when the subject was too tall, their actual stature usually lied outside the range of minimum and maximum estimated statures.

In Carrea's index, successful prediction of stature depends on the alignment of the mandibular anterior teeth as shown by Lima *et al.*^[3] The Carrea's index was more successful in estimating the stature of subjects with crowded dentition followed by normally aligned and least successful in subjects with diastema. A closer look at the formula reveals that the maximum and minimum estimated stature is directly related to the arch and chord dimensions respectively. Presence of crowding in mandibular anterior dentition would reduce the chord dimension without affecting the arch dimension, thus increasing the range between maximum and minimum stature. Hence, the probability that the actual stature lies within this wider range of maximum and minimum estimated stature also increases, thereby increasing the success rate of Carrea's index. On the other hand, presence of diastema in the mandibular anterior region would reduce the success rate of the index.

In this study subjects belonging to 18-30 years were recruited. The growth spurt is almost complete by 18 years of age ensuing the completion of stature and mandibular growth, hence 18 years was selected as the lower limit whereas 30 years was taken as the upper limit in the study. Since Carrea's index is dependent on the alignment of lower anterior teeth, age associated dental disease like periodontitis may manifest with pathological migration thereby affecting the alignment of teeth after 30 years of age. In this study, subjects who had undergone orthodontic treatment were excluded. Further, only two subjects included in this study had diastema in the mandibular anterior dentition. Hence, these points should be borne in mind while interpreting the results of this study. The other limitation of this study is regarding the sampling methodology. To the best of our knowledge, this is the first study to be conducted among Indian races. Although the study was conducted among a convenient sample of 100 subjects, the results shows that the index is valid in stature estimation. Till date, all the studies conducted using the Carrea's index were among the Brazilian population.^[3,14,22] Hence, there was a need to validate the index among other racial groups also, as race is one of the important determinants of stature. The present study showed that Carrea's index was nearly 80% valid in estimating the stature among Indian population also. Further studies are required among subjects belonging to extreme age groups as both dentition and stature undergoes changes in these ages. Children tend to grow till the completion of their growth spurt and hence we need to know the cut off age above which the Carrea's index can predict the height of subjects in a meaningful

manner. In geriatric population, the stature gets reduced due to varied reasons and also there is loss of tooth material due to attrition (both proximal and occlusal) which might influence the arch and chord dimensions. Hence, further studies are strongly recommended in this direction to throw more light on the validity of this index in relation to the fourth "big four" factors of forensic anthropology.

Conclusion

With the use of this easy, practical and inexpensive method, the stature of an individual can be estimated. The Carrea's index was found to be valid in both Aryan and Dravidian population with higher success rate among males. Further, the minimum estimated stature obtained from the Carrea's index was better in predicting the actual height in both males and females of either races.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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