STATURE ESTIMATION BY CARREA'S INDEX AND ITS RELIABILITY IN DIFFERENT TYPES OF DENTAL ALIGNMENT

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ABSTRACT

Stature is a measurable feature of the body, useful in human identification, which may include or exclude an individual from a missing persons list. The aim of this study is to analyze the Carrea´s index for stature estimation in dental arches with normal dentition, crowding and diastema. Plaster casts of 51 students of the Federal University of Paraíba were analyzed. Each hemiarch was divided according to the dental position, and the elements were measured with divider and digital calipers. Considering the normal and crowded dentition, the Carrea´s index presented a satisfactory success percentage, between 72.2% and 95.2%, with no statistically significant difference between sexes or between right and left sides. The presence of diastema reduced the number of matches to less than 62.5%. It was concluded that the Carrea´s index is a reliable method for height estimation in arches with normal and crowded dentitions, useful in males and females, and in the right and left sides. However, the method was not efficient in hemiarches with diastema.

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Running title: Stature estimation, Carrea´s index, reliability in different types of dental alignment

INTRODUCTION

Anthropometry is the branch of physical anthropology that studies the quantitative variations of human features, such as stature.[1-5] In a forensic context, among the information potentially collected from human remains, estimated stature can be an important feature to be added to the criteria, helping to narrow the search from missing person's data.[6-8]

Stature is the total height of a person, and it varies according to sex, age, ancestry, individual development, and hormonal influence. In the deceased 9 to 17mm must be added to the measurement of the body in the supine position due to the natural flattening of the intervertebral discs, varying according to sex, ancestral background, nutrition, body composition, climate, and day length.[9,10] In a full skeleton, the heights of the body segments that contribute to stature are summed, and added to correction factors according to sex and calculated height.[11] The stature, however, is often estimated from various parts of the body, and more commonly from long bones.[1,6,8,12-15] Nevertheless, in many investigations of human remains, not all the bones are present; possibly nothing but the skull and mandible may be recovered. In that regard, the examination of skull and teeth becomes very important, and the stature of the subject can still be estimated based on the proportionality with tooth dimensions. Carrea created a formula that allows the stature to be estimated from measurements of the lower anterior teeth.[2,16-18]

The aim of this paper is to validate Carrea´s index, testing the method reliability in different types of tooth alignment, considering the increasing prevalence of malocclusion among populations.[19]

MATERIALS AND METHOD

Sampling

For this research, data were taken from 51 undergraduate students from the Federal University of Paraíba: 24 males and 27 females, aged between 18 and 30 years. Casts of the lower dental arch of each subject were obtained from alginate impressions immediately poured in plaster. The stature was measured with an anthropometer, by making the subject stand erect on the horizontal plane, barefooted, in the anatomical position according to the Frankfurt plane, in inspiratory apnoea, aligning the posterior surface of heels, pelvic girdle, scapular girdle, and occipital region to the vertical plane. The stature was measured with the rod of the anthropometer

in contact with the vertex. All measurements were performed by a single investigator, in the morning period.

Data collection

For examining the casts, each hemiarch was considered separately, equaling 102 inferior hemiarches, which were divided according to the dental alignment into three groups: normal (n=41), crowded (n=43), and diastema (n=18). The measurements of each hemiarch were performed as described by Carrea (1939):

Arch: the sum of the mesiodistal diameters of the inferior central incisor, lateral incisor, and canine, measured by the labial surface (Figure 1).

Chord: the linear distance between the ends of the arch, represented by the mesial edge of the central incisor and the distal edge of the canine on the same side, measured by the lingual surface (Figure 1).

The intra-examiner test was performed in the measurement of the arch and chord of twelve casts. As ascertained by Carrea, the measurements of the arch and the chord, can be used to estimate the individual stature by the so named Carrea´s index, calculated by the formula below:

$$\text{Maximum stature} = \frac{\textbf{\textit{arch}}\ (\text{in mm}) \times 6 \times 3{,}1416 \times 100}{2}$$

$$\text{Minimum stature} = \frac{\textbf{\textit{chord}}\ (\text{in mm}) \times 6 \times 3{,}1416 \times 100}{2}$$

The mesiodistal diameter of each dental element was taken by the use of a divider caliper (ICE, São Paulo, Brazil) and a millimeter scale (Angelus, Paraná, Brazil). The chord was measured with a digital caliper (Digimess, São Paulo, Brazil). The estimation obtained with the formula was then compared to the real stature of each individual. To evaluate the intra-examiner reliability, twelve hemiarches were re-measured after an eight days interval.

Statistical analysis

All data were inserted in an Excel file, and analyzed using Statistical Package for the Social Sciences (SPSS) version 13.0. The intra-examiner reliability was tested by the Kappa index, and the remaining data, by the Pearson´s Chi-Square test, and Fischer´s exact test, at a 95% confidence interval.

RESULTS

Regarding the intra-examiner test, there was a reliable result by the Kappa index (0.74), with a confidence interval of 95%. The descriptive statistics relating to each kind of dentition among the sexes is shown in Table 1. In addition, the frequency of each type of dental alignment related to the bilateral hemiarches, considering the 51 inferior casts, is shown in Figure 2.

The analysis of Carrea´s index applied to the hemiarches with normal dental position has shown a higher percentage of success in males (81.3%) than in females (76.0%), although without statistically significant difference (p=1.00), as shown on Table 2. The same thing occurred when left and right sides were compared in each dental arch (Table 3). Though the success rates were higher for right side (82.6%) comparing to the left (72.2%), there was no statistical difference between them (p=0.471).

Considering the group of crowded teeth, Tables 4 and 5 demonstrate a higher rate of success for females (95.2%) and for the right side (90.0%), against the results for males (77.3%) and for the left side (82.6%). However, this difference in percentage has not proven to be statistically significant (p=0.185 and p=0.669 for sex and side, respectively).

As for the group with diastema, there was a balanced distribution of success (50.0%) for both sexes (p=1.00), as can be seen on Table 6. By examining both sides (Table 7), the success rates for the right side (62.5%) were higher than the left (40.0%), although the difference was not statistically significant (p=0.637).

DISCUSSION

The Carrea´s index for normal arches, as originally described,[18] has shown significant rates of success in both sexes with no statistical difference between them. The same result was seen on left and right hemiarches, demonstrating that the method can be applied on both sides, without affecting the outcome.

It is worth noting that the studies published by Carrea date back to 1920 and 1939[17,18] when methodological patterns were not observed by the authors, and papers often lack important information. Therefore, there is no Carrea´s paper describing how exactly he got to his formula. It is known, however, that he analyzed dry skulls and mandibles, instead of living people, and does not mention any kind of alignment disorder as a possible cause of failure of the method. His theories discuss the measurements of dental elements, the concept of arch and chord, and its relation with measures of mandible, face and skull. The present study upgrades the concepts stated by Carrea, as it put to the test his stature estimation method in living people of a contemporary population, in which it has shown to be reliable. The variation of the final outcome in dental arches with crowding and diastema was also assessed for the first time in this research.

The sample analyzed was conventionally composed of students of the Federal University of Paraíba, which, as a federal educational institution, is maintained by the State, and not charged to the students. Therefore, studying in a federal educational institution in Brazil does not mean economical prosperity. As to the ancestry, Brazil is known to host one of the most mixed populations in the world. After 510 years of interethnic crosses between Amerindians, Europeans and Africans, Brazilian people should be assessed as one of a kind. Genetic details can be seen in the studies of Pena et al,[20] Santos et al[21] and many others.

In contradiction of Croce & Croce Júnior,[22] who discourage the use of Carrea´s index for crowded arches, this study has obtained significant success rate on this kind of dentition, for both males and females, and both sides, sometimes even higher than in cases with a normal dentition.

Cavalcanti et al[23] had used two methods of measuring cast dental elements for estimating height through the Carrea´s index. In the one he called conventional, the arch was measured with a millimeter tape, and the chord, with a caliper; in the modified method, the arch and the chord were measured with a divider caliper. The study observed that, in the modified method, the rate of success was higher in males (100%) than in females (93.3%), with equivalent rates in both sides. The conventional method has shown lower rates of matching: 35 and 45% for males (right and left sides), and 36.7 and 50% for females (right and left sides, respectively). It should be noted that normal and crowed arches were analyzed together, with no distinguishing between them. The paper does not provide the result of statistical tests between sexes.

There was a consistently higher correlation between stature estimation and the right hemiarch in this study, even though not statistically significant. This finding is in contradiction to the results of Cavalcanti et al[23] which has shown equivalent success rates for both sides by the modified method, and higher correlation to the left hemiarch by the conventional method. As stated by Carrea,[24] any hemiarch can be used to estimate the stature, considering the principle of bilateral symmetry, accepting small variations as normal asymmetries. The statistically insignificance of the variation found by this research sustains Carrea´s theory.

In the study developed by Silva,[16] the chord was measured by a caliper, and the arch by a millimeter tape. The author reported that the real stature of the sample matched the estimations in 70% of the cases. However, there was no distinguishing between normal arches, crowding or any other kind of anomaly. Both hemiarches and sexes were examined together, with no distinction.

Regarding the hemiarches with diastema, the low success rate was caused by the increasing of the chord value, affecting the final result. In these cases, the chord, that predicts the minimal height, was higher than the arch, which estimates the maximum height. The occurrence of these events, in which the error was in the minimal stature, may have been the reason for the low success percentage.

Given the methodology used and results obtained from the sample analyzed, it appears that the Carrea´s index can be used both for males and females as well as in right and left sides, being reliable in the arches with normal and crowded dental positioning. For the hemiarches presenting diastemas, the method was shown not be accurate due to the low rates of success found.

CONCLUSION

Height is a usefel element in human identification and its estimation is not an easy task. The Carrea´s index for stature estimation is a convenient, simple and inexpensive method, and can provide valuable information to the forensic investigation when dental remains are present.

Since the index considers the metric relation between mesiodistal width of anterior elements, the presence of diastema affects the final result, making the estimated minimum stature higher than the maximum stature. Therefore, in hemiarches with diastema, the method presented the lower rate of success.

It should be noted that any human identification method must be tested and validated on local samples. The current level of human variation, especially on interethnic admixed groups, challenges the researchers to keep updated information about local populations.

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TABLES:

***Table 1*:** *Descriptive statistics relating to sex, kind of dental alignment and side of hemiarch.*

Alignment / Sex		Normal		Crowded		Diastema	
		Right	Left	Right	Left	Right	Left
Male		10	06	10	12	04	06
	Total	**16**		**22**		**10**	
Female		13	12	10	11	04	04
	Total	**25**		**21**		**08**	

Table 2: *Distribution of correct and incorrect estimations for arches with normal dentition, according to sex*.

Sex	Correct / Incorrect						*p* value[1]
	Correct		Incorrect		Total		
	n	%	n	%	n	%	
Male	13	81.3	3	18.8	16	100.0	1.000
Female	19	76.0	6	24.0	25	100.0	
TOTAL	**32**	**78.0**	**9**	**22.0**	**41**	**100.0**	

(1): According to Fischer´s exact test.

***Table 3*:** *Distribution of correct and incorrect estimations for arches with normal dentition, according to side.*

Side	Correct / Incorrect						*p* value[1]
	Correct		Incorrect		Total		
	n	%	n	%	n	%	
Right	19	82.6	4	17.4	23	100.0	0.471
Left	13	72.2	5	27.8	18	100.0	
TOTAL	**32**	**78.0**	**9**	**22.0**	**41**	**100.0**	

(1): According to Fisher´s exact test.

Table 4: *Distribution of correct and incorrect estimations for crowded arches, according to sex.*

Sex	Correct / Incorrect						*p* value[1]
	Correct		Incorrect		Total		
	n	%	n	%	n	%	
Male	17	77.3	5	22.7	22	100.0	0.185
Female	20	95.2	1	4.8	21	100.0	
TOTAL	**37**	**86.0**	**6**	**14.0**	**43**	**100.0**	

(1): According to Fisher´s exact test.

Table 5: *Distribution of correct and incorrect estimations for crowded arches, according to side.*

Side	Correct / Incorrect						*p* value[1]
	Correct		Incorrect		Total		
	n	%	n	%	n	%	
Right	18	90.0	2	10.0	20	100.0	0.669
Left	19	82.6	4	17.4	23	100.0	
TOTAL	**37**	**86.0**	**6**	**14.0**	**43**	**100.0**	

(1): According to Fisher´s exact test.

Table 6: *Distribution of correct and incorrect estimations for arches with diastema, according to sex.*

Sex	Correct / Incorrect						*p* value[1]
	Correct		Incorrect		Total		
	n	%	n	%	n	%	
Male	5	50.0	5	50.0	10	100.0	1.000
Female	4	50.0	4	50.0	8	100.0	
TOTAL	**9**	**50.0**	**9**	**50.0**	**18**	**100.0**	

(1): According to Fisher´s exact test.

Table 7: *Distribution of correct and incorrect estimations for arches with diastema, according to side.*

Side	Correct / Incorrect						*p* value[1]
	Correct		Incorrect		Total		
	n	%	n	%	n	%	
Right	5	62.5	3	37.5	8	100.0	0.637
Left	4	40.0	6	60.0	10	100.0	
TOTAL	**9**	**50.0**	**9**	**50.0**	**18**	**100.0**	

(1): According to Fisher´s exact test.

FIGURES

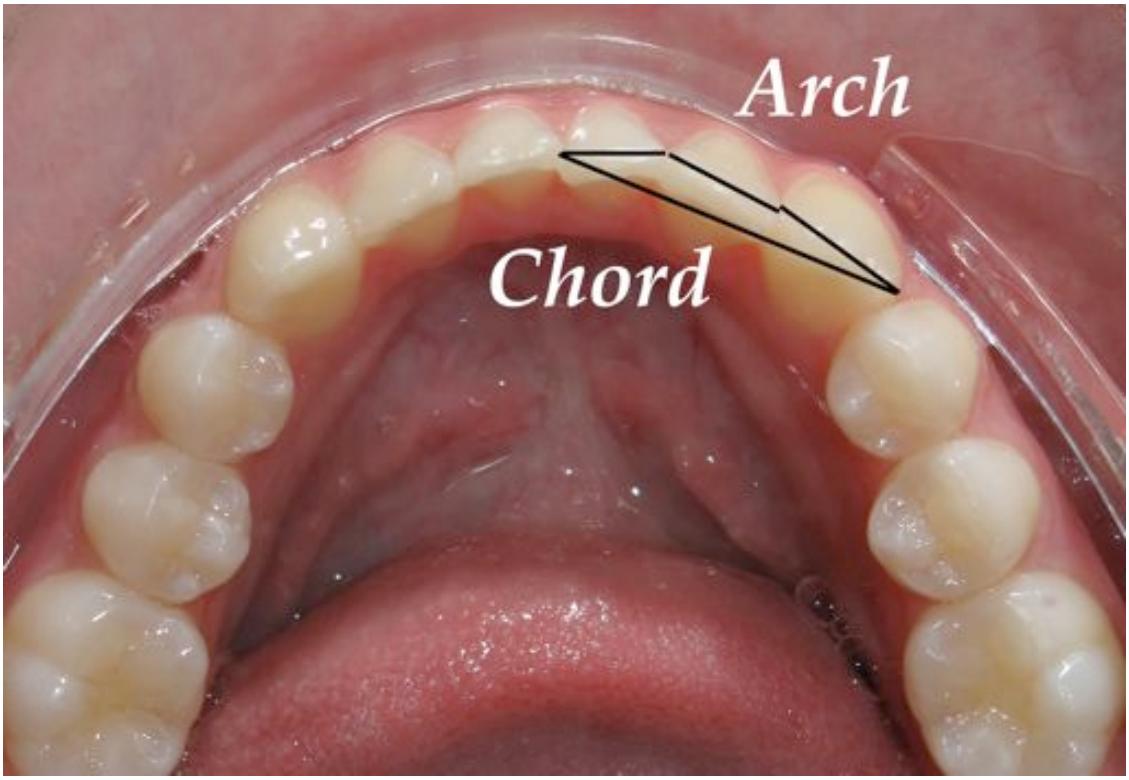

Fig. 1: *Illustrating the measurements of arch and chord.*

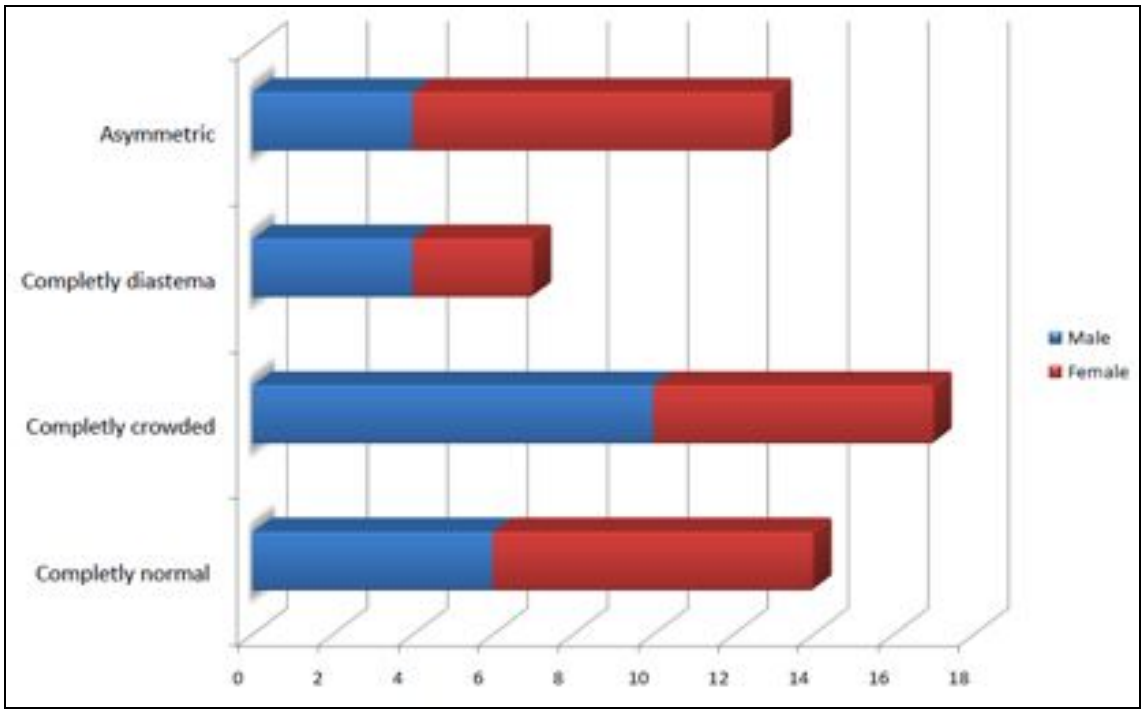

Fig. 2: *Frequency of each type of dental alignment related to the bilateral hemiarches, considering the 51 inferior casts.*