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Validation of a physical anthropology methodology using mandibles for gender estimation in a Brazilian population

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ABSTRACT

Validation studies of physical anthropology methods in the different population groups are extremely important, especially in cases in which the population variations may cause problems in the identification of a native individual by the application of norms developed for different communities. Objective: This study aimed to estimate the gender of skeletons by application of the method of Oliveira, et al. (1995), previously used in a population sample from Northeast Brazil. Material and Methods: The accuracy of this method was assessed for a population from Southeast Brazil and validated by statistical tests. The method used two mandibular measurements, namely the bigonial distance and the mandibular ramus height. The sample was composed of 66 skulls and the method was applied by two examiners. The results were statistically analyzed by the paired t test, logistic discriminant analysis and logistic regression. Results: The results demonstrated that the application of the method of Oliveira, et al. (1995) in this population achieved very different outcomes between genders, with 100% for females and only 11% for males, which may be explained by ethnic differences. However, statistical adjustment of measurement data for the population analyzed allowed accuracy of 76.47% for males and 78.13% for females, with the creation of a new discriminant formula. Conclusion: It was concluded that methods involving physical anthropology present high rate of accuracy for human identification, easy application, low cost and simplicity; however, the methodologies must be validated for the different populations due to differences in ethnic patterns, which are directly related to the phenotypic aspects. In this specific case, the method of Oliveira, et al. (1995) presented good accuracy and may be used for gender estimation in Brazil in two geographic regions, namely Northeast and Southeast; however, for other regions of the country (North, Central West and South), previous methodological adjustment is recommended as demonstrated in this study.

Key words: Validation studies. Forensic Odontology. Physical Anthropology. Sex characteristics. Sex differentiation.

INTRODUCTION

Forensic Anthropology is the practical application of knowledge of General Anthropology to the Law, especially in questions related to the medical-legal identity and judicial or police identity[7], and human identification is one of the great fields of study and research of Forensic Dentistry and Forensic Medicine. In cases of determination of human identity, gender is one of the main characteristics analyzed. This investigation is necessary when dead individuals are involved, because it allows reduction

of the total number of individuals during the identification process (in situations of catastrophes, mass disasters or investigations in archeological sites) and in *in vivo* cases, for situations of intersexuality, pseudo-hermaphroditism, rape, investigation of maternity/paternity, and others[2].

Studies demonstrate an expressive development of Forensic Anthropology in the last 30 years throughout the world, both by application in forensic medical cases and in the number of researches[5,6]. This field has grown in several countries, including China, Hong Kong, Hungary, Japan, South Africa, Turkey, Germany, India, Denmark, Egypt, Poland, Spain, United Kingdom and USA[11].

Within this context, the number of scientists working in the field of Forensics and Anthropology and the degree of international collaboration between the several groups are increasing. There are international efforts for normalization of the quality of techniques and methods applied in different countries, with utilization of better and more efficient methods, such as the Disaster Victim Identification Guide (DVI – Inter http://www.interpol.int/INTERPOL-expertise/Forensics/DVIpol) and the creation of forensic databanks as the Forensic Data Bank (http://fac.utk.edu/databank.html) and the Howells (kttp://konig.la.edu/hoells.htm)[4,5,8,14].

Anthropological patterns have been investigated for gender estimation in specific population of different regions around the world to contribute for human identification. These studies aim to establish protocols for estimation of gender, age, height, ethnic group, individualization factors, image superimposition, facial reconstruction and DNA analysis[5,11].

The regional development of Anthropology with studies in different population groups is extremely important, especially in cases in which the population variations may cause problems in the identification of a native individual by the application of norms developed for different communities[4,5,8,12]. This occurs because the regional ethnic differences directly interfere with the phenotypic patterns of the population, determining inherent morphological characteristics for each group. Thus, a method of physical anthropology that presents high gender dimorphism in a community may reveal inferior results in other, requiring adjustments to increase its accuracy[14,21,22].Validation studies must assure that the method meets the demands of analytical applications, assuring the reliability of outcomes3. The validation of methods assures their reliability during routine and occasional us, it is mentioned as the process that provides documented evidence that the method meets what it is indicated to do[17].

In Brazil, even though several studies have been conducted for gender estimation using Physical[1]Anthropology[1,9,10,15,16,18-20], many such methods were tested in only one of the five regions of the country, thus requiring extension of their validation in other regions, considering the extensive Brazilian territory and the admixture of the population between European, African and Asian immigrants and the native Indian population of the country[23]. Also, there are important scientific studies for gender estimation that have been applied in other countries but not yet in Brazil, thus requiring local studies for their application.

There are some methods for sex determination using the mandible. However, the aim of the study is to evaluate the specific method of Oliveira, et al.[15] (1995), which had already been implemented in the population of Salvador. Thus, this study aimed to apply the method of Oliveira, et al.[15] (1995), previously used in a population sample from Northeast Brazil, to assess its accuracy for the Southeast Brazilian population, validated by statistical adjustments if necessary.

MATERIAL AND METHODS

Sample

The study was conducted on a convenience sample of skulls (n=66) originated from Southeast Brazil, with records as to their age, origin and gender, being 32 females and 34 males, from the archives of the Study and Research Center in Forensic Sciences. Only intact skulls with the mandible and from individuals older than 20 years were included in this study. The study was approved by an ethical committee (FR 365970/Protocol 138/2010).

Calibration

The calibration process involved participation of two examiners, yet later only one examiner conducted the mandibular measurements. Thus, for evaluation of inter-examiner error, all measurements were obtained by two examiners on 32 skulls. To analyze the intra-examiner error, only the examiner conducting the measurements repeated them on 14 skulls. The second analysis was obtained after one month.

Analysis and tabulation of outcomes

The measurements were obtained in millimeters and recorded on a specific form. Data obtained on the anthropological analysis were tabulated on the Excel software (Microsoft Office®). The statistical procedures were run on the software STATA 12, at a significance level of 5%.

Method of Oliveira

The method of Oliveira, et al.[15] (1995) consists of two mandibular measurements for gender

identification, namely the bigonial distance and mandibular ramus height, as explained below.

1. Bigonial diameter or bigonial width – this is the distance between both Gonions, measured with a pachymeter. The Gonion point is defined as the mandibular angle point projected most downward, backward and outward, being easily identified by palpation, according ta Figure 1.

2. Mandibular ramus height – this is achieved by supporting the condyles on a horizontal plate, with the posterior border of the mandibular ramus supported on a vertical plate. This measurement is obtained by placing a metallic tip tangent to the inferior border of the mandibular body, according to Figure 2.

For statistical analysis of the method of Oliveira, et al.[15] (1995), logistic regression was used to propose the gender determination based on the mandibular measurements, according to the following formula: logit (p)=21.9466–0.2444 mandibular ramus height – 0.0812 x bigonial diameter. This logit allowed determination of the probability of pertinence of a mandible to the female gender by the equation: $p=and^{logit}/(1+and^{logit})$. Finally, statistical analyses were performed to compare the results obtained, according to the formula proposed by the author.

RESULTS

Calibration

The paired t-test was applied with accuracy between 50 to 100% (Tables 1 and 2).

Validation of the formula of Oliveira

In the validation of the method of Oliveira, et al.[15] (1995) for the present population, using the formula proposed by the author, the result for gender identification was excellent for females (100% of accuracy), yet much lower for males (11% of accuracy). For this reason, the methodology was validated for the population analyzed by creating a new formula, by logistic discriminant analysis.

Table 3 presents the results for males and females, obtained by the statistical study of data and application of a new formula, presented in Table 4. This formula provides the logit value, which allows definition of the probability of pertinence of a mandible to the female gender by the equation: $p=and^{logit}/(1+ and^{logit})$. Figure 3 shows the different formulas of the method of Oliveira, et al.[15] (1995) in the two regions studied.

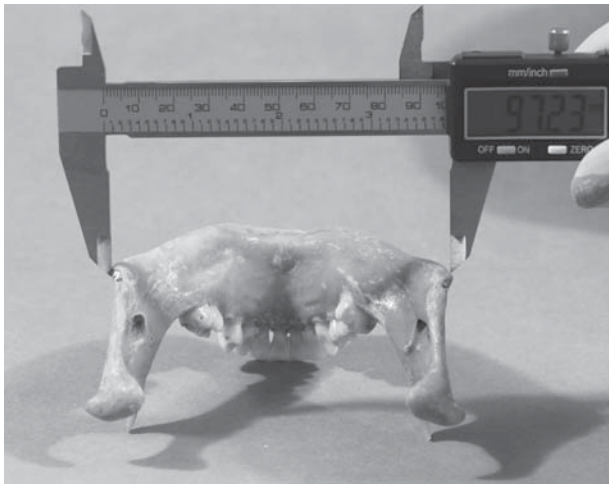

Figure 1- Measurement of bigonial diameter or bigonial width

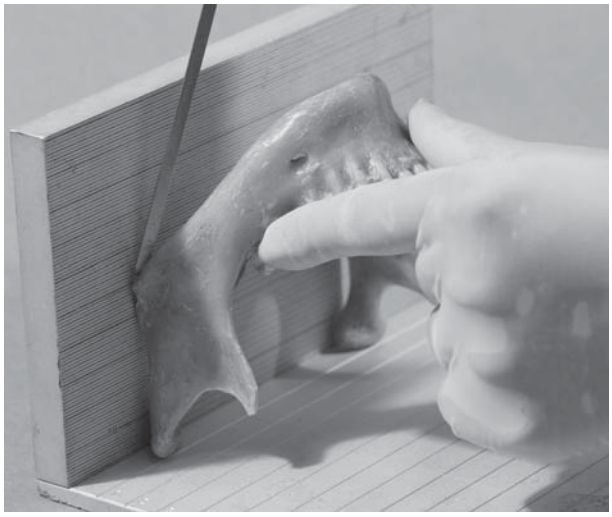

Figure 2- Measurement of mandibular ramus height

Table 1- Distribution of quantitative variables (N=14) according to t-test to verify the reliability intra-examiner

	Time 1		Time 2		Difference	
	Mean	SD	Mean	SD	Mean	P
go-go	94.51	9.12	94.07	8.96	0.44	0.262
M.R.H.D	51	5.91	50.29	5.86	0.71	0.336
M.R.H.L	50.21	49.5	7.08	7.07	43.13	0.336

Legend: go-go=Bigonial diameter; M.R.H.D=Ramus heigth right; M.R.H.E=Ramus heigth left

Table 2- Distribution of quantitative variables (N=32) according to the paired t-test to verify the reliability inter-examiner

	Examiner 1		Examiner 2		Difference	
	Mean	SD	Mean	SD	Mean	P
go-go	93.66	6.76	93.96	6.58	-0.3	0.183
M.R.H.D	49.66	7.73	49.09	5.96	0.57	0.28
M.R.H.L	49.53	5.69	49.28	6.06	0.25	0.55

Legend: go-go=Bigonial diameter; M.R.H.D=Ramus height right; M.R.H.E=Ramus height left

Table 3- Logistic discriminant analysis: method of Oliveira, et al.[15] (1995)

Model	Males (%)	Females (%)	Diff (%)
Sex=M.R.H * go-go	76.47	78.13	-1.66

Legend: go-go=Bigonial diameter; M.R.H.D=Ramus height right; M.R.H.E=Ramus height left

Table 4- Logistic regression: method of Oliveira, et al.[15] (1995)

Model	Discriminate function	P
Sex=M.R.H * go-go	S=-24.41 + M.R.H* 0.14 + go-go * 0.18	p=<0.001

Legend: go-go=Bigonial diameter; M.R.H.D=Ramus height right; M.R.H.E= Ramus height left

Northeast region	Southeast region
Sex=21.9466 - 0.2444 x M.R.H - 0.0812 x go-go	Sex=-24.41 + M.R.H x 0.14 + go-go x 0.18

Legend: go-go=Bigonial diameter; M.R.H.D=Ramus height right; M.R.H.E=Ramus height left

Figure 3- Formulas presented, according to the region of Brazil, to the method of Oliveira, et al.[15] (1995)

DISCUSSION

It is known that gender dimorphism may be influenced by ethnic factors. For this reason, the same methodology may present different outcomes when applied in different communities for gender estimation. This highlights the need of studies of accuracy and validation of methods whose outcomes were promising in different ethnic groups[5,11,14]. Especially in Brazil, this analysis is fundamental because the country presents a multicultural characteristic, with a mixture between individuals of Caucasoid, African and Indian descent and with different regions, with specific admixtures and sites, such as the South and Northeast[13].

The method of Oliveira, et al.[15] (1995) had been previously applied to a sample from the city of Salvador with rate of accuracy of 78.33% and, after the present study, it is now validated for two regions of the country with different cultural, social, geographic and ethnic characteristics. Other aspect that contributed to the attempt of validation of the method of Oliveira is the possible absence or fragmentation of the skull in forensic scenarios, leaving only the mandible for gender determination, which is a more compact and resistant bone.

In their study, Oliveira, et al.[15] (1995) achieved a rate of accuracy of 81.11% for females and 76.47% for males in the population of Salvador. In the present study, validation of the method of Oliveira, et al.[15] (1995) was not successful by application of the formula proposed by the author, with different rates of accuracy between genders, namely 100% for females and only 11% for males, which are very different percentages compared to the results obtained by the author in the population from Northeast Brazil. In this context, the different outcomes between populations from the Northeast – city of Salvador [sample of Oliveira, et al.[15] (1995)] – and Southeast Brazil – city of Guarulhos (present sample) –, by application of the same method, are strongly related to the ethnic differences in Brazil.

The present study conducted a further analysis of the measurements of bigonial diameter and mandibular ramus height, with statistical adjustment for the studied population, then achieving 76.47% of accuracy for males and 78.13% for females after application of the new discriminant formula.

This difference in outcomes between the populations of Guarulhos (present sample) and Salvador [sample of Oliveira, et al.[15] (1995)] highlights the interference of regional disparity in anthropological studies. This precluded application of the formula of Oliveira, et al.[15] (1995) was adapted for the population from Northeast Brazil, but required a new adjustment for the Southeast sample. Forensic Anthropology has been attested by the advantages offered by its methods, such as easy application, low cost and simple equipment required for their utilization[14,21,22]. This fact may be

evidenced across the world, by the high number of studies, high rate of accuracy of anthropological methods and increased collaboration between investigators in the search for protocols. However, validation of these methods is necessary due to the ethnic differences found in population groups, which are directly related with the phenotypic aspects and consequently the anthropological parameters. The results of this study evidence this need, because the same country, Brazil, required adjustment of the same method when two different populations were analyzed.

CONCLUSION

Commonly, the methods involving Physical Anthropology present high rate of accuracy for human identification, as well as easy application, low cost and simplicity of equipment required. However, the methodologies must be validated for the different populations due to differences in ethnic patterns, which are directly related with the phenotypic aspects. In this specific case, the method of Oliveira, et al.[15] (1995) presented good accuracy and may be used for gender estimation in Brazil in two geographic regions, namely Northeast and Southeast; however, for other regions of the country (North, Central West and South), previous methodological adjustment is recommended as demonstrated in this study.

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