Revista Española de Medicina Legal 49 (2023) 143–150

ASOCIACIÓN NACIONAL DE MÉDICOS FORENSES

Spanish Journal of Legal Medicine
Revista Española de Medicina Legal

www.elsevier.es/mlegal

ORIGINAL ARTICLE

Metric evaluation of permanent canines for sexual estimation in the Collection "Prof. Dr. Romulo Lambre", Buenos Aires, Argentina☆

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Received 7 October 2022; accepted 26 December 2022
Available online 24 November 2023

KEYWORDS
Dental anthropology;
Forensic anthropology;
Sexual dimorphism;
Discriminant functions;
Logistic regressions

Abstract
Introduction: Sex estimation is a fundamental aspect of forensic work as a mandatory step for the identification of human remains of unknown origin. The methodological analysis of the dentition as a sexual estimator is important due to its high degree of preservation. Considering the need for specific information regarding the potential of dentition for sex estimation in forensic cases from Argentina, the aim of this study is to evaluate the proposal previously developed by Luna (2019) in a local sample of human skeletal remains.
Materials and methods: A sample of 152 permanent canines belonging to 98 individuals of both sexes was selected. The individuals belong to the Prof. Dr. Rómulo Lambre osteological collection (La Plata, Argentina). Luna's proposal (2019) was applied to estimate sex from canine crown and neck metrics, which considers direct measurements and different types of discriminant functions and logistic regressions.
Results: Only the cervical mesiodistal diameter showed acceptable results (>75%) for sex estimation. Moreover, discriminant function 1 showed a posteriori probabilities of correct classifications greater than 0.75 and logistic regressions 1 and 3 offered acceptable overall results.

☆ Please cite this article as: Garizoain G, Aranda C, Luna L. Metric evaluation of permanent canines for sexual estimation in the Collection "Prof. Dr. Romulo Lambre", Buenos Aires, Argentina. Revista Española de Medicina Legal. 2023. https://doi.org/10.1016/j.reml.2022.12.002.
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Conclusions: This proposal based on the metric recording of permanent canines constitutes an adequate methodological alternative in situations in which the diagnostic bone elements of sex are deteriorated or absent.

PALABRAS CLAVE
Antropología dental;
Antropología forense;
Dimorfismo sexual;
Funciones discriminantes;
Regresiones logísticas

Evaluación métrica de caninos permanentes para la estimación sexual en la Colección "Prof. Dr. Rómulo Lambre", Buenos Aires, Argentina

Resumen
Introducción: La estimación del sexo es un aspecto fundamental de la labor forense ya que constituye un paso obligatorio para la identificación de restos humanos de procedencia desconocida. El análisis metodológico de la dentición como estimador sexual reviste importancia debido al elevado grado de preservación de los dientes. Considerando la necesidad de contar con información concreta respecto del potencial de la dentición en la estimación del sexo en casos locales de Argentina, el objetivo del presente estudio es evaluar la propuesta previamente desarrollada por Luna (2019) en una muestra local de restos esqueléticos humanos.
Materiales y métodos: Se seleccionó una muestra de 152 caninos permanentes pertenecientes a 98 individuos de ambos sexos que forman parte de la colección osteológica Prof. Dr. Rómulo Lambre (La Plata, Argentina). Posteriormente se aplicó la propuesta de Luna (2019) para la estimación del sexo a partir de la métrica de la corona y del cuello de los caninos, la cual considera las medidas directas y diferentes tipos de funciones discriminantes y regresiones logísticas.
Resultados: De las medidas directas consideradas, solo el diámetro mesiodistal cervical ofreció resultados aceptables (>75%) para la estimación sexual. Asimismo, únicamente la función discriminante 1 presentó probabilidades a posteriori de clasificaciones correctas superiores a 0.75 y las regresiones logísticas 1 y 3 exhibieron resultados generales satisfactorios.
Conclusiones: Esta propuesta basada en el estudio métrico de caninos permanentes constituye una alternativa metodológica adecuada en situaciones en las cuales los elementos óseos diagnósticos del sexo se encuentran deteriorados o ausentes.

Introduction

Sex is a fundamental parameter in the construction of an individual biological profile, and it is of maximum importance for bioarchaeology and forensic anthropology.[1,2] The estimation of sex by studying bone and/or dental remains is based on the existence of dimorphism, which is detectable by metric or morphological analysis.[1] It is known that the magnitude of sexual dimorphism varies in the different elements of the human skeleton in a single population; due to this, not all of the said elements are equally useful in properly estimating the sex of an individual.[3,4] Sexual dimorphism also varies between populations in terms of size as well as shape.[5–7] This implies that the methods developed in a certain osteological sample would not necessarily be useful if applied to human remains from other geographical locations or times, so that some type of test is required prior to using them.[2,8]

Of all the bones within the human skeleton, the coxa are the ones that express the greatest sexual dimorphism (mainly through their morphological attributes), followed by the cranium and the proximal epiphyses of the femur and humerus.[9,10] Nevertheless, in forensic or archaeological contexts, when these anatomic features are not well-preserved or complete, or when incomplete skeletons or ones that mix several individuals are recovered, analysis of the teeth is especially important in anthropological practice. Because of their size, shape, and hardness, the teeth are more resistant against the processes that occur after deposition, and they usually deteriorate less than bone remnants.[11]

Methodological analysis of the teeth to estimate sex centres on odontometry.[8,12] Studies in different populations have reported that the crowns usually show percentages of sexual dimorphism that vary from 0.1% to 12.66%.[1,2,4,5,8,12–19] On the other hand, analyses of cervical dimensions show a similar tendency, with values that run from 0.23% to 13.84%,[8,12,15,19,20] which underlines the importance of this in forensic and bioarchaeological studies.

Numerous studies have developed methodologies for the estimation of sex based on coronal and cervical measurements of the teeth using documented and archaeological collections, which generally give satisfactory results in samples with similar geographical and temporal origins.[1,4,12,15,16,21] These studies usually achieve correct assignations in more than 75% of cases in different types of teeth, using univariate

as well as multivariate measurements, and they agree in pointing to the canines as the best sources for estimation. In the specific case of Argentina, few studies have evaluated the potential of the teeth to be used to estimate sex, and there are no previous instances of an approach of this kind used in a local forensic sample. Given the need for concrete information on the potential of methods of this type for use, this study will evaluate the applicability of direct odontometric measurements and different types of formulae (discriminant functions and logistic regressions) as developed by Luna (2019) based on the analysis of a Portuguese sample, for estimating the sex of a set of contemporary individuals belonging to the Professor Dr. Rómulo Lambre Collection (La Plata, Argentina). The development of this research will contribute to the discussion on variations in sexual dimorphism between both samples, evaluating the applicability of using the procedures generated in the first study for the contemporary population of Buenos Aires.

Sample and method

Working protocols were used in this study that follow the lines set out in the "Ethical Code for the study, conservation and management of human remains from past populations" of the Biological Anthropology Association of Argentina.[22] Likewise, the analyses of the Lambre collection were approved by the Bioethics Committee of the Medical Science Faculty of La Plata National University.

The Professor Dr. Rómulo Lambre Collection is composed of 420 individuals and their associated documentation (age, sex, cause, and date of death) who died during the second half of the 20th century in the city of La Plata (Buenos Aires province, Argentina) and who were buried in the municipal cemetery of the said location.[8] Of this total, the sample selected for this study was composed of 152 permanent canines (61 upper canines and 91 lower canines) from 98 individuals of both sexes, aged from 11 to 91 years and with an average age of 51.76 years (Table 1).

The right upper and lower canine teeth were selected, and those from the opposite side were only used in cases when the former were missing. Teeth from the right side were selected because there were more of them in the sample analysed; however, previous studies found no statistically significant differences in the measurements taken of both sides.[8] Likewise, only teeth without disease or any type of post-mortem deterioration that would have hindered recording were measured.

Table 1 Sample distribution according to sex and type of tooth.

	LC		UC	
	N	%	n	%
F	36	39.56	26	42.62
M	55	60.44	35	57.38
Total	91	100	61	100

LC: lower canine; UC: upper canine; F: female; M: male.

Study of measurements and data analysis

Following Luna's suggestion,[15] the coronal and cervical mesiodistal and buccolingual diameters were measured of the selected lower and upper canines. This set of measurements was then analysed taking into consideration the recommendations of Mayhall[23] and Hillson et al.[24] using digital odontometric callipers (0.01 mm precision). As only intact teeth were included, it was not necessary to replace any missing data. To prevent interobserver error, measurements were only taken by a single author (Gonzalo Garizoain). Once all of the data in the set analysed had been obtained, the 4 variables were measured again in a subset of 30 teeth at least 1 week after the first measurements, to evaluate intraobserver error using the intraclass correlation coefficient. The sexual dimorphism (SD) of each variable was then calculated by applying the method proposed by Garn et al. (1967). This expresses sexual differences by means of the following formula, which is widely used in the field of dental anthropology:[8,15] SD = (M-F)/M*100. In this case, to obtain the results, it is necessary to consider the averages of the measurements corresponding to the male (M) and female (F) individuals. The cut-off points proposed by Luna (2019) are then applied for each direct measurement, and the formulae generated in the said study are applied, using data from skeletal remains in a controlled and documented osteological collection in Coimbra University (Portugal). The 115 Portuguese individuals in the sample used in the said study were buried in the *Cemitério Municipal de Conchada de Coimbra*, and they died from 1895 to 1936. Each individual has reliable documental information on their name, sex, place and date of birth, and the date and cause of their death, and their age at the time.

The proposal developed by Luna[15] includes 5 discriminant functions (DF) and an equal number of logistic regressions (LR), which are shown in Table 2. The first use one or more variables to establish belonging to a specific group, and they necessitate compliance with the principles of normalcy (a symmetrical sample distribution around an average which coincides with the median) and homoscedasticity (homogeneity of variances) in the distribution of compared data. The limit that separates both groups, known as the cut-off point, has to be used to assign a case as female (lower values) or male (higher values). On the other hand, the LR relate a set of continuous or categorical variables with a dichotomic variable, sex in this case,[25] generating a *logit* (a linking function that models the equation) which is then used to calculate the probability that an individual is female ($P_{(sex)}$) based on the following formula (see Table 2):

$$P_{(sex)} = 1/(1 + e^{-x})$$

In this case, "e" refers to Euler's constant (or Napierian logarithm), which has a value of approximately 2.718, "x" includes the information on the constant and the coefficient corresponding to each one of the variables considered, and the cut-off point is 0.5; if the final value obtained is higher, the individual must be assigned as female, and if it is lower, as male.

The formulae were generated considering a range of possible recovery situations, so that they include the

Table 2 Discriminant functions and logistic regressions developed by Luna[15] (Table 5) with their respective cut-off points and percentages of correctly classified cases.

Formula	Variables	Formula	PC	Correctly classified cases (%)		
				M	F	M + F
DF1 and DF5[a]	All	$X = -18.016 + 1.833^{a}MDcerCI + 1.055^{a}BLcerCS$	−0.0835	83.94	86.54	85.00
DF2	LC	$X = -17.572 + 2.039^{a}MDcerCI + 0.907^{a}BLcerCI$	−0.0705	80.71	77.54	78.94
DF3	UC	$X = -16.375 + 1.280^{a}MDcerCS + 1.161^{a}BLcerCS$	−0.0774	84.68	80.64	82.45
DF4	Coronal	$X = -16.604 + 2.192^{a}BLcorCI$	−0.0667	78.83	79.00	78.94
LR1	All	$X = \frac{1}{1+e^{-(-32,596+3,793^{a}MDcerCI+[-1,692^{a}BLcorCS]+3,423^{a}BLcerCI)}}$	0.50	82.75	87.10	85.18
LR2	LC	$X = \frac{1}{1+e^{-(-29,340+3,630^{a}MDcerCI+1,405^{a}BLcerCI)}}$	0.50	78.86	83.97	81.63
LR3	UC	$X = \frac{1}{1+e^{-(-215,554+[-1,479^{a}BLcorCS]+2,180^{a}MDcerCS+3,284^{a}BLcerCS)}}$	0.50	76.95	87.10	82.50
LR4	Coronal	$X = \frac{1}{1+e^{-(-32,038+1,326^{a}MDcorCS+2,959^{a}BLcorCI)}}$	0.50	78.86	85.55	82.45
LR5	Cervical	$X = \frac{1}{1+e^{-(-34,515+3,558^{a}MDcerCI+2,058^{a}BLcerCS)}}$	0.50	82.75	85.55	84.20

BL: buccolingual diameter; cer: cervical; cor: coronal; DF: discriminant function; F: females; LC: lower canine; M: male; MD: mesiodistal diameter; LR: logistic regression; PC: cut-off point;[a]UC: upper canine. Given that the measurements selected by the programme for the generation of DF1 and DF5 were the same, their structure is identical.

following diameters of lower and upper canines as variables: (1) mesiodistal coronal (MD_{cor}); (2) buccolingual coronal (BL_{cor}); (3) mesiodistal cervical (MD_{cer}), and (4) buccolingual cervical (BL_{cer}) (Fig. 1). All of the variables were included in the DF1 and the LR1, or only the measurements of the lower canine (DF2 and LR2), those of the upper canine (DF3 and LR3), the coronal (DF4 and LR4), and cervical (DF5 and LR5) measurements. The percentages of correct assignations reported by the author, deriving from the application of the formulae, vary from 78.94% to 85.18% (Table 2), while when the direct measurements are considered to discriminate between the sexes, the values vary from 78.26% to 85.21% (Table 3).

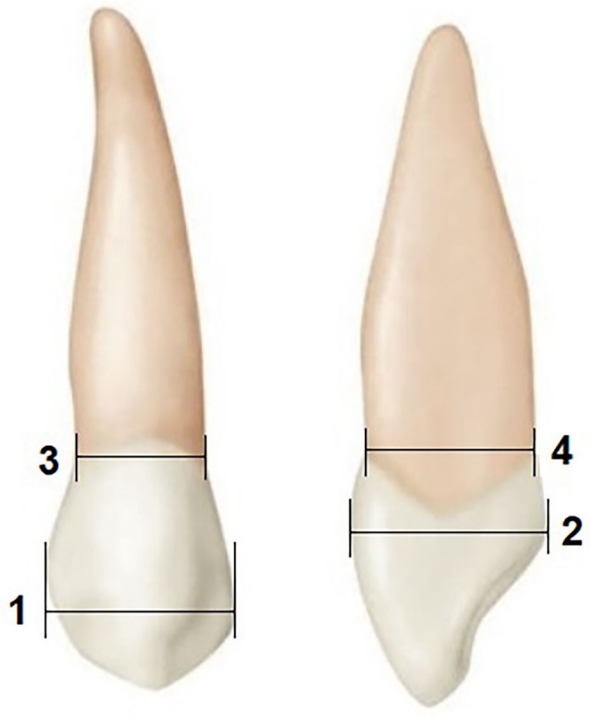

Fig. 1 Variables measured in the canine teeth: (1) coronal mesiodistal diameter (MD_{cor}), (2) coronal buccolingual diameter (BL_{cor}), (3) cervical mesiodistal diameter (MD_{cer}), and (4) cervical buccolingual diameter (BL_{cer}).

To obtain the final estimation the direct measurements and the results of the formulae were compared with their respective cut-off points (Tables 2 and 3). As well as the percentage of correctly estimated cases (P[A | B]), the probabilities of correct assignation were also calculated in each case (P[B|A]), that is, the probability that a new individual of unknown sex would be classified correctly. The results were considered to be adequate when more than 75% of assignations were correct and the probability of correct classification was higher than 0.75. The results of the whole sample were considered as a single set, while also discriminant according to the recorded sex. The statistical tests were performed using SPSS 23.0 software.

Results

The intraclass correlation coefficient values obtained were close to 1 and they were statistically significant (MD_{cor} = 0.95; BL_{cor} = 0.97; MD_{cer} = 0.98; BL_{cer} = 0.97). These results indicate a high degree of reproducibility in the variables considered, with minimum intraobserver error, so that all of the measurements were highly reproducible. Likewise, the measurements analysed showed percentages of sexual dimorphism that varied from 4.37% (UC-MD_{cer}) to 9.85% (LC-MD_{cer}); the others have values of 6.59% (UC-BL_{cor}), 5.44% (LC-BL_{cer}), 5.17% (LC-MD_{cor}), 4.93% (UC-BL_{cer}), 4.85% (LC-BL_{cor}), and 4.57% (UC-MD_{cor}).

Use of the direct measurements to estimate sex gave similar results in terms of correct estimations (P[A|B]). These vary from 61.95% to 76.13% when the men and women were all considered together (Table 4), while when the sexes were evaluated separately, these percentages varied from 28.57%

Table 3 Cut-off point and percentages of correctly estimated cases based on direct measurements (Table 4).

			Correctly classified cases (%)		
Tooth	Variable	PC (mm)	F	M	F + M
LC	MDcor	6.83	92.45	75.80	83.48
	BLcor	7.35	75.47	88.71	82.61
	MDcer	5.25	79.24	90.32	85.21
	BLcer	7.11	75.47	85.48	80.00
UC	MDcor	7.40	75.47	80.64	78.26
	BLcor	7.85	73.59	83.87	79.13
	MDcer	5.48	71.70	87.09	80.00
	BLcer	7.70	84.90	82.26	83.48

Luna 2019.
BLcer: cervical buccolingual diameter; BLcor: coronal buccolingual diameter; LC: lower canine; MDcer: cervical mesiodistal diameter; MDcor: coronal mesiodistal diameter; UC: upper canine.

to 77.14% for the women and from 67.92% to 85.71% for the men. The measurement that gave the best results was the cervical mesiodistal diameter, with 77.14% of correct assignations for the women and 75.47% for the men, and 76.13% for both sexes. On the other hand, the highest probability of correct assignation of a new individual (P[B|A]) was 0.75 for both sexes, and this corresponded to the coronal buccolingual diameter of the upper canine (M = 0.75; F = 0.76). In the other measurements, these probabilities varied from 0.65 to 0.73 (for both sexes), from 0.50 to 0.76 (female individuals) and from 0.69 to 0.80 (for male individuals).

Applying the discriminant functions gave percentages of correct estimations (P[A|B]) that varied from 65.11% to 76.59% when both sexes are considered together, while when they were evaluated separately the results varied from 73.52% to 78.94% for the men and from 50.00% to 76.92% for the women (Table 4). The first discriminant function gave the best results, at above 75% for each sex. This includes the cervical mesiodistal diameter of the lower canine and the cervical buccolingual diameter of the upper canine (F = 75%; M = 78.94%; F + M = 76.59%). On the other hand, discriminant function 4, which only includes the coronal buccolingual diameter of the lower canine, gave the lowest fig. (F = 50.00%; M = 75.00%; F + M = 65.11%). Respecting DF3, it can be underlined that although it achieves 75% of correct estimations when both sexes are considered, this formula classifies female individuals slightly above the threshold (76.92%) and male individuals slightly below it (73.52%) (Table 4). In terms of the probabilities of correct assignation (P[B|A]), values varied from 0.65 to 0.76 when

Table 4 Percentages P(A | B) and probabilities P(B | A) of sex estimations based on direct measurements, discriminant functions, and logistic regressions.

Tooth	Variable	PC (mm)	P(A | B)						P(B | A)					
n/N			%			n/N			*P*					
			F	M	F + M	F	M	F + M	F	M	F + M	F	M	F + M
Direct measurements														
LC	MD_{cor}	6.83	28/39	36/53	64/92	71.79	67.92	69.56	30/47	36/45	66/92	0.64	**0.80**	0.72
	BL_{cor}	7.35	12/39	45/53	57/92	30.77	**84.90**	61.95	16/22	49/70	65/92	0.72	0.70	0.71
	MD_{cer}	5.25	27/35	40/53	67/88	**77.14**	**75.47**	**76.13**	26/40	38/48	64/88	0.65	**0.79**	0.73
	BL_{cer}	7.11	10/35	45/53	55/88	28.57	**84.90**	62.50	9/18	48/70	57/88	0.50	0.69	0.65
UC	MD_{cor}	7.4	14/26	27/34	41/60	53.84	**79.41**	68.33	12/20	28/40	40/60	0.60	0.70	0.66
	BL_{cor}	7.85	16/26	30/35	46/61	61.54	**85.71**	**75.41**	13/17	33/44	46/61	**0.76**	**0.75**	**0.75**
	MD_{cer}	5.48	17/26	26/34	43/60	65.38	**76.47**	71.66	18/25	25/35	43/60	0.72	0.71	0.72
	BL_{cer}	7.7	17/26	27/34	44/60	65.38	**79.41**	73.33	14/20	28/40	42/60	0.70	0.70	0.70
Discriminant functions														
DF1		−0.0835	21/28	15/19	36/47	**75.00**	**78.94**	**76.59**	21/27	15/20	36/47	**0.77**	**0.75**	**0.76**
DF2		−0.0705	26/35	39/53	65/88	74.28	73.58	73.86	27/37	39/51	66/88	0.72	**0.76**	**0.75**
DF3		−0.0774	20/26	25/34	45/60	**76.92**	73.52	**75.00**	24/31	22/29	46/60	**0.77**	**0.76**	**0.77**
DF4		−0.0667	17/34	39/52	56/86	50.00	**75.00**	65.11	17/30	39/56	56/86	0.57	0.69	0.65
Logistic regressions														
LR1		0.5	17/22	21/27	38/49	**77.27**	**77.77**	**77.55**	21/29	14/20	35/49	0.72	0.70	0.71
LR2		0.5	26/35	41/53	67/88	74.29	**77.36**	**76.14**	25/33	42/55	67/88	**0.75**	**0.76**	**0.76**
LR3		0.5	20/26	27/34	47/60	**76.92**	**79.41**	**78.33**	21/27	25/33	46/60	**0.77**	**0.75**	**0.77**
LR4		0.5	16/22	20/26	36/48	72.72	**76.92**	**75.99**	11/16	23/32	34/48	0.68	0.72	0.71
LR5		0.5	17/22	19/26	36/48	**77.27**	73.08	**75.00**	17/23	18/25	35/48	0.73	0.72	073

Results above 75% and 0.75, respectively, are in bold print.
BLcer: cervical buccolingual diameter; BLcor: coronal buccolingual diameter; DF: discriminant function; LC: lower canine; LR: logistic regression; MDcer: cervical mesiodistal diameter; MDcor: coronal mesiodistal diameter; PC: cut-off point; UC: upper canine.

both sexes were considered, and when the sexes were separated, they were close to the threshold of 0.75 (F = 0.72–0.77; M = 0.75–0.76), except for those corresponding to discriminant function 4, which were clearly lower (F = 0.57; M = 0.69).

The percentage of correct assignations in the LR ranged from 75.00% to 78.33% when both sexes were considered in a single set. Similar values were found when the sexes were separated, and they were slightly better for the male cases (F = 72.72%–77.77%; M = 73.08%–79.41%) (Table 4). Only 2 equations (LR1 and LR3) surpassed 75% of correct estimations, for both sexes and for the male and female cases together. In any case, the tendencies of the remaining formulae showed percentages of correct classification close to 75%, with very similar results for both sexes. Respecting the probabilities of correct assignation, the results of analysing the total set varied from 0.71 to 0.77, while for female individuals it ranged from 0.68 to 0.77, and for the male ones from 0.72 to 0.76. In this case too, it was found that the same 2 formulae (LR2 and LR3) showed probabilities higher than 0.75, with very similar values from 0.75 to 0.77 when the sexes were analysed separately (Table 4).

Discussion

Sexual dimorphism is expressed in the human skeleton in a continuum, with a range in which both sexes overlap. This study reports relatively high values, although with appreciable variations of from 4.37% to 9.85%. The highest percentages were identified for the cervical measurements of the lower canines, and this coincides with the findings of an earlier study in the Professor Dr. Rómulo Lambre Collection.[8] These results also agree with those of other studies.[1,2,4,5,8,12–19] The highest percentages obtained in the cervical measurements of the lower canines emphasise the idea that these teeth are relevant for the estimation of sex, as they express the greatest differences in size between the sexes. Nevertheless, it should also be underlined that the percentages obtained for the coronal buccolingual diameter of the upper canines (6.59%) also show a relatively high degree of sexual dimorphism.

The univariate approach made it possible to classify more than 75% of cases in the cervical mesiodistal diameter of the lower canines and the coronal buccolingual diameters of the upper canines. It should be pointed out that while the results were satisfactory for both sexes separately in the first case, in the second case, the correct male assignations were far higher than the female ones. On the other hand, the probabilities of correct classification were only adequate for the coronal buccolingual diameter of the upper canine. A clear tendency was also found for all of the measurements and the percentages as well as the probabilities which indicates that the sex of male individuals may be estimated far better than that of the females.

Although several studies emphasise that univariate methodologies tend to offer adequate results in sex estimation, similar to those obtained using multivariate techniques,[15,26] in this research, the latter showed slightly superior percentages of estimation. It may be added that, of the set of direct measurements, only the BL_{cor} variable in the upper canines is useful in estimating sex in the sample that was analysed. Moreover, the percentages of correct assignations among the male and female individuals were higher than 75% and at similar levels, and this is especially important given that these tendencies guarantee the reliability of the inferences made.

Of the discriminant functions developed by Luna,[15] only DF1 surpassed 75% of correctly classified individuals when the sexes were separated. On the other hand, the probabilities obtained indicate that the majority of these discriminant functions (DF1, DF2, and DF3) make it possible to obtain correct classifications in at least 75% of cases when both sexes are included in the same set. However, only DF1 and DF3 showed similar probabilities higher than 0.75 for both sexes separately. One particularity of both of these functions is that they select the cervical buccolingual diameter of the upper canine as the relevant variable for making estimations. This aspect stands out, as it coincides on the one hand with the proposal by Luna[15] in the original development of the procedure, in which the cervical measurements gave the best results, and on the other hand, it agrees with a previous study using the Lambre collection, which found that the discriminant functions which gave the best results included measurements of the dental neck.[8]

On the other hand, all of the LR achieved correct classifications higher than 75% when both sexes were considered, improving the estimations obtained using direct measurements and the discriminant functions. In turn, when the female and male individuals are compared, better results were found for the latter, and values above 75% were found for LR1 and LR3. In any case, in comparison with the values obtained using direct measurements and the discriminant functions, there are smaller differences in the estimations between the sexes. On the other hand, only the 2 regressions mentioned surpass 0.75 probability of correct classification, with very similar values according to sex. These results show tendencies similar to those observed in previous studies.[27–29]

This study shows that the 3 methods used (direct measurements, DF, and LR) give different results. Although the first methods generate the highest percentages of correct classification, the bias depending on sex was very marked, with a high proportion of male teeth correctly classified and a relevant proportion of the female ones wrongly assigned to the other sex. This tendency to classify female individuals as male indicates that the original sample used to develop Luna's proposal[15] is composed of individuals with average dental dimensions that are smaller than those in the Professor Dr. Rómulo Lambre Collection. Likewise, the vast majority of probabilities of correct classification are lower than 0.75. All of these identified patterns express the low predictive power of direct measurements in the sample that was analysed.

The discriminant functions and logistic regressions differ in this respect. The latter give the most satisfactory results, given that they achieve around 75% of correct classifications and probabilities of 0.75 in all of the formulae. Very slight differences were found in estimations of sex. The results of the discriminant functions DF1 and DF3 are acceptable and similar to those obtained by applying the logistic regressions,

although the latter generate better assignation rates. It is outstanding that all of the said cases consider the cervical measurements of the canines, which is an especially important aspect for the objectives of this study. These results, in agreement with those of other works,[2,8,11,12,15] reaffirm the relevance of the canines and cervical measurements when estimating sex.

Conclusions

Given the importance of sex estimation when preparing an individual biological profile in forensic practice and bioarcheology, the need for studies that validate the methodology used in local samples is especially relevant. Considering that human sexual dimorphism is characterised by wide variations between populations, studies of this type are fundamental in cases when methods developed in populations other than the one in question are applied.

In general terms, these findings indicate that the proposal analysed gives acceptable results for the estimation of sex, although this is only so for some of its formulae. These were found to be applicable and trustworthy in local cases, chiefly when the cervical measurements of permanent canines were considered. The use of discriminant function DF1 is recommended, together with LR2 and LR3 in those cases where the elements of a skeleton which show the greatest degree of dimorphism are lacking or in poor condition.

To end, it is pertinent to underline that the results obtained in this research clearly show the significant impact of the choice of statistical methodology on obtaining reliable results, so that studies with the aim of validating and generating methodologies that improve precision and exactitude are of fundamental importance to improve the quality of local forensic practice.

Declaration of Competing Interest

The authors have no conflict of interests to declare.

Acknowledgements

We would like to thank the staff of La Plata Municipal Cemetery for their help in forming the Professor Dr. Rómulo Lambre Collection. We would also like to thank La Plata National University, which made this research possible through its research project grants.

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