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Case Report

The Use of Odontometric Traits Improves the Chances of Sex Identification in a Contemporary Sicilian Human Population

Andrea Dario Messina*

Dipartimento Scienze e Tecnologie Biologiche, Chimiche E Farmaceutiche, Italy

***Corresponding author:** Andrea Dario Messina, Dipartimento Scienze e Tecnologie Biologiche, Chimiche E Farmaceutiche, LabHomo - Laboratory of Anthropologyvia Archirafi 18, 90123 Palermo, Italy, Tel: +3909123891806; Email: andreamess@gmail.com

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Abstract

Determining the sex is one of the most important steps in the procedure to identify the unknown person. Teeth are a potential source of information on sex.

The research is performed on a total of 187 specimens from the contemporary cemetery in Palermo (Sicily). It is acknowledged that the adult hip-bone (oscoxae) is by far the best non-population-specific indicator for reliable sex determination of adults. Sex is determined on the basis metric criteria of the pelvic bones as described by Murrail et al, as well as odontometric features. Sexual dimorphism of the odontometric features is tested by the Students't test method. Determining the sex on the basis of pelvic features is possible in 61.5% of the cases. Combining the pelvic and odontometric features it is possible to determine the sex in 90.9% of the cases. In cases where ante-mortem data on sex are not available it is best to combine a number of different methods in order to raise the level of confidence and the level of success in sex determination. The aim of this study is to offer a chance to increase the diagnosis of sex in the absence of pelvic or cranial data.

Keywords: Sicily; Sex determination; Odontometrics features

Introduction

The sexual difference in the human skeleton has been well studied in many populations [1]. Most scholars agree that sex diagnosis of adult skeletons can be performed easily and with high reliability [2,3]. The hip-bone is the most suitable bone because of its marked sexual dimorphism which results mainly from selective constraints on males and females imposed by locomotion and childbearing [4,5]. The sexual dimorphism of the hip- bone is non-specific for populations, which is not the case for other parts of the skeleton [1].

Teeth are known for being the most resistant mineralised specimens against different agents of destruction [6]. Further, the biological parameters derived from the study of the teeth offer a good support for the research of human biology [7]. Therefore, teeth are very important elements in the identification of skeletal remains, especially in cases when, due to the poor preservation of skeletal remains, the identification is not possible by standard methods.

Sex determination using dental features is primarily based upon the comparison of tooth dimensions in males and females, or upon the comparison of frequencies of non-metric dental traits, like Carabelli's trait of upper molars, deflecting wrinkle of lower first molars, distal accessory ridge of the upper and lower canines or shoveling of the upper central incisors [8].

Odontometric analysis in human sexual variation had a significant development, in research in fact there are numerous studies in which odontometric characteristics in male and female have been identified [8-12]. These standards can be of use in determining the sex in specific cases: in individual, as well as in groups, forensic cases or archaeological contests [13-15].

The aim of this study is to determine the sex on the basis of metrical variables of pelvis bone [16] from skeletal remains and to integrate the results with odontometric features.

This paper deals with odontometrics as an easy-to-use additional technique to determine the sex in archaeological circumstances without the need to complicate statistical software and techniques. We propose the range of values that can be attributed only to males and only to females.

Material and Methods

Research has been carried out on 187 skeletal remains excavated in the late 19th and early 20th centuries at the contemporary cemetery in Palermo.

Sex determination of the adult skeletons was done using the metric criteria of the pelvic bones as described by Murail et al. [16], on the basis of the 10 hip-bone measurements, according to previous definitions shown in Table 1.

Anthropological tooth labelling system was used [17].

Mesiodistal diameter of the tooth crown is taken as the greatest Mesiodistal dimension parallel to the occlusal and facial surface [18]. Buccolingual crown diameter is the greatest distance between the facial and lingual surfaces of the crown, taken at right angles form the area in which the Mesiodistal diameter is taken [18].

To avoid the possibility of incorrect measurements caused by abrasion, only teeth with a low level of abrasion and without exposed

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Table 1: Pelvic features used for sex determination [16] ("M" refers to the codes of Martin's measurements in Bräuer 1988 [39]).

Variables	Brief definition	Reference
PUM (M14)	Acetabulo-symphyseal pubiclength	[39]
SPU	Cotylo-pubicwidth	[40]
DCOX (M1)	Innominate or coxallength	[39]
IIMT(M15.1)	Greater sciaticnotchheight	[39]
ISMM	Ischium post-acetabularlength	[41]
SCOX (M12)	Iliac or coxalbreadth	[39]
SS	Spino-sciaticlength	[40]
SA	Spino-auricularlength	[40]
SIS (M14.1)	Cotylo-sciaticbreadth	[39]
VEAC (M22)	Vertical acetabulardiameter	[39]

dentine were included. In addition, we have excluded all teeth showing enamel hypoplasia that cause defects in growth [18].

The evaluation of robustness derives from the product of multiplication of the mesiodistal and buccolingual diameter of the tooth crown [19].

All measurements were taken from the teeth of both sides of the dental arches using a digital dental caliper (Masel Orthodontics Inc, USA) with an accuracy of 0.01 mm. Measurements were performed on either the left or right side depending on their availability. If both contralateral teeth were available, the average was calculated.

The measurements were performed by one person and all values were rounded to two decimal places. In order to assess the reliability of the measurements, intraobserver error was tested. Same measurements were obtained from 100 randomly selected teeth from the original sample at a different time by the same author to assess intraobserver error. Another observer measured randomly selected teeth in order to test the interobserver error. All statistical analyses were performed using the STATISTICA 7.0 software program. The data were first assessed for normality using the Kolmogorov-Smirnov one-sample test. Next, a descriptive analysis was performed which calculated the sample size, the mean and the standard deviation for each measurement. This analysis, which characterizes the study population, allowed us to detect possible errors in collection or processing of the database.

Afterwards we analyzed the homogeneity of variance and the differences between mean values of males and females using Student's t-test because the homogeneity of variance is fulfilled. The level of statistical significance was set at $p < 0,05$. After the sex of the hip-bone was assessed on the basis of pelvic features and after the sex specific ranges of measured dental values were established, the final sex assessment was performed.

Result

The determination of the sex, on the basis of metrical variables of the pelvis has allowed the identification of 115 individuals (61.5%), while in 38.5% of the cases it was not possible, mostly due to the poor preservation of the material. Of the pelvis bone on which the sex was determined (Table 2), the sex ratio is: males (29.4%) and females (32.1%).

Table 2: Results of the sex determination using metrical variables of the pelvis bone.

N total (%)	N sex- determined: male + female (%)		N sex - undetermined (%)
187 (100.0)	115 (61.5)		72 (38.5)
	N male (%)	N female (%)	
	55 (29.4)	60(32.1)	

N= number of individuals.

Table 3: t value of intra- and interobeserver error test.

	Intraobserver	Interobserver
Mesiodistal diameter of the tooth crown		
Upperjaw		
I1	0.73	0.11
I2	0.79	-0.72
C	-0.71	-0.76
P1	0.88	1.19
P2	0.84	1.39
M1	0.84	1.06
M2	1.24	1.99
M3	1.51	1.34
Lower jaw		
I1	-0.57	0.51
I2	0.08	0.54
C	0.1	0.55
P1	1.44	0.40
P2	1.7	0.14
M1	1.71	-0.18
M2	0.87	1.00
M3	0.22	0.51
Buccolingual diameter of the tooth crown		
Upperjaw		
I1	-0.21	-0.22
I2	0.08	-0.17
C	-0.12	-0.12
P1	1.56	0.65
P2	1.49	0.98
M1	1.13	-0.91
M2	2.28	0.68
M3	1.14	0.49
Lower jaw		
I1	0.10	-0.03
I2	0.22	0.17
C	0.13	-0.18
P1	2.29	-0.18
P2	2.68	0.19
M1	1.42	-0.27
M2	1.35	0.88
M3	0.17	0.37

None of the t values are significant at the $p < 0.05$ level. I1: Central Incisor; I2: Lateral Incisor; C: Canine; P1: First Premolar; P2: Second Premolar; M1: First Molar; M2: Second Molar; M3: Third Molar.

Table 3 shows the t-values of intra and interobeserver error test and there was no statistical difference between the original measurement and the test measurements suggesting consistency between odontometric values.

The measurement of the mesiodistal diameter was conducted on a total of 908 permanent teeth. There was statistical difference between males and females in the mesiodistal diameter of the crown of the

Table 4: Mesiodistal diameter of the tooth crown.

	Male			Female			p-level
	N	A(mm)	SD (mm)	N	A(mm)	SD (mm)	
Upperjaw							
I1	14	8.28	0.77	19	8.21	0.78	0.853
I2	24	6.21	0.66	23	6.67	0.68	0.415
C	23	7.42	0.73	26	7.21	0.54	0.145
P1	27	6.40	0.85	21	6.34	0.86	0.827
P2	32	6.34	0.8	21	6.17	0.51	0.403
M1	29	9.93	1.18	24	9.67	1.08	0.402
M2	31	9.52	1.06	22	9.17	0.96	0.221
M3	24	8.81	1.16	21	8.34	0.89	0.138
Lower jaw							
I1	16	5.09	0.28	17	5.11	0.29	0.692
I2	19	5.78	0.62	20	5.85	0.32	0.583
C	22	6.85	0.73	19	6.71	0.27	0.110
P1	41	6.30	0.95	36	6.00	0.88	0.011
P2	41	6.91	0.54	38	6.54	0.54	0.026
M1	54	9.98	1.35	42	9.51	1.29	0.040
M2	59	9.52	1.34	40	9.29	1.23	0.389
M3	36	9.04	1.38	27	8.96	1.54	0.825

N: Number of teeth; A: Average; SD: Standard Deviation; *: Statistically Significant; I1: Central Incisor; I2: Lateral Incisor; C: Canine; P1: First Premolar; P2: Second Premolar; M1: First Molar; M2: Second Molar; M3: Third Molar

Table 5: Buccolingual diameter of the tooth crown.

	Male			Female			p-level
	N	A (mm)	SD (mm)	N	A (mm)	SD (mm)	
Upperjaw							
I1	14	7.37	0.25	19	6.96	0.37	0.231
I2	24	6.57	0.59	23	6.10	0.20	0.413
C	23	8.26	0.56	26	7.75	0.50	0.015
P1	27	7.8	1.81	21	6.96	1.89	0.126
P2	33	7.83	1.95	21	7.02	1.93	0.142
M1	30	10.1	2.00	24	9.53	1.6	0.262
M2	34	10.34	2.17	23	9.08	1.85	0.027
M3	23	9.43	1.77	21	8.78	1.97	0.259
Lower jaw							
I1	16	6.07	0.44	17	5.82	0.37	0.369
I2	19	6.27	0.42	20	6.13	0.33	0.216
C	22	7.83	0.56	19	6.65	0.60	0.013
P1	41	6.53	1.62	36	5.71	1.51	0.025
P2	44	6.84	1.75	36	5.81	1.63	0.009
M1	54	9.1	1.66	42	8.63	1.52	0.158
M2	59	8.71	1.59	40	8.27	1.57	0.179
M3	36	8.19	1.46	27	8.13	1.58	0.868

N: Number of Teeth; A: Average; SD: Standard Deviation; *: Statistically Significant; I1: Central Incisor; I2: Lateral Incisor; C: Canine; P1: First Premolar; P2: Second Premolar; M1: First Molar; M2: Second Molar; M3= Third Molar

mandibular first premolar (males 6.30 ± 0.95 mm, females 6.00 ± 0.88 mm, $p < 0.011$), mandibular second premolar (males 6.91 ± 0.54 mm, females 6.54 ± 0.54 mm, $p < 0.026$) and mandibular first molar (males 9.98 ± 1.35 mm, females 9.51 ± 1.29 mm $p < 0.040$), Table 4.

The buccolingual diameter of the tooth crown was measured on a total of 897 permanent teeth. There were statistically significant differences between males and females in the buccolingual diameter of the crown of the maxillary canine (males 8.26 ± 0.56 mm, females 7.75 ± 0.50 mm, $p < 0.001$), maxillary second molar (males 10.34 ± 2.17 mm, females 9.08 ± 1.85 mm, $p < 0.027$); mandibular canine (males 7.83 ± 0.56 mm, females 6.65 ± 0.60 mm, $p < 0.013$), mandibular first premolar (males 6.50 ± 1.60 mm, females 5.70 ± 1.50 mm, $p < 0.025$), and the mandibular second premolar (males 6.80 ± 1.75 mm, females 5.80 ± 1.60 mm, $p < 0.009$), Table 5.

Measurements needed to calculate the robustness of a tooth were performed on a total of 861 permanent teeth. There were statistically significant differences between males and females in the maxillary canine (males 61.28 ± 7.49 mm, females 55.87 ± 7,23 mm, $p < 0.001$),maxillary second molar (males 98.5 ± 29.0 mm, female 83.0 ± 25.0 mm, $p < 0.026$), mandibular canine (males 53.63 ± 6.34 mm, females 44.62 ± 5.87 mm, $p < 0.001$), mandibular first premolar (males 42.0 ± 15.0 mm, female 35.0 ± 15.0 mm, $p < 0.038$), mandibular second

Table 6: Robustness of the teeth.

	Male			Female			p-level
	N	A (mm)	SD (mm)	N	A (mm)	SD (mm)	
Upperjaw							
I1	14	62.04	8.65	19	58.26	8.19	0.304
I2	24	41.85	6.72	23	41.38	4.56	0.291
C	23	61.28	7.49	26	55.87	7.23	0.001
P1	27	51.1	16.2	21	45.3	17.5	0.241
P2	32	50.4	16.5	21	44.1	15.4	0.169
M1	29	101.4	29.4	24	93.4	24.9	0.296
M2	31	98.43	29.4	22	83.26	25.1	0.026
M3	23	84	24	21	74.5	22.9	0.188
Lower jaw							
I1	16	31.68	3.57	17	30.21	3.35	0.624
I2	19	37.45	5.33	20	35.96	4.29	0.705
C	22	53.63	6.34	19	44.62	5.87	0.001
P1	41	42.4	15.1	36	35.4	13.6	0.038
P2	41	44.5	17.1	36	35.8	15.4	0.022
M1	54	90.8	28.9	42	82.07	25.0	0.034
M2	59	84.8	26.9	40	78.5	24.8	0.239
M3	36	75.7	23.9	27	74.8	26.5	0.890

N: Number of Teeth; A: Average; SD: Standard Deviation; *: Statistically Significant; I1: Central Incisor; I2: Lateral Incisor; C: Canine; P1: First Premolar; P2: Second Premolar; M1: First Molar; M2: Second Molar; M3: Third Molar.

Table 7: Degree of sexual dimorphism of the odontometric features in the Palermo sample.

	Male			Female			sexualdimorfism		
	N	A (mm)	SD (mm)	N	A (mm)	SD (mm)	p-level	x[a]	(%)b
Mesiodistal diameter of the tooth crown (mm)									
L-P1	41	6.30	0.95	36	6.00	0.88	0.011	0.3	5.00
L-P2	41	6.91	0.54	38	6.54	0.54	0.026	0.37	5.65
L-M1	54	9.98	1.35	42	9.51	1.29	0.040	0.47	4.94
Buccolingual diameter of the tooth crown (mm)									
U-C	23	8.26	0.56	26	7.75	0.50	0.015	0.51	6.50
U-M2	34	10.34	2.17	23	9.08	1.85	0.027	1.26	13.80
L-C	22	7.83	0.56	19	6.65	0.60	0.013	1.18	17.70
L-P1	41	6.53	1.62	36	5.71	1.51	0.025	0.82	14.30
L-P2	44	6.84	1.75	36	5.81	1.63	0.009	1.03	17.70
Robustness of the teeth (mm)									
U-C	23	61.28	7.49	26	55.87	7.23	0.001	5.41	9.68
U-M2	31	98.8	29.4	22	83.4	25.1	0.026	15.4	18.40
L-C	22	53.63	6.34	19	44.62	5.87	0.001	8.91	20.10
L-P1	41	42.4	15.1	36	35.4	13.6	0.038	7	19.70
L-P2	41	44.5	17.1	36	35.8	15.4	0.022	8.7	24.30
L-M1	54	90.8	28.9	42	82.07	25.0	0.034	8.73	10.63

N: Number of Teeth; A: Average; SD: Standard Deviation; *: Statistically Significant. U: Upper Teeth; L: Lower Teeth; I1: Central Incisor; I2: Lateral Incisor; C: Canine; P1: First Premolar; P2: Second Premolar; M1: First Molar; M2: Second Molar; M3: Third Molar.
[a]X: A male - A female.
[b]% : (A male/A female - 1.0) x 100.

premolar (males 44.5 ± 17.0 mm, female 35.5 ± 15.0 mm, p < 0.022), mandibular first molar (males 90.8 ± 28.9 mm, females 82.07 ± 25.0 mm, p < 0.034), Table 6.

The percentage of sexual dimorphism was calculated for all odontometric features that showed a statistically significant difference between males and females, Table 7. The greatest difference in male and female odontometric features was evident in the robustness of the mandibular second premolar (24.3 %) and in mandibular canine (20,10%).The mesiodistal diameter of the tooth crown showed least difference between sexes, with only 4.94% (mandibular first molar). The buccolingual diameter of the tooth crown showed higher difference between sexes, with the 17.7%, for maxillary canine and second premolar.

Odontometric features that show sexual dimorphism are used in sex determination in cases where the sex could not be determined by the use of metric variables of pelvic bones. On the basis of mean values and standard deviation, we have determined the range of values that can be attributed only to males and only to females, Table 8.

Comparing the odontometric data on the remains of individuals of the unknown sex with the range of odontometric features shown in Table 8 the sex can further be determined on 55 individuals or more;

Table 8: Range of measured odontometric values that show sexual dimorphism.

Range of values characteristic only for males		Range of values characteristic only for females
Mesiodistal diameter of the tooth crown (mm)		
L-P1	6.88 - 7.25	5.12 - 5.35
L-P2	7.08 - 7.45	6.00 - 6.37
L-M1	10.8 - 11.33	8.22 - 8.63
Buccolingual diameter of the tooth crown (mm)		
U-C	8.25 - 8.82	7.25 - 7.7
U-M2	10.93-12.51	7.23-8.17
L-C	7.25 - 8.39	6.05 - 7.17
L-P1	7.21-8.14	4.20-4.91
L-P2	7.43-8.58	4.18-5.09
Robustness of the teeth (mm)		
U-C	63.1 - 68.77	48.64 - 53.79
U-M2	108.51-128.38	58.30-69.40
L-C	50.49 - 59.97	38.75 - 47.29
L-P1	49.01-57.97	21.80-27.30
L-P2	51.26-61.58	20.40-27.40
L-M1	107.07 - 119.7	57.07 - 61.9

U: Upper Teeth; L: Lower Teeth; I1: Central Incisor; I2: Lateral Incisor; C: Canine; P1: First Premolar; P2: Second Premolar; M1: First Molar; M2: Second Molar; M3: Third Molar.

Table 9: Results of the sex determination using metrical variables of the pelvis bone and odontometric features.

N total (%)	N sex- determined:	male + female (%)	N sex - undetermined (%)
187 (100.0)	170 (90.9)		17 (9.1)
	N male (%)	N female (%)	
	74 (39.6)	96 (51.3)	

N: Number of Individuals.

36 females and 19 males. The new sex ratio from the Palermo sample is shown in Table 9.

Including odontometric parameters in the procedure to determine the sex, raises the efficiency from 61.5% (on the basis of metric variables of pelvic bone alone) to 90.9% (combining pelvic and odontometric features), which presents a 29.4% increase in the success of determining the sex.

Discussion

Determination of the sex of human bone remains represents a crucial stage in any palaeoanthropological study. A current opinion suggests that the pelvic bone provides the highest accuracy level for sex determination. However, skeletal remains in archaeology are very often poorly preserved and fragmentary.

The odontometric features of teeth are considered specific of a population [13] and that direct comparison and non-critic analyses can lead to false conclusions.

For this reason it is best to combine several methods to increase the percentage of success in determining the sex. As a method of sex determination, odontometric analysis has been investigated over a long period of time [20-26,10,19,13,27-31], demonstrating that dental dimensions can be used successfully in sexual diagnosis in both living individuals and in skeletal remains in poor and/or fragmented condition.

Muller et al. [10] carried out a research on French students and confirmed the difference between males and females in the buccolingual diameter of the mandibular canine. Iscan & Kedici [13] found that canine teeth of both jaws are more dimorphic. Observing the medieval Croatian population, Vodanović et al. [9] discovered a statistically significant difference between males and females in both jaws for several teeth.

Further, research [32-34] shown that a genetic control of sexual dimorphism exists in permanent tooth size**.** Garn et al. [20], has been shown that the magnitude of sexual dimorphism in tooth size has genetic basis, as confirmed by family-line similarities in the magnitude of brother-sister tooth size dimorphism.

The results in general match reports in the dental literature that emphasize greater sex dimorphism of the canines [35-38,26,19,13,29-31].

Mesiodistal and buccolingual diameters of the permanent tooth crown are the two most commonly used and researched features used in determining sex on the basis of dental measurements [8].

This study reveals that the permanent canine is the tooth with the greatest degree of sexual dimorphism, but also second premolar.

The skeletal remains-including the teeth- contemporary cemeteries in Palermo (Sicily, Italy) are very well preserved. However, there are many limiting factors that hindered collecting dental measurements and therefore significantly decreased the amount of data available for analysis. Among these factors are: dental wear and pathologies.

Crowns of permanent teeth are formed at an early stage and their dimensions remain unchanged during further growth and development, except in cases when specific changes and disorders in terms of functionality, pathology and nutrition can have affect on the normal dimensions of a tooth [8].

However, even in the presence of certain limiting factors, if they have a minimal effect on the tooth or are in specific locations—i.e., not on the reference points for the different measurements—it is possible to obtain a sufficiently large sample of teeth for odontometric analysis.

All of these considerations emphasize the importance of the present study, which attempts to present odontometric analysis as an additional methodology, quick and easy to use, for sex determination of skeletal remains in archaeological contexts and in forensics-as in the case of mass disasters-where identification of individuals is not possible by standard methods.

Conclusion

The purpose of this paper is to determine sex on the basis of pelvic features of the skeletal remains excavated at the contemporary cemetery in Palermo, to make an odontometric analysis of permanent teeth of the sample, and finally to determine sex on the basis of odontometric features.

Our results supply an additional technique in determining the sex in Sicilian human population that can be integrated in standard techniques. This method offers a chance to increase the diagnosis of the sex in the absence of cranial or pelvic data.

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