Forensic Science International 234 (2014) 183.e1–183.e7

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Forensic Anthropology Population Data

Odontometric sex variation in Malaysians with application to sex prediction

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ARTICLE INFO

Article history:
Received 14 September 2012
Received in revised form 17 July 2013
Accepted 16 September 2013
Available online 25 September 2013

Keywords:
Odontometric profile
Malaysian
Sex prediction
Forensic Anthropology Population Data
Tooth size

ABSTRACT

Information about the sex of individuals is important for human identification. This study was conducted to quantify classification rates of sex prediction models for Malaysians using odontometric profiles. Mesiodistal (MD) and buccolingual (BL) crown dimensions of the permanent dentition were studied in 400 young adult Malaysians, giving a total of 28 tooth size variables. The sample consisted of three major ethnic groups, the Malays, Chinese and Tamils, since the aim was to assess sex dimorphism in Malaysians as a whole. Results showed that the mesiodistal diameter of the lower canine was the most sexually dimorphic dimension in Malaysian Malays and Tamils. Univariate analyses showed that the magnitude and pattern of sex dimorphism varies between these three ethnic groups, with Malaysian Chinese and Tamils being more dimorphic than the Malaysian Malays. Stepwise discriminant functions were generated bearing in mind their application in practical forensic situations. The range of classification rates was from 70.2% to 78.5% for the composite Malaysian group, and 83.8%, 77.9%, 72.4% for Malaysian Chinese, Malays and Tamils, respectively. The 'Area Under the Receiver Operating Characteristic Curve statistics' indicated good classification rates for three prediction models obtained using a combination of all tooth size variables, mandibular teeth, and mesiodistal dimensions in the composite Malaysian group, and for all tooth size variables in each ethnic group. The present study provides strong support for the value of odontometry as an adjunct scientific method for sex prediction in human identification.

1. Introduction

Odontometric differences between males and females are reported to be only around 3–4% in magnitude [1] but several researchers have shown promising applications for sex identification in archaeological and forensic situations using a combination of tooth sizes, with the success rates ranging from 71% to 93% [2–8]. Sex prediction has also been successful, with a probability of up to 80–90%, by utilizing a combination of tooth sizes and root lengths [9], by using the ratio between canine width and intercanine distance [10], by obtaining diagonal tooth measurements [11] or by using a combination of incisor and canine indices [12].

Knowing the sex of an individual is an important step in reconstructing identity. This information is crucial in searching for potential ante-mortem evidence for the comparative identification process. Odontometric methods are obviously only applied in cases where the sex organs, other secondary sexual characteristics, and deoxyribonucleic acid are not available for analysis. The physical robustness of teeth, which can withstand decomposition processes and adverse environmental conditions, for instance heat up to 1000 °C [13] and submersion in water [14], is an advantage for forensic investigations.

Currently, there are no reference studies for sex prediction using odontometric data in the Malaysian population. According to the Malaysian census 2010, the Malays, Chinese and Tamils are the majority ethnic groups in Malaysia [15]. From an historical perspective, the Malaysian Chinese came mainly from Southern China while the Malaysian Tamils came mainly from Southern India [16]. Since there is obvious population variation in the pattern and magnitude of sexual dimorphism [17–19], this study aims to quantify success rates of sex prediction models for the Malaysian population as a whole and also for each of the ethnic groups. In addition, the predictive models developed should be suitable to be used in real forensic situations.

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http://dx.doi.org/10.1016/j.forsciint.2013.09.019

Table 1
Sample distribution.

	Ethnic group	Sex		Total
		Males	Females	
Original sample	Malays	67	69	136
	Chinese	66	64	130
	Tamils	67	67	134
Total original sample		200	200	400

2. Materials and methods

Dental models were collected from 400 secondary school children, consisting of 136 Malays, 134 Tamils and 130 Chinese from several different states. In order to study sex dimorphism in the Malaysian population as a whole, a composite of these ethnic groups was recruited. Four hundred dental models were used in univariate and multivariate analyses (Table 1). Young adult participants were selected so that interproximal tooth wear would be minimal.

All participants and parents of participants were asked to complete questionnaires seeking information about the participants' demography, ancestry and health. For underage (<18 years old) schoolchildren, written consent was obtained from parents before any procedure. Inclusion criteria were as follows: Malaysian citizens; healthy; no craniofacial anomalies; and measurement landmarks not obscured by any restorations, caries, calculus, partial eruption of teeth, excessive tooth crown wear or casting defects.

Alginate impressions were obtained and dental models constructed according to the manufacturer's instructions. All oral examinations and impressions were carried out in a mobile clinic vehicle, and diestone was poured immediately after rinsing the impressions under running tap water.

2.1. Definitions of measurements

Digital callipers (Mitutoyo, Japan) with modified beaks were used to record crown size measurements to an accuracy of 0.1 mm. The callipers were connected to a personal computer that enabled data to be transferred automatically to an Excel program (Microsoft Officeworks).

Measurements of mesiodistal crown diameters followed the definition of Moorrees [20]; i.e., the maximum mesiodistal (MD) diameter of the dental crown was measured with the callipers held parallel to the labial/buccal and incisal/occlusal surfaces. The buccolingual diameter (BL) was measured perpendicular to the mesiodistal plane and represented the greatest distance between buccal/labial and lingual surfaces [21].

All right teeth, except third molars, were measured. Replacement with the value for the left tooth was considered when the right tooth failed to comply with the inclusion criteria, e.g., was missing or damaged due to caries. This enabled sample sizes to be maximized.

2.2. Univariate statistical analyses

Sexual dimorphism in the data, for each ethnic group and Malaysians, was assessed by the *t*-test for independent samples. Percentages of sex dimorphism were calculated according to Garn et al. [3] using the formula $(M - F) * 100/F$, where M is the mean of male tooth sizes and F is the mean of female tooth sizes. Sexual dimorphism values of each tooth were ranked accordingly.

2.3. Multivariate statistical analyses

Five stepwise discriminant functions were generated for Malaysians, taking into account practical applications in a forensic context, as follows: all 28 tooth size variables, all maxillary teeth, all mandibular teeth, all mesiodistal diameters and all buccolingual diameters. One stepwise discriminant function was also generated for each of the Malaysian Malay, Chinese and Tamil ethnic groups. Stepwise procedures determine the most discriminative predictors based on the Wilks' Lambda method and using the *F* value criteria; *F* entry was 3.84 and *F* remove was 2.71. The statistical significance of each discriminant function was assessed using Wilks' Lambda. Probabilities of group membership were used to compute the 'Area Under the Receiver Operating Characteristic' (ROC) Curve statistics to rate the performance of the classification rates. The stepwise discriminant analysis also generated a group centroid for each male and female grouping. Unstandardized discriminant function coefficients were used to calculate the discriminant scores. SPSS PASW v. 18.0 was used to analyze the data (SPSS Inc., IL, USA). *P*-values less than 5% were considered to be significant.

3. Results

3.1. Observer variation

The mesiodistal and buccolingual diameters of 30 subjects were measured twice on different occasions to test for intra- and inter-

Table 2
Descriptive statistics and percent of sexual dimorphism in Malays.

Tooth	Male			Female			% Dimorphism	*P* value[a]
	N	Mean	SD	*N*	Mean	SD		
MD11	67	8.66	0.459	69	8.44	0.506	2.6	0.009
MD12	67	7.07	0.536	69	6.91	0.618	2.3	0.109
MD13	67	8.25	0.383	69	7.81	0.457	5.7	<0.001
MD14	67	7.47	0.447	69	7.40	0.383	1.0	0.285
MD15	67	7.03	0.399	69	6.96	0.406	1.1	0.262
MD16	67	10.62	0.478	69	10.47	0.464	1.4	0.069
MD17	67	10.13	0.477	69	9.90	0.512	2.3	0.007
BL11	67	7.35	0.487	69	7.08	0.478	3.9	0.001
BL12	67	6.69	0.472	69	6.43	0.459	4.0	0.001
BL13	67	8.24	0.547	69	7.94	0.494	3.7	0.001
BL14	67	9.74	0.548	69	9.46	0.420	2.9	0.001
BL15	67	9.55	0.569	69	9.39	0.480	1.7	0.082
BL16	67	11.54	0.559	69	11.18	0.472	3.2	<0.001
BL17	67	11.32	0.711	69	10.99	0.574	3.0	0.004[b]
MD41	67	5.54	0.343	69	5.43	0.302	1.9	0.063
MD42	67	6.13	0.341	69	6.06	0.361	1.0	0.302
MD43	67	7.19	0.412	69	6.77	0.342	6.3	<0.001
MD44	67	7.39	0.493	69	7.27	0.416	1.5	0.158
MD45	67	7.34	0.466	69	7.32	0.403	0.4	0.723
MD46	67	11.60	0.526	69	11.32	0.458	2.5	0.001
MD47	67	10.55	0.636	69	10.27	0.565	2.7	0.009
BL41	67	5.91	0.348	69	5.75	0.312	2.9	0.004
BL42	67	6.24	0.433	69	6.13	0.354	1.9	0.088
BL43	67	7.41	0.572	69	7.10	0.400	4.3	0.001[b]
BL44	67	8.28	0.503	69	8.01	0.421	3.4	0.001
BL45	67	8.75	0.417	69	8.60	0.411	1.7	0.044
BL46	67	10.97	0.521	69	10.78	0.458	1.8	0.025
BL47	67	10.78	0.581	69	10.40	0.436	3.6	<0.001[b]

SD, standard deviation; MD, mesiodistal dimension, BL, buccolingual dimension.
[a] Independent *t*-test.
[b] Unequal variance from Levene test.