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Sexual dimorphism involved in the mesiodistal and buccolingual dimensions of permanent teeth

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Abstract

Studies indicate that tooth crown diameters are clinical markers for sex differentiation. Therefore, the aim of this study was to assess the degree of sexual dimorphism in different teeth. Maximum mesiodistal (MD) and buccolingual (BL) dimensions of 2400 permanent teeth from 100 pretreatment orthodontic dental study casts and clinical records (50 males and 50 females) from the Department of Pediatric Dentistry and Orthodontics, Federal University of Rio de Janeiro, Brazil, were examined. Comparison of the MD and BL dimensions between males and females was performed using the Student's *t* test with alpha 0.05, effect size, and discriminant function analysis. Comparisons in MD and BL widths between sexes demonstrated that the combined mean in the female group presented reduction when compared with the male group, except for the BL dimension of tooth 26. In regard to the MD dimensions, statistically significant differences were observed in various dental groups. The greatest sexual dimorphism was observed in the left mandibular canine (p<0.001) with effect size over 0.8 (0.94), which characterizes large effect. In BL dimension, numerous teeth demonstrated statistical differences between the sexes. Our findings reinforced the magnitude of sexual dimorphism in tooth size, and, in addition, highlighted the differences in specific dental groups.

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Introduction

The sexual dimorphism is explained by different effects of the human X and Y chromosome genes on various somatic features, such as the frequency of some dental anomalies and the tooth crown size [1-3].

Various explanations for tooth-size dimorphism between males and females have been proposed: the differences in hormonal balance [4], the effect of the Y chromosome in increasing mitotic activity within the developing dental lamina, and the fact that the chromosome X is known to be involved in the enamel formation [2]. Some authors suggested that this difference is due to the amount of enamel [5], while others found significant differences in the amounts of dentine [6].

The tooth crown size is a valuable tool and provides significant information on human evolution [7] and biological alterations [8], a in forensic evaluation [9,10] and clinical odontology [11]. Tooth crown diameters are reasonably accurate predictors of sex and are good adjuncts for sex differentiation [12]. Although the degree of dimorphism varies within different populations, generally, males have larger tooth crowns than females [13-16].

Therefore, the present study was conducted to assess the degree of sexual dimorphism in permanent teeth of patients recruited at the Federal University of Rio de Janeiro, Brazil.

Materials and Methods

A total of 2400 permanent teeth from 100 pretreatment orthodontic dental study casts and clinical records from the Department of Pediatric Dentistry and Orthodontics, Federal University of Rio de Janeiro, Brazil, were examined. Patients with underlying syndromes and oral clefts were not included in this study. Patients who had their pretreatment orthodontic records performed between 2000 to 2010 were available for this study. Fifty males and 50 females were selected at random. Ethical approval was obtained from the Human Ethics Committee of the Health Department of the city of Rio de Janeiro, Rio de Janeiro, Brazil (113/09). Written informed consent was obtained from all participating individuals or parents/legal guardians.

The population included in this study resides in the metropolitan area of Rio de Janeiro, Brazil, and is comprised of a mixture of Caucasians (mainly European desce-

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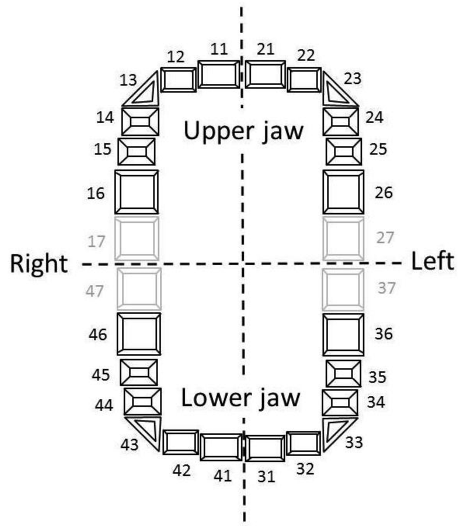

Figure 1. Dental diagram. This diagram represents the permanent dentition. Second molars are presented in gray color since they were not evaluated in this work. Third molars are not presented in this diagram. This diagram is labeled according to the Federation Dentaire Internationale Numbering System.

Table1. Characteristics of the individuals studied.

	Male	Female	p-value
Mean age (Standard Deviation)	17.2(±4.6)	19.8(±6.3)	**0.02***
Ethnicity (%)			
Caucasian	37 (74%)	30 (60%)	0.1**
African descendant	13 (26%)	20 (40%)	

Note: * T-test; ** Chi-square test; bold emphasis indicates statistical significance (p≤0.05).

ndants (53.6%) and African descendants (33.6% obviously mixed Portuguese, 12.3% not obviously mixed Africans). The remaining 0.5% of the population is Amerindian or Asian descendants. The ethnicity was based on the self-reported description.

Assessment of tooth dimensions

Dental casts were used to obtain data regarding tooth dimensions. A dental diagram with the tooth nomenclature used in this work is presented in Figure 1. Dental casts were excluded from assessment if they fell into one of the following criteria: teeth with restorations extending both for the mesiodistal and for the buccolingual surfaces, teeth displaced or crowded, and teeth not fully erupted. Second and third molars were excluded due to the young age of many of the subjects. Maximum mesiodistal (MD) and buccolingual (BL) dimensions of fully erupted permanent teeth were measured to the nearest 0.1 millimeters using the digital Mitutoyo caliper. MD is defined as the maximum distance between the most mesial and the most distal point of the crown, whereas BL is defined as the maximum distance between the most lingual/palatal and the most buccal/labial point of the crown. The dimensions were recorded for each tooth using the method proposed by Moorrees and Reed [17].

All measurements were undertaken by one operator (T.M.S.), with a strict criterion in order to reduce variation. Five models were analyzed per day during two months to prevent depletion of the operator. Each tooth was measured three times and, if the measurements differed by more than 0.2 millimeters, was measured three times again.

Statistical Analysis

An intra-class correlation coefficient was calculated to assess random error of intra-observer variability. The dental casts of ten subjects were selected and all tooth measurements were assessed on two occasions at least two weeks apart. The level of agreement was equal to 0.99, indicating an excellent level of reproducibility of the tooth dimension measurements. The descriptive values of MD and BL dimensions (means and standard deviations) were recorded. Comparison between MD and BL dimensions of the male and female permanent teeth was performed using the Student's t test with an alpha of 0.05. Effect sizes were calculated as the difference between the means (measurements for each tooth in relation to sex) divided by standard deviation of either group. The widely used benchmarks, suggested by Cohen [18], indicated the magnitude of the change observed. That is, effect sizes of 0.2 were taken to be small, 0.5 to be moderate, and 0.8 or above to be large. Comparison between MD

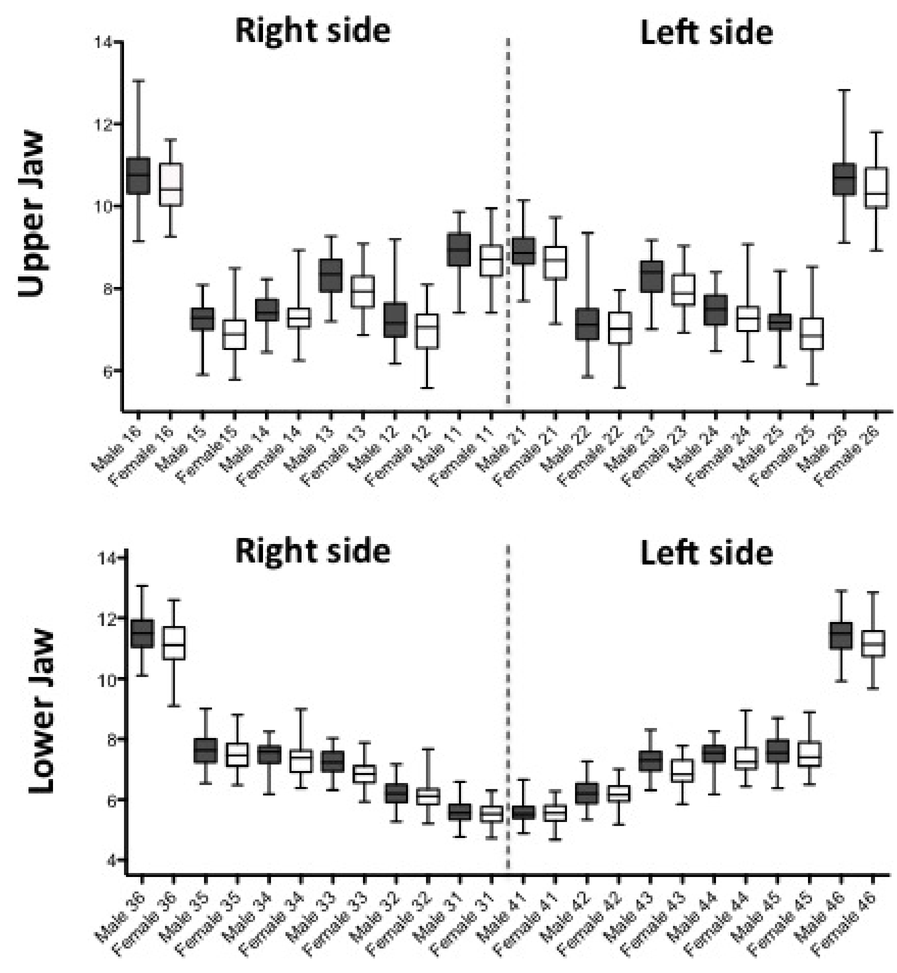

Figure 2. Box plot showing quartiles and mean of the mesiodistal dimensions of upper and lower teeth. Statistical difference between genders is represented in Table 2. Tooth numbers correlate to the numbers in Figure 1.

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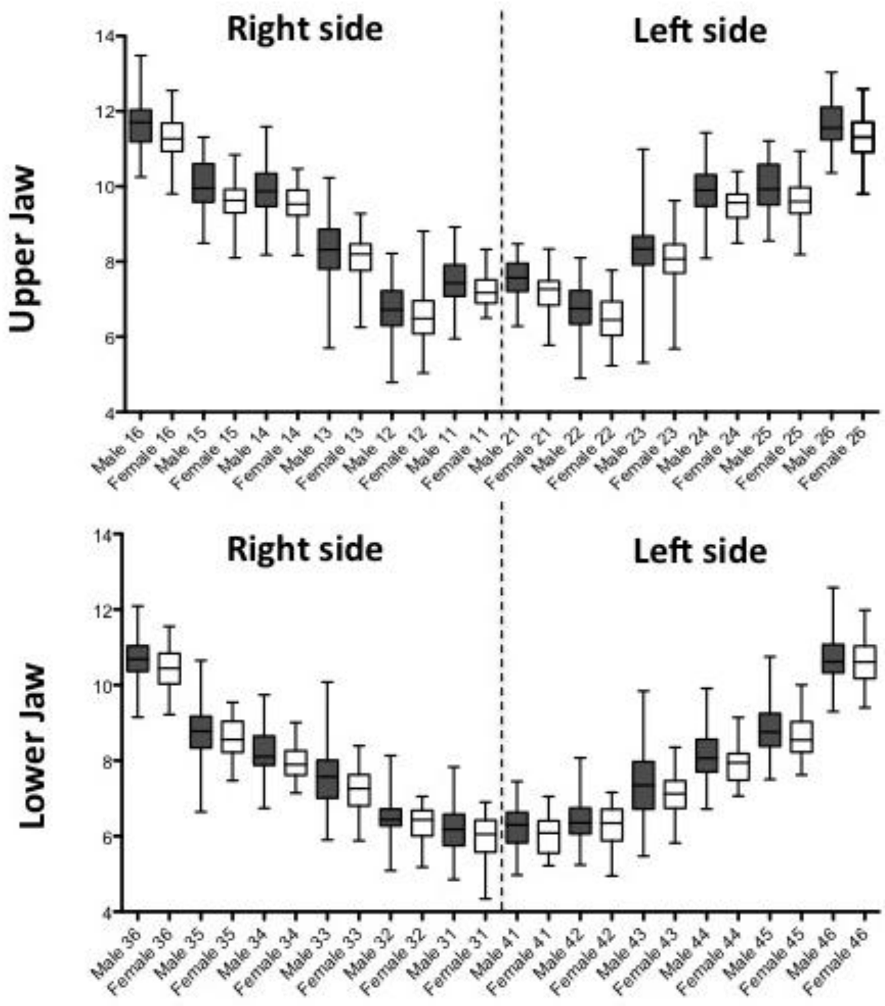

Figure 3. Box plot showing quartiles and mean of the buccolingual dimensions of upper and lower teeth. Statistical difference between genders is represented in Table 2. Tooth numbers correlate to the numbers in Figure 1.

and BL dimensions of the Caucasian and African descendants' permanent teeth was also performed using the Student's *t* test with an alpha of 0.05. For the dimensions that were different between ethnicities, logistic regression analyses were performed including ethnicity as covariates. Results were reported according to the STROBE guidelines for cohort.

Results

The univariate analysis showed that there are no significant differences in ethnicity between male and female (p=0.1). The demographic characteristics of the studied individuals are summarized in Table 1.

In both comparisons, MD and BL widths between sex demonstrated that the combined mean of each tooth in the female group presented reduction when compared with the male group. Out of the 48 variables measured, male teeth exceeded female teeth significantly in 26 variables (p<0.05). Of these, 13 belonged to the maxillary and 13 were BL dimensions.

In regard to the MD dimensions, statistically significant differences were observed in various teeth, the greatest of which were observed in the mandibular left canine (33) (p<0.001), with effect size over 0.8 (0.94), and in the mandibular right canine (43) (p<0.001), with effect size over 0.8 (0.88). In BL dimension, many teeth demonstrated statistical differences between the sexes. These results were observed in Table 2. A graphical representation of MD and BL dimensions are also provided in Figure 2 and Figure 3.

In regard to the differences between the ethnicities, Caucasians presented statistically significant reduced dimensions in specifics cases. In males, differences were observed in the MD dimension of upper right second premolar (15) and in the BL dimension of upper right (12) and left (22) lateral incisor. In females, differences were observed in the MD dimension of the first molars (16, 26, 36 and 46) and the lower left lateral incisor (32). Differences were also observed in the BL dimensions of the lower second right premolar (45). The results of the logistic regression analyses for these dimensions, using the ethnicity as covariant, are presented in Table 3.

DISCUSSION

The general structure and morphology of the teeth are similar in both men and women, however, there are subtle differences, such as variation in dental size, that can give a clue about differences between the sexes. Following this pattern, teeth can be considered an important step for sex determination as they are resistant to postmortem destruction and fragmentation. The accessibility for measuring the dimensions of the teeth using morphometric devices would be a reliable method for solving medicolegal investigations and to identify victims of crime, natural disasters, and severe accidents.

In this study, we analyzed the degree of the sexual dimorphism in different teeth by measuring the maximum diameters, mesiodistal and buccolingual, of fully erupted permanent teeth from study casts. Our results raise an interesting possibility that could be used to clarify this difference. Measurement of the MD width of the mandibular and maxillary canines provides good evidence of sex identification due to dimorphism, since this measurement showed higher effect sizes than other teeth. These results are consistent with previous studies that found the canine to be one of the most dimorphic teeth [19-21].

It was previously proposed that the magnitude of the difference of canine size is not isolated and that there is a "field" of sexual dimorphism that includes the teeth adjacent to the canines (incisors and premolars) [22, 23]. Interestingly, this study provided evidence of strong difference between the first premolars (BL dimensions of 14, 24, 34, 44) and lateral incisors (MD dimension of 12 and BL dimension of 22) of males and females.

Regarding the difference in tooth size between men and women, MD and BL dimensions were smaller in females than males in almost all teeth, corroborating with previous studies [20, 24].

Several studies have investigated the possible reasons for the morphological and developmental difference in teeth between men and women. Animal model studies suggested that specific genetic factors might be involved with specific types of tooth development [25]. According Schwartz and

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Table2. Effect size of the mesiodistal (MD) and buccolingual (BL) dimensions of the permanent teeth between male and female.

Tooth Type	Male		Female		Difference	Effect Size	p-value*
	Mean	Standard Deviation	Mean	Standard Deviation			
MD 33	7.24	0.41	6.85	0.42	0.39	0.94	**<0.001**
MD 43	7.29	0.45	6.90	0.43	0.39	0.88	**<0.001**
MD 13	8.32	0.50	7.94	0.50	0.38	0.76	**<0.001**
MD 23	8.32	0.48	7.96	0.52	0.36	0.72	**0.001**
BL 25	9.99	0.69	9.55	0.58	0.44	0.69	**0.001**
BL 15	10.00	0.69	9.58	0.53	0.42	0.68	**0.001**
BL 21	7.53	0.54	7.21	0.47	0.32	0.63	**0.002**
BL 24	9.86	0.70	9.51	0.43	0.35	0.61	**0.003**
BL 33	7.58	0.77	7.18	0.63	0.40	0.57	**0.005**
MD 25	7.16	0.39	6.88	0.59	0.28	0.56	**0.006**
BL 34	8.25	0.65	7.93	0.47	0.32	0.56	**0.006**
BL 14	9.86	0.66	9.54	0.44	0.32	0.56	**0.006**
BL 16	11.63	0.69	11.30	0.57	0.33	0.52	**0.010**
MD 15	7.21	0.40	6.97	0.53	0.24	0.52	**0.011**
BL 22	6.76	0.69	6.46	0.53	0.30	0.50	**0.014**
BL 11	7.47	0.60	7.22	0.43	0.25	0.49	**0.017**
MD 21	8.90	0.53	8.65	0.55	0.25	0.47	**0.021**
BL 44	8.18	0.69	7.90	0.54	0.28	0.45	**0.027**
MD 36	11.47	0.62	11.16	0.75	0.31	0.45	**0.027**
MD 26	10.69	0.63	10.40	0.66	0.29	0.45	**0.028**
MD 12	7.19	0.57	6.95	0.55	0.24	0.43	**0.033**
MD 16	10.79	0.67	10.52	0.62	0.27	0.42	**0.038**
MD 11	8.91	0.55	8.68	0.57	0.23	0.41	**0.044**
MD 46	11.45	0.64	11.18	0.71	0.27	0.40	**0.047**
BL 23	8.34	0.89	8.04	0.67	0.30	0.38	0.057
BL 45	8.83	0.70	8.60	0.55	0.23	0.38	0.061
BL 12	6.77	0.69	6.53	0.63	0.24	0.38	0.063
BL 36	10.71	0.64	10.49	0.54	0.22	0.36	0.072
BL 13	8.33	0.78	8.08	0.62	0.25	0.36	**<0.001**
BL 43	7.37	0.77	7.13	0.56	0.24	0.35	**<0.001**
BL 26	10.71	0.09	10.49	0.07	0.22	0.35	0.071
MD 22	7.19	0.63	6.99	0.54	0.20	0.34	0.094
BL 41	6.19	0.56	6.02	0.49	0.17	0.33	0.104
MD 24	7.47	0.46	7.32	0.57	0.15	0.30	0.137
BL 46	10.72	0.63	10.55	0.60	0.17	0.27	0.177
BL 35	8.80	0.79	8.62	0.52	0.18	0.27	0.182
BL 31	6.11	0.57	5.97	0.59	0.14	0.26	0.205
MD 34	7.49	0.44	7.37	0.54	0.12	0.25	0.210
MD 44	7.48	0.42	7.38	0.52	0.10	0.23	0.250
MD 32	6.23	0.41	6.13	0.44	0.10	0.23	0.254
BL 42	6.40	0.52	6.29	0.52	0.11	0.22	0.266
MD 45	7.60	0.51	7.48	0.52	0.12	0.22	0.270
MD 35	7.62	0.53	7.50	0.56	0.12	0.21	0.285
MD 14	7.42	0.43	7.33	0.50	0.09	0.21	0.305
BL 32	6.45	0.56	6.36	0.43	0.09	0.19	0.353
MD 31	5.60	0.39	5.53	0.36	0.07	0.17	0.399
MD 42	6.20	0.42	6.15	0.38	0.05	0.14	0.490
MD 41	5.58	0.36	5.54	0.36	0.04	0.11	0.600

Note: Effect size of the MD and BL dimensions of the permanent teeth between male and female. Tooth numbers coorelate to the numbers in Figure 1.
*Student's t test was used to compare the means between males and females.

Dean [6], sex hormone concentrations during development could relate to dental tis sue proportions in teeth forming at different moments. Smith et al. [26] obtained histological sections from molars and observed that males showed significantly greater dentine area, enamel—dentine junction length, and bi-cervical diameters in certain tooth types, while women presented significantly thicker average enamel. These results are consistent with the study of Saunders et al. [23], who noted that male canines and premolars have significantly more dentine than their female counterparts, as well as relatively more dentine with respect to overall crown size. The female canines and premolars have significantly more enamel relative to overall crown area than those of the males. Following this pattern, we presented some evidence that in humans, different dental groups might respond differently to the influence of sex chromosomes/hormones on crown development.

Another important aspect that should be taken into considerations is the ethnicity differences. Caucasian subjects presented some reduced dimensions when compared with African descendants. This should be taken into consideration in mixed populations, like Brazilians.

Table 3. Logistic regression analysis using ethnicity as covariates.

Tooth Type	p-value
BL 12	0.029
MD 15	0.005
BL 22	0.010
MD 16	0.021
MD 26	0.017
MD 32	0.150
MD 36	0.012
BL 45	0.029
MD 46	0.024

Note: Using maximum measurements of the mesiodistal (MD) and buccolingual (BL) dimensions. Tooth numbers coorelate to the numbers in Figure 1.

In summary, our findings reinforced the magnitude of sexual dimorphism in tooth size, and, in addition, highlighted the differences in specific dental groups. The approach taken in this manuscript (oversimplified with only tooth size variant analyzed) is a limitation to properly assess the explanations for tooth-size dimorphism between males and females.

Thus, further investigations, based on genetic, evolutionary, and metabolic/hormonal reasons for sexual dimorphism, will hopefully further clarify the etiology of sexual dimorphism in tissue proportions and dental development. In conclusion, our results established the degree of sexual dimorphism in permanent teeth of Brazilian individuals.

Conflict of interest: There are no conflicts of interest to report.

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