Sex Dimorphism in the Deciduous Dentition of Modern Pima

ANNALISA ALVRUS
Department of Anthropology, Box 872402, Arizona State University Tempe, AZ 85287-2402, U.S.A.

ABSTRACT A sample of primary teeth from a Pima Native American population was measured to determine the presence and amount of sex dimorphism. An average percent sex dimorphism of 2.40 was found. This finding is in accord with the findings of other researchers of low sex dimorphism in the primary dentition. The percent sex dimorphism for the primary dentition of the Pima was compared to percentages for the primary dentitions of a Caucasian and an Australian population. The amount of sex dimorphism in the Pima was found to be less than that in the Australians, but greater than that in the Caucasians. Finally, the hypothesis that the amount of sex dimorphism in primary and secondary dentitions is similar was tested and found to be true for this population of Pima.

INTRODUCTION

The presence of sex dimorphism in the size of the human permanent dentition has been extensively documented (Anderson and Thompson, 1973; Taylor, 1978; Hillson, 1986; de Paula et al., 1995). Sex dimorphism in the expression of certain nonmetric characters has also been noted (Kirveskari, 1974). This dimorphism has been applied to various archaeological and forensic problems, and its potential for identifying the sex of skeletal remains discussed (Garn et al, 1977; Lukacs and Hemphill, 1991; Bayer-Olsen and Alexandersen, 1995).

At least two questions arise from such research. One question is whether similar sex dimorphism exists in the human deciduous dentition and, if so, whether such dimorphism is also applicable in the archaeological and forensic realms. Numerous researchers have approached this question and have noted sex dimorphism in both size (Lukacs et al., 1983; Axelsson and Kirveskari, 1984; Farmer and Townsend, 1993) and nonmetric trait expression (Kitagawa et al., 1995) of the deciduous dentition. Other researchers have examined the possibility of using size dimorphism in deciduous teeth for sexing skeletons in forensic investigations (Bailit and Hunt, 1964; De Vito and Saunders, 1990), as well as in archaeological studies (Sawyer et al., 1982). A second question which might be asked is whether there is correspondence between the degree of sex dimorphism in the primary and secondary dentitions. This is a question that has not been addressed to a significant extent in the literature.

This paper addresses both of these questions. Results from a study of the deciduous dentition of a population of Native Americans (Pima) from Arizona are described. The teeth were first measured and the measurements tested to determine the presence and quantify the amount of dimorphism. This sex dimorphism was compared to the published information on sex dimorphism in the deciduous dentition of a Caucasian and an Australian aboriginal population. Finally, the percentages of sex dimorphism were compared to the published percentages of dimorphism in the permanent dentition of the Pima.

MATERIALS AND METHODS

The casts were drawn from an assemblage of over 9,000 dental casts of Pima Indians from Arizona. These casts are part of the Arizona State University cast collections. The Pima casts were made under the direction of Albert A. Dahlberg and Thelma Dahlberg, who kept demographic and genealogical data on each individual.

Casts of the deciduous dentition were selected by visual inspection. When possible, casts with a complete set of twenty primary teeth were chosen. Since many of the casts had flaws such as casting defects, caries destruction, excessive interproximal wear, or broken or otherwise abnormal teeth, some casts missing up to two deciduous teeth (usually mandibular central incisors) were used to increase the sample size. Originally, a sample of 50 individuals (25 males and 25 females) was selected; after

measurements were made, however, problems were found with three of these casts. These three sets of measurements were discarded, leaving a total sample of 24 males and 23 females.

The mesiodistal and buccolingual dimensions of each tooth were measured. Following Hillson (1986:233), mesiodistal diameter is defined as the distance between the point of contact with the other teeth in the dental arcade or, if the tooth was rotated slightly, where these points of contact should have been. Buccolingual breadth is defined as the maximum diameter of the crown, including the cingulum bulge. Measurements were made by a single observer and no more than seven casts were measured at a single sitting to avoid mismeasurements due to fatigue on the part of the observer. Measurements were taken using needlepoint Hellos dial calipers reading to 0.05 mm. Intraobserver error was checked by randomly selecting and remeasuring casts on different days than when measurements were originally taken. A remeasured sample of 17% of the original sample indicated a mean measurement error of 0.30 mm for this observer. Only measurements of left teeth left were used in the comparisons made in this paper, after (DeVito and Saunders, 1990).

RESULTS

Tables 1 and 2 have summaries of the results of the measurements made on the dental casts. The number of dimensions available for measurement, the mean, range, standard deviation, and percentage of dimorphism for each tooth class are indicated. Percent sex dimorphism ranges from -1.13% for the buccolingual diameter of the lower first molar to 8.12% for the mesiodistal diameter of the lower central incisor. The average percent sex dimorphism for the dentition overall is 2.40.

A Student's t-test was run on those dimensions which exceeded 3.00% sex dimorphism. The results are as follows: MD i_1: t=0.229 (35 df); MD m_2: t=0.122 (43 df); BL i^2 t=0.175 (45 df); BL c^1: t=0.178 (45 df); BL i_1: t=0.103 (35 df). None of these results are significant at the $p \geq 0.05$ level, reinforcing the finding of low sex dimorphism for this population of Pima.

Table 3 gives the results of the analysis of the percent sex dimorphism in the deciduous teeth of three populations: the Pima studied in this report, Australian aboriginal children examined by Margetts and Brown (1978), and Caucasian children from Michigan studied by Black (1978). Margetts and Brown used averaged values from left and right teeth to derive their figures, and their sample sizes for different tooth dimensions range from 8 to 115. Black used the right deciduous teeth of 69 males and 64 females.

Finally, Table 4 has the results of a chi square test of the percent sex dimorphism in the maxillary and mandibular primary and secondary dentitions of the Pima. Data on sex dimorphism in the secondary dentition of the Pima is taken from published information in Garn et al., 1967. The result of the chi square test indicates that the null hypothesis of no difference between percent sex dimorphism in the primary and secondary dentitions cannot be rejected for this population.

DISCUSSION

Sex dimorphism in the permanent and deciduous dentitions has been shown to be due to a longer period of amelogenesis in males than in females, which results in a thicker layer of enamel in male teeth than female teeth (Moss and Moss-Salentijn, 1977; Moss, 1978). While certain environmental factors may influence the morphology and metrics of developing permanent and deciduous teeth (Garn et al., 1979; Hershkovitz et al., 1993; May et al., 1993), for the most part prenatal tooth formation appears to be under strong genetic control (Goose, 1971; Thesleff, 1995) and "absolute variation in prenatal tooth formation is . small" (Smith, 1991:155). This suggests that the sex dimorphism measured by this and other studies is measuring real, genetically determined differences between males and females and not random fluctuations of tooth size.

This study has positively determined the presence and has quantified the amount of sex dimorphism in a sample of a Pima Native American population. The figure of 2.40% average dimorphism is expected in light of the published reports of similar amounts of sex dimorphism in the permanent dentition of the

TABLE 1. Mean mesiodistal measurements (in mm) of left deciduous teeth and percent (%) dimorphism.

	MALES				FEMALES				Dimorphism
Tooth	N	Mean	Range	SD	N	Mean	Range	SD	%
i^1	22	6.83	5.55-7.55	0.494	22	6.81	6.30-7.40	0.284	0.29
i^2	24	5.76	4.95-6.80	0.420	23	5.73	5.30-6.55	0.291	0.52
$c^{maxilla}$	24	7.13	6.20-7.80	0.405	23	6.96	6.10-7.95	0.450	2.44
m^1	23	7.49	5.50-8.50	0.595	22	7.36	6.80-8.05	0.342	1.77
m^2	24	9.75	8.75-10.90	0.509	22	9.53	8.35-10.50	0.459	2.31
i_1	18	4.66	4.25-6.00	0.398	19	4.31	4.00-6.15	0.333	8.12
i_2	23	4.97	4.40-5.55	0.304	23	4.89	4.40-6.15	0.350	1.64
$c_{mandible}$	24	6.14	5.80-7.05	0.317	23	6.03	5.25-6.65	0.341	1.82
m_1	23	8.17	7.70-9.05	0.406	21	8.05	7.15-9.00	0.474	1.49
m_2	23	10.84	10.15-11.90	0.481	22	10.44	9.25-11.85	0.548	3.83
Average									2.42

% dimorphism = 100 (male mean/female mean)-100 (Black, 1978). N number of dimensions available for measurement. SD atandard deviation

TABLE 2. Mean buccolingual measurements (in mm) of left deciduous teeth and percent sex dimorphism

	MALES				FEMALES				Dimorphism
Tooth	N	Mean	Range	SD	N	Mean	Range	SD	%
i^1	23	5.20	4.35-5.95	0.352	22	5.06	4.10-6.45	0.490	2.77
i^2	24	5.15	4.60-5.70	0.321	23	4.88	4.30-5.70	0.380	5.53
$c^{maxilla}$	24	6.37	5.60-7.40	0.439	23	6.03	5.40-7.30	0.428	5.64
m^1	23	9.17	8.50-10.30	0.413	23	9.01	8.30-9.95	0.418	1.44
m^2	24	10.63	9.90-11.80	0.518	21	10.43	9.70-11.40	0.372	1.92
i_1	18	4.09	3.50-4.80	0.310	19	3.94	3.05-4.60	0.414	3.81
i_2	23	4.62	4.30-5.15	0.228	23	4.52	3.90-5.75	0.485	2.21
$c_{mandible}$	24	5.89	5.20-6.60	0.342	23	5.75	5.00-6.65	0.395	2.43
m_1	24	7.86	7.10-8.90	0.424	22	7.95	7.00-9.80	0.714	-1.13
m_2	24	9.64	8.95-10.75	0.357	23	9.72	9.00-11.10	0.513	-0.82
Average									2.38

Pima (Garn et al., 1967) and the fact that sex dimorphism is usually low in the human primary dentition (Black, 1978; Margetts and Brown, 1978; Farmer and Townsend, 1993).

Whether the sex dimorphism found in the primary dentition could be applied to forensic and archaeological problems is questionable because the mean measurements for females occasionally exceed those of males. Table 2 reflects this fact; the female means for the buccolingual diameter of both the mandibular molars exceed the male means. Additionally, a glance at Tables 1 and 2 indicate that the range of size variation can be quite extreme, with the female range extending well into and even surpassing the male range: or example, the mesiodistal ranges for the maxillary canines and the mandibular incisors. Although some of the peculiarities of the figures determined by this study (e.g., the 12% sex dimorphism in the mesiodistal diameter of i_1) might be "smoothed" by a larger sample size, it appears that the generally low sex dimorphism, in combination with the wide range of tooth size variation, make the applicability of sex dimorphism in deciduous teeth to problems of skeletal identification problematic (Taylor, 1978). Other researchers believe, however, that they are able to achieve a more reliable result through the use of multivariate statistical methods (De Vito and Saunders, 1990). In sum, tooth size might be used, in conjunction with other skeletal or cultural evidence, to support a sex assignment for human remains.

The average percent sex dimorphism can vary among populations (Harris and Rathbun, 1991), as shown by the comparisons of deciduous dentitions in Table 3 and as shown by Garn et al. (1967) in their Table 2, which compares the permanent dentitions of nine different populations. In this study of primary teeth, the Pima exhibited less sex dimorphism than Australian children, but more than children of European ancestry. The variation in amount of dimorphism among populations is one fact which must be kept in mind when attempting to use the teeth to make a suggestion about the sex of skeletal remains. The percent sex dimorphism and the ranges of male and female variation must be known for the specific population to which those remains belonged before the teeth can be used to bolster a hypothesis concerning the individual's sex.

TABLE 3. Percent (%) dimorphism in deciduous teeth from three different populations.

Tooth Class	Caucasians	Pima	Australians
Maxilla			
i^2	-1.50	1.53	2.66
i^2	-0.09	3.03	2.85
c	2.07	4.04	3.49
m^1	2.34	1.61	3.54
m^2	1.25	2.12	3.09
Mandible			
i_1	-0.60	5.97	3.57
i_2	-1.26	1.93	2.03
c	0.62	2.13	3.14
m_1	1.12	0.18	3.68
m_2	2.13	1.51	2.71
Average %	0.61	2.41	3.08

That the primary dentition may impact the secondary dentition in certain ways (see, e.g. Schulz, 1992) and that certain nonmetric traits may differentiate between populations only in the deciduous dentition (Kitagawa et al, 1995) have been shown. However, the precise correspondence between metric and nonmetric characteristics of the two dentitions has not yet been completely investigated. While, this study did not find a statistically significant difference between the percent sex dimorphism in the permanent and deciduous teeth of the Pima (Table 4), this result may not be true for all populations. In this study the Pima exhibit less sex dimorphism in the primary teeth than do the Australian children, yet more than the Caucasian children. This is interesting when compared with the findings of Garn et al. (1967) who stated that the permanent dentition of the Pima "is characterized by large teeth but small percent dimorphism; Ohio [Caucasian] subjects . . . have absolutely smaller teeth, but a larger percentage dimorphism"(p. 965). While this may be due to the different populations of Caucasians in the two studies, the differences nonetheless suggest that the examination of correspondence (or lack thereof) in size, dimorphism, and nonmetric trait expression between the primary and secondary dentitions could be a fruitful field of study.

TABLE 4. Chi square test of sex dimorphism percentages in Pima deciduous and permanent dentitions.

	Observed	Expected	Observed	Expected	Totals
Maxilla	2.47	2.40	1.67	1.74	4.14
Mandible	2.34	2.42	1.84	1.76	4.18
Totals	4.81		3.51		8.32

$x^2 = 0.50$ (after corrections with Yates correction factor)

SUMMARY and CONCLUSIONS

The measurements from the deciduous teeth of the Pima used in this study indicate a fairly low degree of sex dimorphism. This is expected given the published reports of low sex dimorphism in the deciduous teeth of other human groups. The amount of sex dimorphism was similar between the permanent and deciduous dentitions of the Pima. Sexing subadult remains is always a difficult task; the findings of the paper suggest that using the deciduous dentition to assign a sex may be problematic. A number of research questions concerning the potential of the primary dentition to answer certain archaeological and forensic questions still remain to be explored.

ACKNOWLEDGEMENTS

I am indebted to Dr. Christy G. Turner, II for his advice and direction in this research and paper preparation.

LITERATURE CITED

Anderson DL, Thompson GW. 1973. Interrelationships and sex differences of dental and skeletal measurements. J Dent Res 52:431-438.

Axelsson G, Kirveskari P. 1984. Crown size of deciduous teeth in Icelanders. Acta Odontol Scand 42:339-343.

Bailit H, Hunt EE Jr. 1964. The sexing of children's skeletons from teeth alone and its genetic implications. Am J Phys Anthropol 22:171-174.

Beyer-Olsen EMS, Alexandersen V. 1995. Sex assessment of Medieval Norwegian skeletons based on permanent tooth crown size. Int'l. J Osteoarch 5:274-281.

Black TK III. 1978. Sexual dimorphism in the tooth-crown diameters of the deciduous teeth. Am J Phys Anthropol 48:77-82.

De Vito C, Saunders SR. 1990. A discriminant function analysis of deciduous teeth to determine sex. J Foren Sci 35:845-858.

Farmer V, Townsend G. 1993. Crown size variability in the deciduous dentition of South Australian children. Am J Hum Biol 5:681-690.

Garn SM, Cole PE, Wainwright RL, Guire KE. 1977. Sex discriminatory effectiveness using combinations of permanent teeth. J Dent Res 56:697.

Garn SM, Lewis AB, Swindler DR, Kerewsky RS. 1967. Genetic control of sexual dimorphism in tooth size. J Dent Res Supp 46:963-972.

Garn SM, Osborne RH, McCabe KD. 1979. The effect of prenatal factors on crown dimensions. Am J Phys Anthropol 51:665-678.

Goose DH. 1971. The inheritance of tooth size in British families. In: Dahlberg AA, editor. Dental Morphology and Evolution. Chicago: Chicago University Press, p. 263-270.

Harris EF and Rathbun TA. 1991. Ethnic differences in the apportionment of tooth sizes. In: Kelly MA, Larsen CS editors. Advances in Dental Anthropology. New York: Wiley Liss, p. 121-142.

Hershkovitz I, Livshits G, Moskona D, Arensburg B, Kobyliansky E. 1993. Variables affecting dental fluctuating assymetry in human isolates. Am J Phys Anthropol 91:349-365.

Hillson S. 1986. Teeth. Cambridge: Cambridge University Press.

Kirveskari P. 1974. Morphological Traits in the Permanent Dentition of Living Skolt Lapps. Turku, Finland: University of Turku.

Kitagawa Y, Yoshitaka M, Oyamada J, Rokutanda A. 1995. Deciduous dental morphology of the prehistoric Jomon people of Japan: comparison of nonmetric characters. Am J Phys Anthropol 97:101-111.

Lukacs JR, Hemphill BE. 1991. The dental anthropology of prehistoric Baluchistan: a morphometric approach to the peopling of South Asia. In: Kelly MA, Larsen CS editors. Advances in Dental Anthropology. New York: Wiley Liss, p. 77-119.

Lukacs JR, Joshi MR, Makhija PG. 1983. Crown dimensions of deciduous teeth of prehistoric and living populations of Western India. Am J Phys Anthropol 61:383-387.

Margetts B, Brown T. 1978. Crown diameters of the deciduous teeth in Australian aboriginals. Am J Phys Anthropol 48:493-502.

May RL, Goodman AH, Meindl RS. 1993. Response of bone and enamel formation to nutritional supplementation and morbidity among malnourished Guatemaian children. Am J Phys Anthropol 92:37-51.

Moss ML. 1978. Analysis of developmental processes possibly related to human dental sexual dimorphism. In: Butler PM, Joysey KA, editors: Development, Function and Evolution of Teeth. New York: Academic Press, p. 135-148.

Moss ML, Moss-Salentijn L. 1977. Analysis of developmental processes possible related to human dental sexual dimorphism in permanent and deciduous canines. Am J Phys Antropol 46:407-414.

de Paula S, de Oliveira Almeida MA, Lee PCF. 1995. Prediction of mesiodistal diameter of unerupted lower canines and premolars using 45 degree cephalometric radiography. Am J Orthod Dentofac Orthop 107:309-314.

Sawyer DR, Allison MJ, Pezzia A, Mosadomi A .1982. Crown dimensions of deciduous teeth from pre-Columbia Peru. Am J Phys Anthropol 59:373-376.

Schulz PD. 1992. Turner teeth and childhood caries in a protohistoric California Indian population. Int J Osteoarch 2:263-270.

Smith BH. 1991. Standards of human tooth formation and dental age assessment. In: Kelly MA, Larsen CS editors: Advances in Dental Anthropology. New York: Wiley Liss, p. 143-168.

Taylor RMS. 1978. Variation in Morphology of Teeth: Anthropologic and Forensic Aspects. Springfield, IL: Charles C. Thomas.

Thesleff I. 1995. Homeobox genes and growth factors in regulation of craniofacial and tooth morphogenesis. Acta Odontol Scand 53:129-134.