A STUDY OF MESIO-DISTAL TOOTH DIMENSION OF PRIMARY CANINES AND MOLARS IN TWINS

by

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A Thesis

Presented to the Department of Pedodontics and the Graduate Committee of the University of Oregon Dental School in partial fulfillment of the requirements for the degree of Master of Science in Dentistry

June, 1963

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ACKNOWLEDGMENTS

The investigator wishes to express appreciation to the members of the Advisory Committee; Dr. Donald R. Porter, Dr. Kuo Hwa Lu, and Mr. Myron D. Tedford, for their constructive criticisms and kind assistance in conducting this research project and preparing this paper.

The investigator also wishes to acknowledge the generosity of Dr. Bhim S. Savara of the Child Study Clinic in providing the materials used in this study.

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INTRODUCTION

Genetic control of differences in tooth size has long been assumed. As early as 1880, it was held that inheritance of large teeth out of proportion to the inherited jaw was one of the causes of irregularities of the teeth (13). Today, discrepancy in arch length and tooth size is considered a prime factor in malocclusion. These discrepancies have directed attention to analyzing the effect of heredity on the size of teeth in the permanent dentition.

The primary canines and molars assume an important role in the development of occlusion. Their size, both actual and relative to their permanent successors, is a major factor in the position of the first permanent molars. An understanding of genetic control of the size of these primary teeth will contribute toward an appreciation of one of the variables affecting the problem of discrepancy within the dental arch.

The mesio-distal tooth dimension is directly related to the position of teeth in the dental arch.

The objective of this investigation is to determine the effect of genetic control on the variation observed in the mesio-distal dimension of each of the right and left, maxillary and mandibular primary canines and molars.

REVIEW OF THE LITERATURE

The Twin Study Method

The use of twins in genetic research dates back to Galton in 1875 (6), who first recognized the genetic significance of twins in evaluating the 'nature-nurture' problem. However, it was not until 1920 (8) that objective comparisons of twins began to appear in the literature.

The theory that there are only two distinct and distinguishable types of twins, monozygotic (single ovum) and dizygotic (double ova), is basic to the method. The two members of a monozygotic (identical) twin pair are assumed to have identical genetic endowments or a coefficient of genetic relationship of 1.0. Observable differences between two members of a monozygotic twin pair must result from environmental influences alone. The two members of a dizygotic (fraternal) twin pair have an average coefficient of genetic relationship of 0.5, which is the same degree of similarity found in ordinary siblings. Differences between members of dizygotic twin pairs must result not only from environmental influences but also from differences in their genetic constitutions (17).

Recognition of the foregoing allows interpretation of genetic control of a quantitative character, such as mesio-distal tooth dimension. The genetic identity of the monozygotic pairs affords a basis for evaluating the relative contribution of genetic factors to total observed differences within pairs of dizygotic twins. Thus, accurate diagnosis of zygosity, i.e., determining whether the pairs are monozygotic or dizygotic, is critical in studies which compare the two twin categories.

The number of chorions, as reported by obstetrical records, served as the criterion for diagnosis of zygosity by early workers. This has since been shown to be fallible (3).

In 1927 Siemens (25) introduced the similarity method for diagnosis of zygosity. Based on phenotypic resemblances, twins very similar in their physical make-up were regarded as monozygotic, and those less similar sets were classified as dizygotic. Objections raised to Siemens' method were concerned with the intangible nature of the differences or similarities used as diagnostic criteria, and subjectivity involved in diagnosis.

The dermatoglyphic characters were used to extend the criteria used in zygosity determination. Evidence for the reliability of this method was derived from testing for agreement with a diagnosis made by Siemens' similarity method (18). This involved an element of circular reasoning in testing for reliability, which tended to overestimate heritability. Dermatoglyphics can be an aid in diagnosis, but never is conclusive proof of zygosity, since Smith and Penrose (26) showed a range of overlap between total ridge counts of monozygotic twin pairs and like-sex sibling pairs.

With advances in serological genetics in about 1940, blood group systems were included in statistical calculation of probability values in twin diagnosis. However, it was not until 1955 that an increase in the number of available antisera made it possible to diagnose zygosity of twins with a high degree of accuracy (18, 26).

The blood groups have great value in diagnosis of twin zygosity. Their mode of inheritance has been established as major gene traits, with a high level of penetrance. These phenotypic characteristics have been shown to have a uniformity of expression which permits an objective and reliable classification of its variants. Thus, obvious conclusions drawn from earlier twin research without blood group tests to determine zygosity were of questionable validity, due to the unreliable methods used in zygosity diagnosis.

Studies of Genetic Control of Tooth Size

In 1928, Reif (22) reported findings concerning the significance of heredity in relation to the mesio-distal size of the permanent maxillary central and lateral incisors and the first molars of both arches. He utilized twenty-seven monozygotic twin pairs, eighteen like-sex dizygotic pairs, and four unlike-sex dizygotic pairs in his study. Difference within the pairs of twins was expressed as a percentage of the average value of the pair. For the central incisors and the first molars, no differences in measurements were demonstrated between the right and left teeth which were combined for analysis. Variations between right and left maxillary lateral incisors necessitated separate analysis of each. His findings showed a higher intra-pair difference in the dizygotic twin group.

Korkhaus, in 1930 (14), studied the same teeth in forty-two monozygotic and thirty-three dizygotic twins. His findings supported those of Reif. Both reports imply that genetic factors are of importance in the mesio-distal dimension of the teeth studied. Korkhaus also calculated the differences between right and left sides in individual twin members as to width and thickness of the permanent maxillary lateral incisors. The mean differences expressed in percentage of the averages showed greater similarity between the right and left sides in monozygotic twins than dizygotic twins.

Bratengeier, in 1934 (2), measured the mesio-distal width, thickness, and height of the twelve permanent anterior teeth of thirty-eight pairs of twins (twenty monozygotic and eighteen dizygotic). His data showed a higher intra-pair variation for dizygotic twins than the monozygotic twins, using the percentage difference described by Reif.

From a study of the shape of dental arches of fifteen pairs of monozygotic twins, Goldberg, in 1929 and 1930 (8,9), noted that bilateral differences within an individual twin member were greater than unilateral differences with the co-twin for respective mesio-distal tooth widths. Photographs of dental casts were used to measure all of the permanent teeth. Bilateral differences within the individual, as well as unilateral differences between twins for corresponding teeth, were determined. Goldberg stated that the relationship between the unilateral and bilateral differences constituted a measurement of the effect of heredity in relation to that of environment; i.e., the less the quotient, the greater the significance of heredity.

Lundstrom, in 1948 (15), studied tooth size and occlusion in a large Swedish sample of one-hundred monozygotic twins and one-hundred-two dizygotic twins of the same sex, ranging in age from eight to forty years. Mesio-distal measurements were made on teeth of the permanent dentition from the central incisors to the first molars. Types of variations examined were as follows: (1) asymmetric variability between right and left sides of an individual, (2) environmentally controlled variability between monozygotic twins, and (3) genetically controlled variability between dizygotic twins. Lundstrom found generally moderate asymmetric variability and monozygotic intra-pair variability with a considerably larger dizygotic intra-pair variability. He concluded that genetic factors were of greater significance than asymmetry and environmental factors in accounting for the variability in permanent tooth size. Walker (27), challenged these findings by questioning the diagnosis of zygosity of the twins, which was done with the physical similarity method.

In a thesis entitled, "Heredity's Part in Tooth Size as Observed in Twins, Siblings, and Non-blood-related Individuals," Rivera, in 1954 (23), studied twelve permanent teeth. The maxillary and mandibular teeth from central incisors to, and including, the first molars of the right side, were measured for width and thickness. His findings showed that the mean of the differences for each tooth of monozygotic twins was below the lowest limit of the range of differences of pooled dizygotic twin and sibling pairs. The mean of the differences of dizygotic twins plus siblings was below the lowest limit of the range of non-blood-related pairs. This finding was true whether combined or single measurements were considered. In the dizygotic twin and sibling groups, the means and ranges fell within close proximity of each other for separate or combined tooth groups.

Rivera concluded that heredity played the greatest part in determining tooth size, since the monozygotic twins showed less dissimilarity than the pooled dizygotic twin and sibling pairs. The latter, in turn, showed less dissimilarity than the non-blood-related paired individuals. This was the first study of tooth dimension to use blood group tests as diagnostic criteria of zygosity. Zygosity determinations were also supported by tests in secretor factor, PTC taste reaction, and dermatoglyphics.

In 1958, Horowitz, Osborne and DeGeorge (10) analyzed hereditary variation in mesio-distal tooth dimension in fifty-four twin pairs, thirty-three monozygotic and twenty-one like-sex dizygotic, with an average age of twenty-seven years. The teeth studied were the twelve permanent anterior teeth. Mean intra-pair variances were calculated for each tooth in both twin categories, expressed as a ratio, and a table of "F" distribution was used to determine the significance of the difference in variances between the categories.

Their results demonstrated significantly greater mean dizygotic than monozygotic intra-pair variances for the incisors and the right mandibular canine, which they interpreted as indicating a highly discernible genetic control of the mesio-distal dimensions of these teeth. The mean intra-pair variances of the three remaining canine teeth were not significantly different for the two twin categories, and were judged to have a low genetic control. Analysis of bilateral asymmetry in monozygotic twins of this study indicated that variability of teeth on the left side is sex-influenced, with greater variation in the male than in the female group. Diagnosis of zygosity was based on proving dizygosity by blood groups, eye color, ear form and dermal patterns. This method would tend to underestimate the inheritance factor of the trait studied if error should occur in diagnosis.

Using the same twin material, Osborne, Horowitz and DeGeorge (19), studied genetic control of the interrelationship of the mesio-distal dimension of the permanent anterior teeth. They found that the correlation coefficients between different teeth within individuals and between co-twins of monozygotic pairs were significant. This finding was interpreted as indicating genetic control of tooth size common to adjacent teeth, and supportive of the hypothesis of genetic control for general tooth size. The correlation coefficients obtained in a similar analysis of the dizygotic twin pairs were interpreted as evidence of some "genetically conditioned independence of maxillary lateral incisors and canines of both arches, so that other genetic factors, in addition, affect the size of these specific teeth." These investigators reasoned that completion of maximum size of the permanent anterior teeth occurred at different times; and thus, their findings that the size of these teeth were under different genetic control indicated a possibility of association in time of development, size, and genetic control.

In 1962, Armstrong (1), studied the permanent anterior teeth on five sets of triplets. Blood group tests were supplemented by other similarity tests for zygosity diagnosis. The mean value of the right and left sides were used. His findings showed a genetic control in the combined mesio-distal dimensions of the teeth studied. When each tooth type was separately analyzed, only the maxillary lateral incisor and canine demonstrated a genetic control of their variation.

The past literature has revealed information on the inheritance of the mesio-distal tooth dimension in the permanent dentition. No similar analysis has been made of the primary dentition. Publication of measurements of primary teeth by Seipel (24) and Moorrees (16) present the only data that are sufficient for comparative studies. The mean mesio-distal crown diameters of the primary teeth are smaller for the North American white population studied by Moorrees than for the Swedish population studied by Seipel, except for the maxillary second primary molars. The standard deviations of the measurements of primary canines and molars indicate a degree of variation comparable to that of their successors.

MATERIALS AND METHODS

The Sample and Diagnosis of Zygosity

A group of forty-four pairs of Caucasian twins of the middle-income population of Portland, Oregon, and vicinity was studied. These twins are enrolled in the Child Study Clinic of the University of Oregon Dental School. There were twenty-nine monozygotic pairs (seventeen male and twelve female), and fifteen like-sex dizygotic pairs (seven male and eight female), who had study casts with tooth structure available for study. Subjects ranged in ages from 3.5 years to 10.5 years.

Zygosity diagnosis was based entirely on tests of the blood group systems. Blood samples were collected from subjects and both parents for typing studies by the Division of Experimental Medicine of the University of Oregon Medical School. Blood groupings tested and the antisera used were as follows:

Blood Group System	Serum Antibodies Used
ABO	A, A_1, B
MNS	M, N, s
Rh	C, D, E, c, e, C^w
P	P
Kell	K, k, Kp^b
Duffy	Fy^a
Kidd	Jk^a, Jk^b

Discordance for any one of these antisera was regarded as sufficient evidence for dizygosity. In this study, the level of probability of dizygosity for concordant twins was established at five percent, according to the method described by Smith and Penrose (26).

Measurement Method

Stone models, prepared from alginate impressions of the maxillary and mandibular teeth of each subject, were used for measurement of the primary teeth. Teeth with proximal restorations as checked against intra-oral roentgenograms, or proximal caries with a breakdown of marginal ridges, and those with cast defects were excluded from the study material.

With the cast viewed from the occlusal, anatomical landmarks of each tooth were defined for orientation during measurement using Wheeler's (28) description of tooth anatomy. Contact areas between teeth were disregarded. The beaks of the caliper were held parallel to the landmarks in order to register the largest measurement as the mesio-distal dimension. The following landmarks were used for this orientation and are shown in Figure 1 (See page 15):

1. Canines. A line along the center of the labial prominence, from the gingival margin toward the cusp tip, and extended over to the lingual surface along the center of the lingual ridge, served to guide the placement of caliper beaks. The centers of abraded areas were used as the cusp tips when these were worn, as was done for landmarks of other teeth.

2. Maxillary First Molar. The tips, or estimated loci, of the two major cusps, the mesio-buccal cusp and the mesio-lingual cusp, were joined to form an imaginary line to which the beaks of the caliper were held parallel.

3. Mandibular First Molar. The midpoint between the two buccal cusps along the occlusal margin was joined in a line with the midpoint

between the two lingual cusps to allow reorientation of the caliper beaks. The easily visible triangular ridges of the two mesial cusps were, at times, conveniently used when they occurred in a direction parallel to the estimated line.

4. Maxillary Second Molar. The point at which the buccal developmental groove crossed from the occlusal surface onto the buccal surface was accepted as the midpoint between the two buccal cusp tips. This point, joined with the estimated midpoint between the two lingual cusp tips, (usually mesial to the disto-lingual developmental groove), was used to guide the caliper beaks in determination of mesio-distal dimension.

5. Mandibular Second Molar. The trapezoidal shape of the occlusal surface of this tooth posed the least problem in measuring the widest mesio-distal dimension. The tip of the middle, disto-buccal cusp was joined with the lingual developmental groove to guide the caliper placement.

Second molars were measured only when the distal marginal ridge was completely visible. Those teeth in which this ridge was partially covered by tissue were excluded from the study material. Whenever possible, primary second molars were measured after the permanent first molars had erupted, since casts of the same child at different ages were available.

The same light source was used in a consistent manner for placement and reading of the instrument. The caliper was removed from the cast and read along a straight line with the light source, to reduce errors of parallax.

All measurements were made to the nearest 0.1 millimeter. The same Boley gauge with Vernier calibrations, sharpened to a point, was used throughout. This instrument was standardized against a John Bull caliper

(British Indicators Ltd.) at three separate occasions, before and during the process of measuring, and after measurements were completed. Care was taken to avoid measuring casts of twin pairs during the same period. The teeth of right and left sides of each cast were measured separately, in a nonspecific order, and at different times as unknowns relative to zygosity. A set of duplicate measurements was taken for all teeth to assess measurement error after the first set was completed. All observations were made by the same person. Errors which might have arisen because of differences in the handling of the impressions and their pouring were assumed to be randomly distributed between the groups.

Statistical Analysis

Attention has been called recently to those environmental factors, especially prenatal (12,21), that have different effects; both on individual twin members, and on monozygotic and dizygotic twin pairs. It is to be expected that a certain degree of variability results from forces common to both members of a pair, and some degree of variability results from forces acting on each individual of the pair. In other words, the two members of a pair have something in common and each individual has a variation peculiar to himself which is not shared by the co-twin.

The total observed variance in mesio-distal dimension for the individual teeth measured was partitioned into the following components: measurement error (σ_m^2), individual variation (σ_i^2), differences between twin pairs (σ_p^2), sex difference (σ_s^2), and difference in zygosity (σ_z^2). In order to extract the components due to these various factors, the analysis of variance with hierarchal classification (11) was used. A diagram of the statistical model is shown in Figure 2.

The analysis of variance is shown in Table 1.

The expected values of the different components of variance were calculated with the appropriate coefficients (k) according to Gates and Shiue (7).

In this study, the component of the between-zygosity variance was the focal point of interest, and was attributed to genetic effect. All other effects (error, individual, pair, sex) were sorted out by partition. Given the estimate of each component of variance, the proportion of genetic effect on the variability of mesio-distal tooth dimension observed in an individual may be derived by the ratio:

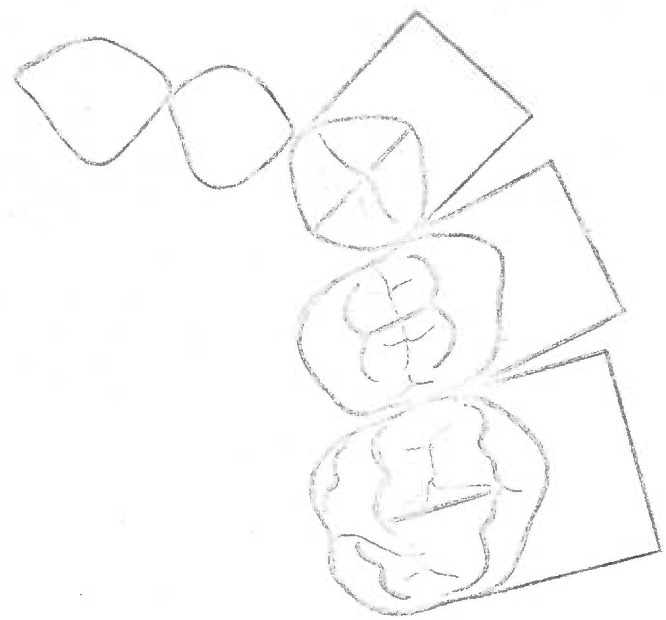
$$h^2 = \frac{\sigma_z^2}{\sigma_z^2 + \sigma_i^2}$$

where h^2 = heritability estimate in percentage

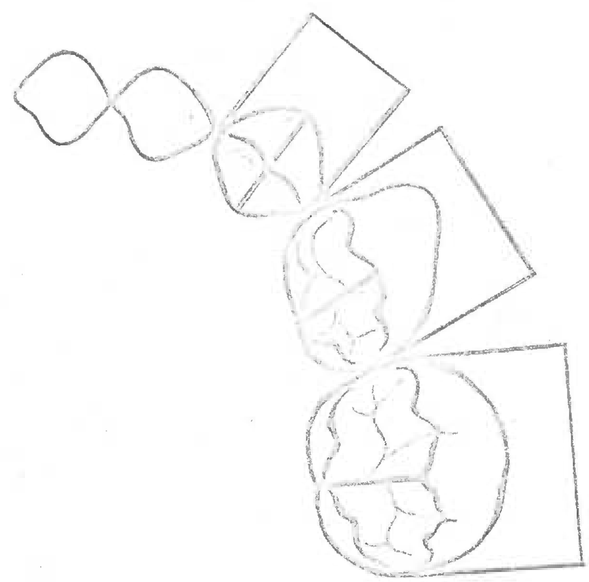
σ_z^2 = variance due to zygosity difference

σ_i^2 = variance due to an individual

A separate analysis was performed for each of the twelve teeth studied. A complete calculation leading to the mean square estimate of the different components of variance, from which an intraclass correlation (ratio) was computed for heritability estimate, is exemplified in Table 2 for the mandibular right first primary molar. All calculations were carried to the 6th decimal place, with the last two digits rounded off in the tabulations.



A. Maxillary primary canine, first molar, and second molar.



B. Mandibular primary canine, first molar, and second molar.

Figure 1. Landmarks to which Caliper Beaks were Paralleled for Reorientation.

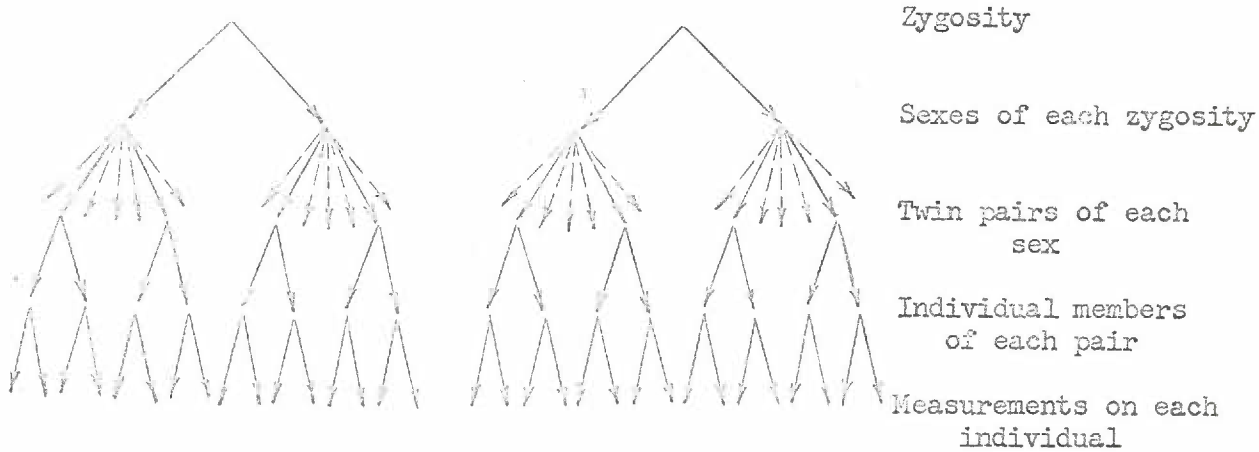


Figure 2. A Diagram of the Statistical Model in the Hierarchal Classification of the Analysis of Variance.

Table 1.

The Analysis of Variance for the Hierarchal Classification.

Source of Variation	d.f.	Sums of Squares	Mean Square Estimate of:				
			σ_m^2	σ_i^2	σ_p^2	σ_s^2	σ_z^2
(z) Between zygosities	z − 1	$\sum \frac{X_z^2}{N_z} - \frac{X^2}{N}$	1	k_{14}	k_{13}	k_{12}	k_{11}
(s) Between sex groups within zygosities	s − z	$\sum \frac{X_s^2}{N_s} - \sum \frac{X_z^2}{N_z}$	1	k_{24}	k_{23}	k_{22}	
(p) Between pairs within sex groups	p − s	$\sum \frac{X_p^2}{N_p} - \sum \frac{X_s^2}{N_s}$	1	k_{34}	k_{33}		
(i) Between individuals within pairs	i − p	$\sum \frac{X_i^2}{N_i} - \sum \frac{X_p^2}{N_p}$	1	k_{44}			
(m) Between measurements within individuals	m − i	$\sum X_m^2 - \sum \frac{X_i^2}{N_i}$	1				
Total	n − 1						

Table 2.

Hierarchal Analysis of Variance for Mesio-Distal Dimension of the Mandibular Right First Primary Molar of Monozygotic and Dizygotic Twin Pairs.

Source of variation	d.f.	Sums of squares	Mean square	Estimate of:					Derived intraclass correlation
				$\sigma_m^2 =$ 0.0056	$\sigma_i^2 =$ 0.0372	$\sigma_p^2 =$ 0.1060	$\sigma_s^2 =$ 0.0061	$\sigma_z^2 =$ 0.0224	$h^2 = \frac{\sigma_z^2}{\sigma_i^2 + \sigma_z^2}$
Between zygosities	1	1.9635	1.9635	1	2	4	27.0667	57.6	0.3759 (Heritability Estimate)
Between sex groups within zygosities	2	1.3533	0.6766	1	2	4	28		
Between pairs within sex groups	26	13.1129	0.5043	1	2	4			
Between individuals within pairs	30	2.405	0.0801	1	2				
Between measurements within individuals	60	0.3400	0.0056	1					
Total	119								

FINDINGS

The estimated values of the different components of variance, and the heritability estimates for all teeth studied are shown in Table 3.

Variances between zygosities, (σ_z^2), were generally low, with negative values for the four canines and the two second molars on the left side of both arches of the primary dentition. Heritability estimates were negligible except for three teeth. Only the primary maxillary first and second molars and the mandibular first molar, all on the right side, showed a percentage of genetic control on the variation of their mesiodistal tooth dimensions of 20, 24, and 37.5 percent respectively.

The relative magnitude of the error variance, (σ_m^2), as tabulated for each tooth, showed the relative difficulty in measuring those teeth studied. The largest errors in measurement were found for the primary maxillary second molars and mandibular first molars.

Variance due to sex, (σ_s^2), differed considerably for each tooth. Greater variances were found for the teeth on the left side than the corresponding teeth on the right side. Five teeth demonstrated no sex differences for the trait. These teeth were the two primary mandibular canines, the two maxillary first molars and the maxillary right second molar.

Individual variations, (σ_i^2), and variations common to a twin pair, (σ_p^2), constituted the largest values of estimated variances for all components.

Table 3.

Estimated Values of the Components of Variance and Derived Intraclass Correlations (Heritability Estimates) for Primary Canines and Molars.

Tooth	σ_m^2	σ_i^2	σ_p^2	σ_s^2	σ_z^2	$h^2 = \frac{\sigma_z^2}{\sigma_i^2 + \sigma_z^2}$
<u>Right</u>						
Maxillary						
Canine	.0017	.0266	.0973	.0012	0	0
First molar	.0032	.0233	.2333	0	.0059	20.1%
Second molar	.0061	.0328	.1831	0	.0105	24.2%
Mandibular						
Canine	.0027	.0160	.0877	0	.0001	1.0%
First molar	.0056	.0372	.1060	.0061	.0224	37.5%
Second molar	.0029	.0249	.1426	.0429	.0017	6.5%
<u>Left</u>						
Maxillary						
Canine	.0022	.0434	.0759	.0039	0	0
First molar	.0037	.0305	.2022	0	.0022	6.8%
Second molar	.0057	.0272	.1766	.0193	0	0
Mandibular						
Canine	.0025	.0190	.0676	0	0	0
First molar	.0040	.0434	.0863	.0355	.0015	3.5%
Second molar	.0027	.0272	.1916	.0616	0	0

DISCUSSION

In theory, twins provide a unique approach for appraising the effects of heredity and environment on specific traits. However, the method of analyzing twin data must be improved, giving consideration to all factors contributing to observed variations between zygosities in the trait studied. Historically, twin studies have assumed that environmental effects on within-pair differences are comparable in the twin categories, and the contribution of other variables have not been considered (1, 10, 15).

Differences in prenatal and postnatal environment between members of a pair, and between twin pairs of each category (12, 21), demand a method of analysis to partition all factors contributing to the total variation, in order to estimate variance due only to zygosity difference. The hierarchal classification of the analysis of variance applied to the data in this study has the advantage of extracting the between-zygosity or genetic variance to estimate heritability of the trait studied. Those components of variance not pertinent to the problem may thus be eliminated, including measurement error.

This study suggests that the mesio-distal dimensions of three specific teeth are still in the process of evolutionary change. Consequently, these teeth exhibit a degree of heritability in variation of this dimension. The other teeth are probably relatively stable, so that observed variations in their mesio-distal dimension are due to nongenetic or environmental factors.

The three genetically variable teeth clustered on the right side are interesting to geneticists, anthropologists, and students of dentition. This observation suggests a possible genotypic asymmetry as described by Dahlberg (5).

It is interesting to note that two of the three genetically variable teeth are primary first molars which are morphologically dissimilar to any other primary or permanent tooth. The mandibular first primary molar demonstrates the strongest genetic control in the present study. This tooth has been described as the most primitive of the human dentition in morphology, exhibiting an overdeveloped mesial marginal ridge which resembles a retained fifth cusp (28).

Dahlberg (4) described a difference in the shape of the occlusal surface of the mandibular first primary molar between white children and American Indian children. In the whites, mesially and distally, the bucco-lingual measurements had a one-to-one proportion so that the occlusal surface was trapezoidal. In American Indians the bucco-lingual measurements distally were much larger than mesially, so that the occlusal surface formed a triangle with the base distal and the apex mesial.

The findings of a strong genetic control of the variation of mesio-distal dimension on this tooth suggest that further studies of its characteristics be pursued.

The findings in this study also suggest a greater magnitude of sex influence on variation on the left side than the right side. This concurs with the findings of Horowitz (10) of a sex-influenced asymmetry operating more strongly on the left side.

The generally low heritability in the variation of the mesio-distal dimension of the primary teeth studied tends to indicate that whatever variation is observed may be accounted for, in the most part, by nongenetic or environmental factors.

In a study by Paynter and Grainger (20) of tooth morphology of rats as related to caries susceptibility, their objective was to establish whether morphology and size of teeth were entirely dictated by some uncontrollable genetic mechanism, or due to a more optimal environment (through nutrition) during the time these teeth were developing. Their analysis established that measurable morphological and size differences, over and above those contributed by genetic variations, could be produced in rat teeth by alteration of the diet (nongenetic factor) of the mother. Reduction of the mesio-distal dimension of the rat molar was found to be significant at the 1% level.

It must be considered that the genetic constitution of an individual determines the upper limit of growth of his parts; i.e., the maximum growth which may be obtained under ideal environmental conditions. Factors which upset the ideal conditions produce a situation where maximum growth is not attained. Such factors, if sufficiently severe and active during the life cycle of the ameloblast cells, will have their influence reflected as gross abnormalities such as hypoplasia. Paynter and Grainger's findings indicate that changes from the ideal environment may produce more subtle and less easily recognizable alterations than gross abnormalities, an alteration in tooth dimension.

Limited work in this area indicates that the nongenetic aspect of tooth development requires further investigations.

In general, the results of this study on primary canines and molars do not indicate as strong a genetic control of the variability of the mesio-distal tooth dimension as reported for some classes of permanent teeth in other studies (1, 10, 15). The tooth classes studied and the methodology of analysis differ altogether so that no comparison of results can be made. In this study, findings of no discernible genetic control of variability of the mesio-distal dimension of the primary canines concur with findings of the permanent canines reported in Horowitz's (10) and Lundstrom's (15) studies. However, there is a need for more understanding of the interaction of heredity and environment on the mesio-distal dimension of the teeth comprising this segment of the arch length, primary and permanent.

SUMMARY

The twin study method was utilized in a quantitative study to determine the magnitude of genetic control of the variability of the mesio-distal dimension of each of the twelve primary canines and molars. Blind, duplicate measurements of teeth were taken from stone models of twenty-nine monozygotic and fifteen dizygotic twin pairs. Measurements were made to the nearest 0.1 millimeter.

The hierarchal analysis of variance was used to analyze the data. The total variance was partitioned to eliminate other factors contributing to the total variation, and the component of variance due to zygosity difference was extracted and estimated. This was then used in a heritability estimate to determine the magnitude of genetic control on the variation of the tooth dimension studied.

Genetic control of variability of the mesio-distal dimension of primary canines and molars is not discernible except for three teeth, all on the right side. When expressed in percentage, it may be stated from these findings that heredity controls approximately 37 percent of the total variation observed in the right mandibular first molar, 20 percent in the right maxillary first molar, and 24 percent in the right maxillary second molar.

CONCLUSIONS

1. No discernible genetic control of the variability in mesio-distal dimension of primary canines and molars was observed in this study, except for three teeth on the right side.

2. By a heritability estimate, heredity was found to control one-fifth of the total variation observed in the mesio-distal dimension of the right maxillary first and second primary molars.

3. The highest genetic control among the twelve teeth studied was observed in the right mandibular first primary molar and amounted to about one-third of its total variation in mesio-distal dimension.

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