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A Correlation Study of the a-b Ridge Breadth to Selected Bodily Dimensions

Martha Jane Eblen

To the Graduate Council:

I am submitting herewith a thesis written by Martha Jane Eblen entitled "A Correlation Study of the a-b Ridge Breadth to Selected Bodily Dimensions." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Richard L. Jantz, Major Professor

We have read this thesis and recommend its acceptance:

P. S. Willey, William M. Bass

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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A CORRELATION STUDY
OF THE A-B RIDGE BREADTH
TO SELECTED BODILY DIMENSIONS

A Thesis
Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Martha Jane Eblen

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DEDICATION

To my mother, Roberta Simmons Eblen, for teaching me the gratification of knowledge and supporting me in my endeavors to attain it, thank you.

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ABSTRACT

The correlation of the a-b ridge breadth to 12 anthropometric measurements was investigated in this study. The two samples used were 165 Armenians residing in Australia and 100 American Caucasions. Results of the analysis indicated that the a-b ridge breadth is correlated to seven specific body measurements. In order of decreasing correlation, they were wrist breadth, weight, stature, bicondylar femur, upper arm circumference, biacromial diamter, and calf circumference. It was also evident that bone was the only body size component that was correlated to the a-b ridge breadth.

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INTRODUCTION

Anthropological dermatoglyphic data have become invaluable in the study of human variation and heredity. In the past, ridge breadth has not been as popular as other dermatoglyphic quantifications because it relies on two components: count and distance. Unlike ridge configurations, the distance between ridges is not finally established in fetal development. Thus, distance may be affected by growth, age, and environment. David (1981) showed that mean ridge breadth significantly increased with age in both sexes until the age of sixteen years. Recently, however, ridge breadth data have received recognition by revealing information about developmental differences between and within individuals and populations.

In the past, several studies have indicated that there is a correlation of ridge breadth to body size (Cummins et al., 1941; Penrose and Loesch, 1967; and David, 1981). This study will use the a-b ridge breadth and 12 anthropometric measurements to examine the relationship of ridge breadth to certain bodily dimensions. The data were drawn from two samples: Armenians residing in Australia and Caucasions living in North Carolina.

The purpose of the study will be threefold. First, the research will seek to verify whether there is a correlation between adult epidermal ridge breadth and body size. Second, the study will report specific bodily dimensions that are correlated to the a-b ridge breadth. Finally, the thesis will determine which components of body size (skeletal, fat, or muscle tissue) are better correlated with ridge breadth.

The hypotheses made in this research are as follows:

H_1 The a-b ridge breadth will correlate significantly with specific bodily dimensions.

H_0 There is no correlation between the a-b ridge breadth and bodily dimensions.

CHAPTER I

BACKGROUND

The purpose of this chapter is to summarize basic information and current ridge breadth research that will provide a foundation for the research and analysis of this thesis. The chapter will first define the functional meaning of ridge breadth and describe general tendencies that have been reported in the literature. The chapter will then proceed to more specific information on ridge breadth inheritance and morphogenesis. Finally, a review of previous studies on the correlation of dermatoglyphic features to bodily dimensions will be provided.

Penrose (1968) defined ridge breadth or ridge width as the distance from the center of one furrow to the center of the next along a line at right angles to the ridges. It is not feasible to make this minute measurement from a print, so ridge breadth is calculated by determining the number of ridges within a certain distance. Jantz and Parham (1978) pointed out that this measurement is more of a ridge density than ridge breadth. They cautioned the researcher to be aware that differences in ridge breadth may be due to variability of the actual ridge breadth, the furrow breadth, or some combination of both.

Researchers have described the following general tendencies of palmar and digital ridge breadth:

1. Ridges are coarser in males than in females. Ohler and Cummins (1942) found in their research of European-Americans that the average ridge-count (mean of twenty regional counts) for females was 23.4 per centimeter and for males 20.7 per centimeter. More contemporary research by David (1981) computed the a-b mean ridge breadth in 1000 adult English subjects and established a mean ridge breadth of 541.3 for males and 492.5 for females.

Penrose and Loesch (1967) investigated ridge-width in the a-b interval of the palm in patients with sex chromosome aneuploides. There was a tendency for ridge widths to increase with the number of sex chromosomes; the finer ridges were seen in Turner's syndrome (X) and the wider ridges in XXXXY males. The significant increase of ridge widths in males as compared to females may suggest that the Y chromosome has more effect on this characteristic than the X.

2. In both males and females, the ridges on the soles are coarser than those on the hands, and the ridges on the palms are coarser than those on the digits. On the hand there is a disto-proximal gradient of increasing ridge breadths (finger tips < distal palm < proximal palm).

3. The digits of the right hand have coarser ridges than the left hand.

4. The thumb has coarser ridges than the other digits; the order of decreasing ridge breadth is II, III, V, IV.

5. On the palm the coarsest ridges are in the thenar/first interdigital area; the order of decreasing ridge breadth is hypothenar, interdigital II, interdigital IV, and interdigital III.

6. There is a trend in the digits for ulnar loops to have slightly coarser ridges than whorls (Cummins, Waits, and McQuitty, 1941; Ohler and Cummins, 1942; Holt, 1968).

7. Another general feature of ridge breadth that Cummins et al. (1941) described along with Hecht (1924), was the correlation of ridge breadth to body size. Cummins et al. stated that there was a clear tendency toward coarser ridges with increasing height and weight even though the correlation coefficients of stature to ridge breadth (-0.16 + 0.05) and weight to ridge breadth (-0.26 + 0.04) were low. These measurements were taken on the digits and palms and expressed as number of ridges per centimeter. These authors also stated that there were low correlations of ridge breadth with hand length, hand breadth, and digital breadth. In conclusion, they suggested that there is in some degree a common regulation of ridge breadth and bodily dimensions.

Penrose and Loesch (1967) also suggested a correlation of ridge breadth to body size using aneuploid states as evidence. In Down's Syndrome patients there is an association of low ridge breadth to short stature.

Rothhammer, Llop, and Neel (1982) found a small but significant correlation between a-b ridge count and finger length, hand width, hand length, and stature in 105 unrelated adults. These authors stated that these findings may suggest that, at the time the dermatoglyphic features are developing, the responsible genetic factors are interacting with other factors ultimately related to body and hand shape.

The inheritance of ridge breadth is a complex problem due to structural and biological features, as well as genetic. Data are available on the inheritance of the a-b ridge count. Fang (1950, cited in Holt, 1968) analyzed 73 British families and found significant familial correlations ($r = .82$ in monozygotic twins) indicating that a-b ridge count is genetically controlled. However, the prenatal environment has greater effect on this feature than it does on finger ridge counts because the hereditary component in palmar quantitative characters is considerably less than in digits (Roberts, 1979). Fang (1951) proposed that the mechanics of a-b ridge count inheritance were due to a major gene effect. The allele for the "high" counts, exceeding 79 ridges, was shown to be dominant over "low" counts. Other authors (Pons, 1964; Pateria, 1973; Mitra, Chattropadhyay, Dashsharma and Bardhan, 1966) confirm the heritability of a-b counts, but support the concept that the a-b counts are controlled by a polygenic system with additive genes. It is clear that more research must be undertaken to determine the degree of genetic effect and the specific compenents of the inheritance for the a-b ridge count and ultimately, the a-b ridge breadth.

Researchers in the area must also consider the relationship of ridge breadth to prenatal development. Mulvihill and Smith (1969) and Babler (1978a) demonstrated that dermatoglyphic patterns reflect the interaction between the shape of the fetal pad and the timing of ridge formation and pad regression during the tenth through the seventeenth weeks of gestation. Since the volar pads regress during ridge formation, investigators hypothesized that ridges differentiating during the early stages when the pad is high will result in a whorl. An arch will form when the pad is regressed and lower in shape. A loop will form when an intermediate pad is offset to a side of the digit (Hale, 1952; Mulvihill and Smith, 1969; Babler, 1978a).

The extent of the relationship of ridge breadth to volar pad topography and developmental timing is unclear. Babler (1978b, 1979) has discovered some fascinating clues in his analysis of the morphogenesis of ridges. During the initial appearance of primary ridges around the tenth or eleventh week post fertilization, the growth of the epidermal ridges can be divided into three basic components. These include (1) the amount of penetration into the dermis by a primary ridge, named ridge depth (RD), (2) the width of the primary ridge (RW), and (3) the amount of dermis between primary ridges (IRD). The combination of RW and IRD corresponds with the surface ridge breadth. In two different correlation studies, one comparing spontaneous to elective abortuses and the other comparing "normal" Black and White fetuses, the only ridge dimension that was different was the primary ridge depth. No significant differences were found in the two components responsible for surface ridge breadth (RW or IRD). This intriguing result suggests that it is only the dimension of ridge depth that is affected by different rates of development at this point in fetal growth.

However, evidence that differing developmental rates during prenatal growth does influence ridge breadth is found indirectly in a study by Jantz and Parham (1978). The authors demonstrated that the Black African Yoruba have significantly wider ridges than a Caucasian sample. The differences could not be explained by differences in hand or body sizes, so they apparently resulted from developmental differences during ridge formation. The authors suggested that wider ridges in Blacks may result from slower intrauterine development. Babler's (1978b, 1983) data revealed that Black fetuses had significantly less ridge depth and slower ridge maturation relative to White fetuses of comparable size and age.

In summary, the results of Jantz and Parham (1978) and Babler (1978b, 1979, 1983) suggest at least two interesting possibilities. First, their findings indicate that varying rates of dermal ridge development does effect ridge dimension as well as configuration, and this most probably includes ridge breadth. Second, it seems that differences in developmental rates of epidermal ridges between populations may be an explanation for variable postnatal ridge breadths between these populations.

Differences in developmental rates are not the only areas of interest concerning prenatal growth and ridge breadth. Current literature provides exciting information on developmental relationships between epidermal ridges and other tissues of the fetus.

Hale (1949) was one of the first to report on the general correlation of the breadth of dermal ridges and the growth of the fetal hand. According to the author, during the thirteenth week when the general configuration of ridge skin become apparent, the increase in ridge breadth accompanies the growth of the digit's surface.

During the fourteenth through nineteenth week, the ridges undergo multiplication and do not keep pace with surface growth. After nineteen weeks, the configuration is established and no new ridges develop, but as the hand grows, the ridges broaden.

Babler (1980, 1981, 1983) developed this general knowledge in his various research on communalities in the developing fetus. The results of Babler's study (1980, 1983) using 158 normal human fetuses 11-28 weeks post fertilization suggested epidermal ridge dimensions correlated with specific skeletal and dermal dimensions of the hand. Ridge depth and interridge width were significantly correlated with length of the distal phalanx but not with the width of the bone. Interridge distance, one component of surface ridge breadth, was also highly correlated with two measures of the soft tissue, dermis depth and digit width. It is interesting that ridge width, the other component of surface ridge breadth, showed no significant correlation with other ridge dimensions, bones, or soft tissues of the hand. These data imply that interridge distance, the dermis between the primary ridge, is associated with the dimensions of the developing hand.

Babler (1981, 1983) took this research one step further by comparing ridge dimension with facial dimensions and tooth germ size on 158 normal fetuses. The results indicated that ridge depth was correlated with bony dimensions of the face and primary ridge width was correlated with the mesial-distal diameter of developing primary tooth germs. As Babler pointed out, this last correlation is significant because primary ridge width (a component of surface breadth) shows no other development communality with the fetus. Because tooth germs and ridges develop at the mesoderm-ectodermal juncture, this may suggest a developmental relationship between ridges and primary dentition.

CHAPTER II

MATERIALS AND METHODS

The Sample

The data consist of palmar prints and 12 anthropometric measurements of subjects 18 years of age and older. Only adults were used in this analysis because ridge breadth is related to growth. The data were taken from two samples: Armenians residing in Australia, and American Caucasians residing in Asheville, North Carolina.

All dermatoglyphic prints and anthropometric measurements of the Armenians were taken by Richard L. Jantz in 1979. These Armenians originally lived in south and west Asia but migrated to Australia because of political pressures after World War II (Kirkland, 1980 cited in Hawkinson, 1981.)

The author of the present study finger printed and measured the second sample of White Americans during the winter of 1982-1983. The sample was predominately volunteer general physical education students at The University of North Carolina in Asheville. Other volunteers included secretaries from a local bank, karate school students and acquaintances of the author.

All volunteers from these groups were measured. No attempt was made to select individuals from these groups. Therefore, the sample represents a group of self-selected male and female adult Caucasians.

A description of the sample is provided in Table 1.

<u>The Methods</u>

All necessary quantitative data on the Armenian sample were made available for this study by Richard Jantz and Cleone Hawkinson. The author of the present study collected and analyzed the Caucasian data.

The twelve anthropometric measurements selected to establish the fat, muscular, and skeletal components of body size were: stature, sitting height, bicondylar femur breadth, calf circumference, wrist breadth, upper arm circumference, biacromial diameter, transverse chest, biilicrestal diameter, subscapular skinfold, tricep skinfold, and weight. An explanation of the abbreviations of these measurements that are used throughout the analysis is found in Appendix A. All measurements and techniques of measuring were taken from the standardized basic list of the International Biological Program Handbook #9 (Weiner and Lourie, 1969). Subjects removed shoes, but otherwise remained fully clothed during measurements. An accurate portable spring scale was used in weighing. Spreading calipers, an anthropometer, measuring tapes, and skinfold calipers were used as required for the other measurements.

TABLE 1. Description of the Samples.

	N	$\bar{x}$ Age	s.d.
<u>Armenian</u>			
Male	91	39.2	13.89
Female	74	37.4	13.17
	165		
<u>Asheville</u>			
Male	50	24.4	8.59
Female	50	28.0	10.93
	100		

Palm printing employed standard methods using white paper, printing ink, and a roller. The subjects spread their fingers and used moderate to heavy pressure to insure good prints. Some authorities question the effect of extended fingers and heavy pressure on increasing finger ridge breadth. However, unpublished research conducted by a graduate student, Patti Driscol, at The University of Tennessee, Knoxville, analyzes this question. A comparison of the prints made with flexed fingers and heavy pressure to those made with less pressure and flexion shows there is no significant difference in the ridge breadth between the two (Jantz, Personal Communication).

The ridges were counted by the method described by Holt (1968). The second interdigital area of the palm, containing the a and b triradius, was the region used for determining ridge breadth. This area is the one most often used in ridge breadth analysis because the ridges are well defined and usually run perpendicular to the line of count between the a and b triradius. Fewer patterns in this region make counting simpler. The distance between the a-b triradius was measured with a dial caliper and recorded in hundredths of a millimeter.

Ridge breadth was calculated by using the formula $(D_L + D_R)/(C_L + C_R + 2)$ as described by Penrose and Loecsh (1967). D is the distance between the a-b triradii and C is number of ridges counted between the a-b triradii (both quantities taken on the left and right hands). Two must be added to the ridge count because each triradial point is omitted in the ridge counting procedure. Ridge breadth was recorded in micrometers (μm) to eliminate decimals.

A SAS statistical package program was used for the statistical analysis. The procedures included the estimation of means and proportions, simple linear correlation and multiple regression of the general linear model. All statistical analyses were done at The University of Tennessee Computing Center.

CHAPTER III

RESULTS

Chapter III reports the statistical analysis of the data collected on the two samples. This chapter identifies the bodily dimensions that are correlated with ridge breadth and provides the results of tests of the hypotheses offered in Chapter I.

The preliminary phase of the analysis was establishing the means and standard deviations of the anthropometric measurements for both sexes in each sample. This information is provided in Table 2. In general, it can be stated that the Armenians are shorter and more stocky than the individuals in the Asheville sample. The difference in the mean age may be a factor in this distinction.

The next calculations were the means and standard deviations for the ridge count, a-b distance, and ridge breadth for each sample. This information is divided by sample and sex and is presented in Table 3.

As expected, both groups exhibit sexual dimorphism in the a-b ridge breadth, females having the lower value because of a smaller a-b distance. There is a notable difference in the mean ridge breadth between the Asheville and Armenian males due to a greater intertriradial distance in the Asheville sample. The female ridge breadth means also show difference due to a higher ridge count of the

TABLE 2. Anthropometric Means and Standard Deviations of the Armenian and Asheville Samples.*

	Armenian				Asheville			
	Male N=96		Female N=77		Male N=50		Female N=50	
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.
STAT	1701.0	62.64	1562.0	56.16	1763.8	69.70	1642.2	59.83
WEIGHT	165.4	10.16	138.05	9.56	165.6	29.71	127.5	17.49
SH	898.7	33.05	838.1	33.66	919.5	34.62	871.5	32.37
BICONF	97.0	4.48	92.9	5.58	94.0	5.50	84.6	4.76
CC	363.9	30.17	354.0	32.49	359.5	30.45	335.5	23.23
WB	55.1	2.98	49.3	3.04	57.0	2.86	48.6	2.86
UAC	296.2	23.98	281.9	39.59	283.0	32.16	246.2	27.47
BIACD	396.5	17.36	356.4	15.90	380.6	29.87	341.4	19.67
TC					274.1	44.44	233.1	22.44
BI					277.6	27.66	267.6	27.47
TRI	11.0	3.66	24.0	6.90	15.7	7.22	21.9	7.11
SUBS					17.8	9.34	19.0	7.76

*All measurements are in millimeters except weight which is in pounds.

TABLE 3. Means and Standard Deviations of a-b Ridge Count, a-b Distance, and a-b Ridge Breadth of Armenian and Asheville Samples.

	Armenian				Asheville			
	Male N=91		Female N=74		Male N=50		Female N=50	
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.
a-b Ridge Count	80.8	10.68	82.7	11.65	82.3	10.42	79.3	10.02
a-b Distance	47.9	5.53	45.5	5.32	51.9	5.92	45.6	4.63
a-b Ridge Breadth*	582	50.29	540	51.84	618	51.06	563	42.44

*a $(D_L + D_R)/[(C_L + C_R) + 2] \times 1000$

Armenian women. Using a statistical test to determine the difference between two population means (large sample) where

$$z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

and the Student's t critical values (Sincich, 1982), it was found that there were significant differences between means for both sexes ($p<.005$).

An analysis of the limited comparative data on a-b ridge breadth has demonstrated that there is a great range of ridge breadth means in Caucasian samples (Hawkinson, 1981). A list of other group a-b ridge breadth means can be found in Table 4.

Hawkinson (1981) pointed out that Student's t tests show the Armenian a-b ridge breadth means for both sexes differ significantly from the English (David and Ajdukiewicz, 1978) and the Jewish sample (Katznelson and Ashbel, 1973) as well as the Yoruba sample (Jantz and Parham, 1978).

The high range of variation in a-b ridge breadth means may be due to small sample size and sampling variation. It must also be considered that the a-b ridge breadth may not be a good indicator of human variation because of the several components that affect it. No conclusions on the inconsistencies of ridge breadth means can be made until more comparative data are available.

TABLE 4. Comparative Data on a-b Ridge Breadth Means.

	Males			Females		
	N	$\bar{x}$	s.d.	N	$\bar{x}$	s.d.
Asheville White	50	618	51	50	563	42
UT Students(a)	98	581	45	157	520	42
Armenians	91	582	50	74	540	51
English(b)	259	541	48	381	493	43
Jewish(c)	100	558	45	100	507	74
English(d)	60	565	41	60	514	39
Black African Yoruba(e)	119	605	55	52	556	41

(a) Jantz (1983)
(b) David and Ajdukiewicz (1978)
(c) Katznelson and Ashbel (1973)
(d) Penrose and Loesch (1967)
(e) Jantz and Parham (1978)

In this research, the important quantification is the correlation coefficient of ridge breadth to bodily measurements and these are the data that will be used for group comparisons. Therefore, the high varibility of sample ridge breadth means should not be crucial.

The next step in the analysis was to compute the correlation coefficients in order to measure the strength of the relationship between a-b ridge breadth and each bodily measurement. The coefficient of correlation, r, was found for each sex in both groups. The results of the correlation coefficient and the attained significance level, p, for each varible is found in Table 5.

The only correlation coefficient that is significant for all four groups (both sexes in both samples) is wrist breadth. This component has a relatively high significance level and must certainly have meaning.

It is also noted that weight is significant for three of the groups: the Armenian males and females and the Asheville males. This is an interesting result because past literature (David, 1981; Penrose and Loesch, 1967) has assumed ridge breadth would be more highly correlated with stature rather than with weight. As it was stated in Chapter I, Cummins et al. (1941) did find a significant correlation between ridge breadth and body weight. Even though they used a different method for determining ridge breadth (count of ridges crossing

TABLE 5. Correlation of a-b Ridge Breadth to Twelve Anthropometric Variables in Armenian and Asheville Samples.

	Armenian				Asheville			
	Male N=91		Female N=74		Male N=50		Female N=50	
	r	p	r	p	r	p	r	p
STAT	.029	.7829	.204	.0801	.416	.0026	.179	.2117
WEIGHT	.250	.0166	.261	.0242	.351	.0122	.088	.5399
SH	-.095	.3665	.100	.3940	.313	.0282	.206	.1497
BICONF	.212	.0437	.121	.3006	.439	.0014	.186	.1943
CC	.157	.1358	.118	.3155	.258	.0697	.127	.3767
WB	.281	.0069	.337	.0033	.398	.0042	.271	.056
UAC	.254	.0148	.145	.2165	.350	.0127	-.051	.7272
BIACD	.112	.2885	.166	.1565	.288	.0424	.136	.3434
TC					.252	.0770	.160	.2647
BI					.371	.0078	.229	.1094
TRI	.069	.5135	.082	.4846	.350	.0307	-.044	.7578
SUBS					.150	.2963	.053	.7129

transversely an one centimeter line) and made the counts on ten digits and five territories of each palm, these authors found a correlation coefficient (r=-.26) similar to those in this research and higher than their correlation for height.

These results are further enhanced by dermatoglyphic data on University of Tennessee students provided by Richard Jantz (1983) and summarized in Table 6. In the sample of 157 female and 98 male White students there is a significant ridge breadth to weight correlation in the numerical range of the other groups reported in this paper. The correlation of ridge breadth and height is not significant for either sex. Therefore, it is also suggested that a-b ridge breadth is meaningfully correlated to body weight.

Other than wrist breadth and weight, the four samples do not present any other clear evidence for ridge breadth to body measurement correlations. This disagreement among the samples may be due to sampling variation or due to actual differences in the populations represented by the samples. Therefore, a chi square statistic (x^2) was computed for each varible to test a null hypothesis that the samples are homogeneous and that the variability in the sample's data is due to chance. The results of this test is presented in Table 7. As noted, none of

TABLE 6. Correlation of a-b Ridge Breadth to Height and Weight in UT Students Sample.

	Male N=98		Female N=157	
	r	p	r	p
Stature	.090	.3762	.064	.4202
Weight	.230	.0225	.168	.0352

the chi square statistics are significant and therefore there is not evidence to reject the null hypothesis.

Since the variation among the samples is not significant, it is possible to pool the coefficients for each varible. The correlation coefficient is not normally distributed so the correlation averages are based on the Fisher Z transformations of the coefficient. The mean values of Z and their conversion back to the correlation coefficient, r, are found in Table 7. With the four samples' data pooled, it is noted that several bodily dimensions are significantly correlated ($p<.05$) with ridge breadth. As expected these include wrist breadth and weight and in order of decreasing correlation: stature, bicondylar femur, upper arm circumference, biacromial diameter and calf circumference.

One observation that can be made from the pooled data is that the purer bone measurements exhibit higher correlations. Wrist breadth and bicondylar femur are true skeletal measurements with relatively high correlations. The circumferences are composite measurements of fat, muscle, and bone and have significant, but lower correlations. The skinfold measurement of fat is clearly not correlated to ridge breadth.

Stature and weight both have skeletal components and are also correlated well with ridge breadth. There is a discrepancy in that stature is a purer measure of

TABLE 7. Chi Square Statistic and the Mean Value of Fisher Z and Converted r for the Pooled Correlations of the Armenian and Asheville Samples.

Armenian and Asheville Pooled Correlation
N=265

	x^2(a)	Z(b)	r(c)
STAT	5.30	.184*	.18*
WEIGHT	1.89	.248*	.24*
SH	6.26	.094	.09
BICONF	3.67	.231*	.23*
CC	.68	.161*	.16*
WB	.71	.328*	.32*
UAC	4.74	.189*	.19*
BIACD	1.09	.166*	.16*
TRI	1.09	.107	.11

(a) x^2 test:
DF = 3
critical value of x = 7.8

(b) Fisher Z transformation:
DF = 253
$p<.05$*

(c) r
$p<.05$*

bone than weight, but is not as highly correlated as weight. This can be explained by deducing that the influencing factor in the ridge breadth relationship is either 1) bone mass or 2) the transverse dimensions of bone instead of the linear dimensions. The acceptance of the transverse measurements' claim is supported by the other data. Wrist breadth, bicondylar femur, and biacromial diameter are transverse bone measurements that are significantly correlated to ridge breadth. It is also noteworthy that sitting height, a linear skeletal measurement, is not correlated with ridge breadth.

The muscle component's relationship to ridge breadth is obscure due to the fact it can only be assessed in composite measurements with fat and bone. As mentioned previously, the circumferences have lower correlations than the pure skeletal measurements. The degree of the influence of muscle can be checked by calculating the partial correlation between ridge breadth and weight (also a composite measurement) holding wrist breadth constant. If weight maintains its correlation after controlling for the bone component (WB), then it is evident that the muscle component also contributes to the ridge breadth to weight correlation. The formula used for the partial correlation was:

$$r_{12\cdot 3} = \frac{r_{12} - (r_{13} \times r_{23})}{\sqrt{(1 - r_{13}^2)(1 - r_{23}^2)}}$$

$r_{12\cdot 3} = r_{12}$ with $_3$ held constant

The partial correlation was calculated for both sexes in each sample and for the pooled correlations of the four values. The chi square test determined that the samples were homogeneous. The correlation coefficient was transformed to a Fisher Z and then the means were calculated and converted back to r. The results of these calculations are available in Table 8. None of the partial correlations are significant. Therefore, muscle is not a significant body size component in the correlation of ridge breadth to bodily dimensions.

In summary, from this pooled data, it is possible to conclude that the primary component of body size that is correlated to the a-b ridge breadth is bone. There is also evidence that it is bone mass and/or transverse bone dimensions that influence the ridge breadth to bodily dimension relationship.

It must be mentioned that a correlation coefficient analysis was performed on a third sample, the Cashinahua Indians. The Cashinahua are a culturally and genetically unmixed Indian group from the rain forest of Peru and Brazil (Jantz, Johnston, Walker and Kensinger, 1969). The Cashinahua prints and measurements were made available by Richard Jantz. Because of the small sample size, 24 females and 36 males, the sexes were combined for

TABLE 8. Partial Correlation of a-b Ridge Breadth to Weight with Wrist Breadth Held Constant in the Armenian, Asheville, and Pooled Samples.

	Armenian		Asheville		
	Male N=91	Female N=74	Male N=50	Female N=50	Pooled N=265
RB to Weight	.250	.261	.351	.088	.25
RB to WB	.281	.337	.398	.271	.33
Weight to WB	.512	.588	.478	.506	.52
Partial r*	.048	.067	.205	.168	.09

*No partial correlations are significant.

the correlation analysis. Even with this sample (N=60), there were no significant ridge breadth to body measurements correlations. However, wrist breadth data were not available for the Cashinahua, which means a significant correlation for that measurement cannot be ruled out.

Other somatic dimensions that were available for the Armenian sample were seven cranial measurements and hand length and breadth. A correlation of ridge breadth to these measurements was calculated and is presented in Table 9.

The only cranial measurement correlations with ridge breadth is nasal breadth. There is a strong correlation between ridge breadth and hand length and breadth.

With this information available, it was intriguing to determine the correlation between hand size dimensions and wrist breadth. The coefficients were significant in both sexes as seen in Table 10.

A partial correlation of a-b ridge breadth and wrist breadth holding hand breadth constant was made on the Armenian sample. This was done to test the possibility that the ridge breadth correlated with wrist breadth simply because wrist breadth reflected the hand size. The results of this calculation are presented in Table 11.

The American male and combined sex partial correlations were significant at the $p<.05$. The female partial correlation

TABLE 9. Correlation of a-b Ridge Breadth to Cranial and Hand Measurements in Armenian Sample.

	Male N=91		Female N=74		Combined Sex N=165	
	r	p	r	p	r	p
Hand length	.138	.2092	.388	.0006	.251	.0011
Hand breadth	.192	.0669	.400	.0004	.280	.0003
Cranial length	.121	.2514	.020	.8612	.077	.3249
Cranial breadth	.077	.4680	.005	.9632	.043	.5829
Bizygomatic breadth	.175	.0961	.033	.7738	.117	.1324
Min. frontal breadth	.154	.1441	-.031	.7908	.082	.2902
Facial length	.041	.6974	-.221	.0578	-.068	.3839
Nasal height	.142	.1774	-.098	.4040	.037	.6307
Nasal breadth	.229	.0288	.119	.3113	.184	.0178

TABLE 10. Correlation of Wrist Breadth to Hand Length and Breadth in Armenian Sample.

	Male N=96		Female N=77		Combined Sex N=175	
	r	p	r	p	r	p
Hand length	.370	.0002	.393	.0004	.380	.0001
Hand breadth	.491	.0001	.561	.0001	.519	.0001

TABLE 11. Partial Correlation of a-b Ridge Breadth to Wrist Breadth with Hand Breadth Held Constant in Armenian Sample.

	Male N=91	Female N=75	Combined Sex N=173
RB to WB	.281*	.337*	.306*
RB to Hand Breadth	.192	.400*	.280*
WB to Hand Breadth	.491*	.561*	.519*
Partial r	.219*	.149	.196*

*significant at $p<.05$

is not significant so the evidence is not absolute. The ridge breadth to wrist breadth correlation is probably valid when hand size is held constant, but more data is necessary for conclusive statements.

The final statistical test made on these data was a multiple regression analysis. This involved using a more complex model in which several anthropometric measurements could be related to the dependent variable, ridge breadth. In this analysis, each independent variable is tested on condition of the other variables.

The nine anthropometric measurements that had the highest correlation coefficients for each sample were used in the multiple regression (See Table 12). The sexes were run separately and combined for the Armenian and Asheville White samples.

In each sample's multiple regression analysis no individual varible was found to be significant. In other words, no single varible made a significant contribution to ridge breadth over and beyond the other varibles. However, the test statistic, F, that tests the whole model's utility was statistically significant ($p<.01$) in several of the samples. These results are reported in Table 12. The Armenian female and combined sex samples and the Asheville white male and combined sex samples all have attained significance levels so small that there is ample evidence to indicate that bodily dimensions

TABLE 12. Multiple Regression Analysis of a-b Ridge Breadth to Bodily Dimensions in Armenian and Asheville Samples.

	DF	SS	F	p	R^2
Armenian					
Male	8	.030	1.57	.1460	.132
Female	8	.047	2.57	.0169	.240
Both	8	.066	3.60	.0007	.155
Asheville					
Male	9	.054	3.53	.0028	.449
Female	9	.016	1.02	.4408	.186
Both	9	.042	2.48	.0141	.200

Independent Varibles:

Armenian: STAT, Nasal Breadth, BICONF, WB, UAC, WEIGHT, Hand Length, Hand Breadth

Asheville: STAT, SH, BICONF, WB, UAC, WEIGHT, TRI, SUBS, BI are useful for predicting ridge breadth. The R^2 value represents the fraction of variation that can be explained by the independent varibles. It is impressive that in the Asheville male sample 44% of the variation can be attributed to the bodily dimensions. The other sample's R^2 values also demonstrate that the bodily measurements do contribute to ridge breadth variation.

CHAPTER IV

SUMMARY OF RESULTS

The goal of this thesis was an exploration of the relationship of a-b ridge breadth to certain bodily dimensions. The hypothesis tested was to verify a significant correlation between a-b ridge breadth and body size. It was also the purpose of this research to determine specific body measurements that correlated to ridge breadth and decide if they represented particular body size components such as skeletal, fat, or muscle tissues.

Statistical evidence from simple linear correlation and multiple regression indicates that the null hypothesis should be rejected and the alternative hypothesis supported for these data. The a-b ridge breadth does correlate with selected bodily dimensions.

A summary of the correlation analysis suggests the following:

1. A positive linear trend exists between a-b ridge breadth and body size. There were significant correlations ($p<.05$) in all samples including a proportion of 75% significant correlations in the Asheville White male sample.

2. Two anthropometric variables, wrist breadth and body weight, were meaningfully correlated to ridge breadth in both samples. This relationship indicates that as

wrist breadth and body weight increase, a-b ridge breadth will tend also to increase.

3. It was determined with a chi square test that the four sample groups were homogeneous and the discrepancy in the data was due to sampling variation. Therefore, the four separate values were pooled to get a single correlation for each measurement. From these pooled values there were significant correlations of ridge breadth and wrist breadth, weight, bicondylar femur, stature, upper arm circumference, biacromial diameter and calf circumference listed in order of decreasing correlation value.

4. Bone is the component of body size that demonstrates a correlation to a-b ridge breadth. It is evident that the transverse dimension of bone is better correlated than linear dimensions. Fat and muscle are not significant body size components in the ridge breadth and bodily dimension correlations.

5. The significant F test and relatively high R^2 values in the multiple regression analysis also support a positive relationship between ridge breadth and bodily dimension. However, no single measure was found to be significant when tested against the other variables. This indicates that the model of a positive relationship between a-b ridge breadth and certain bodily dimensions is meaningful, but how it works is still unclear.

CHAPTER V

CONCLUSIONS

Not enough information was found to explain why or how the ridge breadth to body size correlation exists. The relationship seems on one hand to be amazing and on the other hand to be very appropriate. If ridge breadth is viewed as another minute bodily dimension, then it is only reasonable that it should be correlated to other bodily dimensions, like the gross correlations height and weight, arm length and leg length, etc. This simplistic idea inspires more questions on the complex relationships of human development.

Returning to the data, it is found that the intertri-radial distance is predominately the contributing variable to the significant ridge breadth and body size correlations. Table 13 illustrates this point. Even though the a-b distance is as easily measured as a bone length, it is unique because it is defined by two triradii and a predictable number of dermal ridges. These dermal configurations are formed from the mesoderm-ectoderm juncture by the seventeenth week after gestation (Babler, 1978a). The distance between the triradii is influenced by growth and does not become constant until sixteen years of age (David, 1981). And yet, this measurement is related to other bodily dimensions! Oddly enough, it is calculated from data in this research that the a-b distance is not

TABLE 13. Correlation of a-b Distance, a-b Count and a-b Ridge Breadth to Anthropometric Varibles in Armenian and Asheville Samples.

		Armenian						Asheville					
		Male N=91			Female N=74			Male N=50			Female N=50		
		D	C	RB	D	C	RB	D	C	RB	D	C	RB
WB	r	.13	.06	.28	-.01	.28	.33	.45	.14	.39	.29	.07	.27
	p	.20	.51	.006	.87	.01	.003	.001	.30	.004	.03	.62	.05
WT	r	.27	.08	.25	.17	.05	.26	.32	.04	.35	.19	.09	.08
	p	.008	.44	.01	.14	.65	.02	.01	.75	.01	.18	.49	.53
BICONF	r	.16	.005	.21	.21	.07	.12	.51	.17	.43	.35	.18	.18
	p	.12	.96	.04	.06	.52	.30	.001	.21	.001	.01	.20	.19
UAC	r	.36	.16	.25	.09	-.03	.14	.23	.02	.35	.11	.11	.05
	p	.0003	.11	.01	.43	.76	.21	.09	.84	.01	.40	.42	.72
Hand Length	r	.13	.02	.13	-.04	-.25	.38						
	p	.20	.83	.20	.70	.02	.0006						
Hand Breadth	r	.15	.01	.19	.003	-.31	.40						
	p	.13	.87	.06	.97	.006	.0004						

correlated with hand dimensions, although the count is in the Armenian females, but has a meaningful relationship with a gross body dimension, such as weight and transverse bone measurements. The grand question is determining what factors are responsible and how they work in maintaining bodily proportions.

Garn, et al. (1975) reported that the growing bones of the prenatal hand reach bone to bone proportions similar to those of adults by thirteen intrauterine weeks. As stated in Chapter I, Babler (1981) has also found intercorrelations between dimensions of tissues (dermal ridges, soft tissues and bones of the hand, and tooth germs) in fetal samples. Garn et al. (1974) have found that male embryos exhibit more advance stages of skeletogenesis than females through the eighth week post gestation. Yet, females have greater intercorrelations in the skeletal unit than males at this same developmental stage (Burdi, Garn, and Babler, 1974). This data suggests that this synchronization of bodily dimensions begins at the earliest stages of development, at which time sexual variation can already be observed. The prenatal data cited above and the data from this thesis contribute exciting information to the understanding of human development. They suggest that from the earliest stages of prenatal development and throughout postnatal growth there is a developmental syndronization that maintains certain bodily dimensions and proportions.

Babler (1983) defines development as:

> a set of developmental potentialities delineated by the genetic material of the conceptus and their interaction with a variety of environmental inputs, both intercellular and extracellular. Most developmental processes are closely linked and involve a precisely coordinated interaction of genetic and environmental factors (p. 3).

It seems that the procedures that "link" and "coordinate" are the most intriguing elements of development. What is the range of normal variation in these "procedures"? What are their sexual and racial variations? Why? How? These questions may eventually be answered as more research determines the correlations or communalities of bodily dimensions.

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APPENDIX

ABBREVIATIONS OF THE ANTHROPOMETRIC MEASUREMENTS

Stature	STAT
Sitting height	SH
Bicondylar femur	BICONF
Calf circumference	CC
Wrist breadth	WB
Upper arm circumference	UAC
Biacromial diameter	BIACD
Transverse chest	TC
Biilicrestal diameter	BI
Tricep skinfold	TRI
Subscapular skinfold	SUBS

VITA

Martha Jane Eblen was born in Asheville, North Carolina, on July 6, 1954. She was married to J. Richard Perkins in 1975 and has a son, Jamie, born 1979 and a daughter, Jewel, born 1983.

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