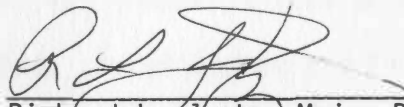
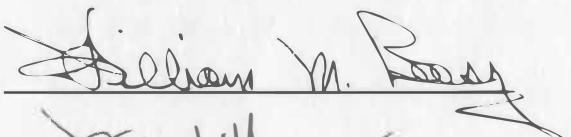
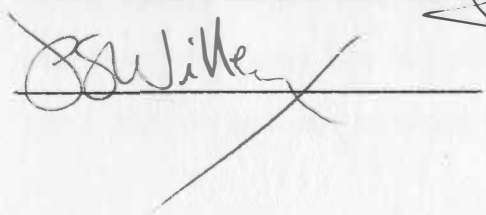


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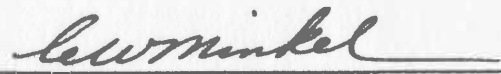
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TURNER SYNDROME DERMATOGLYPHICS:

A PRINCIPAL COMPONENTS ANALYSIS

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DEDICATION

This thesis is dedicated to my very best friend in the world, Begee Erb. I have known Begee for several years and she has remained my true friend during many difficult transitions in my life. Her faith in me has never wavered and her encouragement kept me going many times when the temptation was to quit. Such a person comes along once in a lifetime and I consider myself lucky to call her friend. Thank you, Begee, for everything.

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An important place is reserved in these acknowledgments for a very special person in my life, a person whose presence and faith in my ability gave me the inner strength to complete this manuscript. Thank you, Richard Wikander, for coming into my life and for loving me.

ABSTRACT

This thesis investigates the general hypothesis that developmental stress resulting from monosomy of the X chromosome will result in changes in the dermal ridge system of the fingers and palms. The specific hypotheses proposed are that when contrasting Turner syndrome females to controls of both sexes the results will be that Turners will exhibit increased total variance in ridge counts, increased directional asymmetry, changes in growth gradients, and deviations in lateralization.

Using principal components analysis for the fingers and palms, Turners were found to exhibit increased total variance, an increased directional asymmetry on the fingers and a deviation from the normal pattern in lateralization. Differences in growth gradients were not discernible. It appears that the radial and ulnar sides of the fingers are under the control of different maturational gradients.

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CHAPTER I

INTRODUCTION

This thesis investigates the hypothesis that developmental stress resulting from monosomy of the X chromosome will be reflected in the dermal ridge system of the fingers and palms. The samples used in this analysis are all German and composed of 45,X (Turner syndrome) females, a small comparative group of Klinefelter syndrome males, and controls of both sexes. It is hypothesized that the Turner syndrome females experience greater environmental or prenatal insults than the control groups and therefore when contrasted with the control groups will exhibit:

1. Increased total variance in the ridge counts for the fingers and palms.
2. Increased directional asymmetry.
3. Changes in growth gradients.
4. Deviations in lateralization.

The Klinefelter syndrome is included for comparative purposes because they also exhibit an abnormal sex chromosome karyotype, but the sample size is too small for adequate statistical inference. Of greatest interest is the exact nature of the differences among the groups and these variations are explored statistically since the use of dermatoglyphics in the study of chromosomal abnormalities is not clear-cut and variations are not easily quantified. Regarding this issue, Stough and Seely (1969:33) commented:

The significance of dermatoglyphics in clinical medicine is rarely if ever related to abnormal patterns, but rather to an increased or decreased frequency of normal patterns in unusual places, and to unusual combinations of normal patterns.

The use of statistics is essential for pinpointing the dermatoglyphic variation among groups and the past few years have seen the use of increasingly sophisticated methods of statistical analysis by specialists in the field. No longer is it sufficient to use only simple ridge counts, counts of pattern frequencies, and measurements of distances. This preliminary work has been repeated many times for Turner syndrome individuals (Borgaonkar and Mules 1970, Farman et al. 1979, Holt and Lindsten 1964, Loesch 1971, Miller 1973, Penrose 1963, Penrose and Loesch 1967, Preus and Fraser 1972, Reed et al. 1977, Saldana-Garcia 1977 and 1979, Stough and Seely 1969, White and Marx 1978) and has yielded essentially the same results for the contrast of Turners to controls:

1. Increased TRC (Total Ridge Count)
2. Increased mean summed a-b (distance between a and b triradii) ridge counts due to ulnar displacement of the b triradius
3. Large patterns on the digits
4. Higher incidence of axial triradius displacement
5. Increased incidence of large hypothenar patterns
6. Fewer whorls and increased number of ulnar loops

While this is useful information and a necessary first step in investigating the dermatoglyphics of Turner syndrome, it is nothing new. What is needed is to investigate areas attempting to explain what happens in utero which results in differences in the phenotype that are observed postnatally.

An in-depth study of the embryogenesis of Turner syndrome individuals is beyond the scope of this study, but perhaps some general conclusions may be drawn regarding their prenatal development. Sometimes when studying a trait such as dermatoglyphics, researchers forget that they are dealing with the whole individual and that any developmental insult will affect the whole person, not just one system, although different systems are not affected in the same way or to the same degree. Therefore, as preliminary work for this analysis, an extensive literature review was carried out on Turner syndrome and all physical anomalies which are characteristic of the syndrome. All of these anomalies result from the developmental disturbance created by the lack of an X chromosome so their study is relevant to this analysis of the dermatoglyphics of the affected individuals.

CHAPTER II

LITERATURE SURVEY

Turner syndrome was first formally described as a specific condition in 1938 by H. H. Turner, who described a syndrome affecting females and characterized by infantilism (short stature and underdeveloped secondary sexual characteristics), webbing of the neck, and cubitus valgus (an elbow deformity consisting of an increase of the carrying angle). Since 1938 there has been much additional research performed on Turner syndrome but instead of clarifying the issue, the picture of this syndrome has become increasingly complicated. Indeed, there are many more than three physical anomalies associated with Turner syndrome, but not all anomalies are found in all patients.

Classic Turner syndrome was originally thought to be the result only of monosomy of the X chromosome but it has since been found that the various anomalies associated with Turner syndrome can result from karyotypes ranging from 45,X, mosaicism, isochromosomes, ring chromosomes, deletions of portions of the X chromosome and even an XY karyotype.

According to Barlow (1973), all sex chromosomes but one X chromosome become heterochromatic early in embryonic development, but Ferguson-Smith (1965) suggests that because both X chromosome are active for several days after conception, the absence of or

abnormality of one of the X chromosomes would perhaps serve to disturb embryogenesis and affect the adult phenotype. According to Ferguson-Smith (1965) and Bocian et al. (1971), the abnormal X chromosome is always the chromosome eventually inactivated, so perhaps it is necessary for two X chromosomes to be present early in embryogenesis for normal development to proceed.

The physical problems associated with Turner syndrome individuals are most pronounced in the bones, gonads, and connective tissues, which are all of mesodermal origin (Boczkowski et al. 1978). Skin tissue (which incorporates the dermal ridges) and tooth enamel are ectodermal in origin (Patten 1968:59) and the effect of sex chromosome aneuploidy is apparently not as pronounced in these tissues. The aneuploid condition does affect tooth enamel thickness (Alvesalo and Kari 1977, Townsend et al. 1984), but its effect on the dermal ridges appears to be partially because the dermal ridges interface with mesodermal tissues.

Although not specified by Turner, it is now commonly accepted that Turner syndrome individuals are also usually affected with gonadal dysgenesis, primary amenorrhea being one of the commonest presenting complaints. A few mosaic women are fertile but there are few reports of spontaneous menstruation in women with monosomy of the X chromosome (Grace et al. 1973). A few of the other many stigmata frequently associated with the syndrome are a shield-shaped chest, low posterior hairline, multiple pigmented naevi (Haddad and Wilkins 1959), medial tibial exostosis, abnormal angle of the

radius and carpals, short middle phalanx of the fifth finger and short third to fifth metacarpals and/or metatarsals (Park 1976b). Park (1976a) also notes an enlarged and lowered medial femoral condyle, enlarged medial tibial metaphysis, with the possibility of increased osteoporosis from an abnormal trabecular pattern. Although mental retardation is common in many cases of aneuploidy of the sex chromosomes, this does not appear to be the case with Turner syndrome (Nielsen et al. 1973, Summitt 1969).

Morphology of the hands may be related to the dermal ridge differences observed in Turner syndrome individuals. Rothhammer et al. (1982) worked with hand shape and dermatoglyphic characters and found that children with square hands exhibit higher main line indices, higher a-b ridge counts and more open atd angles (angles formed by lines drawn from the a triradius to the t triadius and from the d triradius to the t triradius). These characters also describe Turner syndrome dermatoglyphics; perhaps a portion of the variance observed in Turners reflects an in utero developmental pathway which results in a particular hand morphology. As previously mentioned, Turner patients exhibit a pattern of reduction in metacarpal-phalangeal length, particularly in the fourth metacarpal, and this reduction would affect hand morphology and subsequently the configuration of the dermal ridges and position of the triradii.

Garn et al. (1975) looked at metacarpal-phalangeal proportions and length rankings of embryos to adults in a normal population, and they found that by the seventh intrauterine week adult length

rankings are attained and by the thirteenth intrauterine week, adult bone-to-bone proportions are attained. Garn et al. (1975:331) concluded that:

Relative metacarpal and phalangeal lengths characteristic of the adult are established in the mesenchymal and cartilaginous human hand models well before initial bone-collar and distal-tuft calcification begins.

If the bone-to-bone proportions are reached at such an early intrauterine age, then it must be assumed that the abnormal growth found in Turner syndrome is the result of an early deviation from the normal developmental pathway. Garn and Rohmann (1962) found evidence of sex chromosome influence on developmental timing, particularly in regard to osseous maturation.

Because it is the contention of Boczkowski et al. (1978) that the tissues most affected by Turner syndrome are of mesodermal origin, but the dermal ridges are of ectodermal origin, there must be some relationship between the two systems. Cummins and Midlo (1961:183) have found that growth disturbances during the period of ridge formation result in dermal ridge distortion in persons with congenital hand and foot defects. In human embryos, the cartilaginous precursors of the carpal, metacarpal, and proximal phalangeal bones are present by the eighth week of prenatal development and ossification centers have appeared at the mid-diaphyses of the metacarpals by the ninth week (Patten 1968:224-225). It is thus obvious that the cartilaginous precursors of the bones of the hands are all present before the completion of the dermal ridge system.

The presence of these precursors undoubtedly affects the developing ridge system because they continue to enlarge, and some begin to ossify while the ridges are being formed and any abnormality in the underlying structure would affect the ridge formation. According to White and Marx (1978:366):

Factors thought to influence ridge alignment, pattern type, and location of landmarks such as triradii include stress on the skin induced by differential growth in various regions of the palm or sole, amount of tissue fluid, presence of neurovascular complexes, and contour of volar pads.

An obvious initial step in undertaking the study of the deviations from the normal pattern in the dermal ridges of individuals with abnormal sex chromosomes karyotypes would be to attempt to determine the means by which the genotype is translated into the phenotype. This step could be accomplished by the study of morphogenesis of the dermal ridge system. This is not a novel idea and has been done previously by many researchers (Babler 1978; Hale 1952; Hirsch and Schweichel 1973; Okijama 1975). Perhaps the relevance of this approach, using a genetic inheritance viewpoint, was best expressed by Hirsch and Schweichel (1973:58):

Embryology, anthropology, and clinical research of congenital disturbances indicate that the development of biological forms and their disturbances are genetically determined. Genetic information becomes manifest through numerous biochemical and morphological stages of differentiation. To comprehend the laws of development and their conceivable disturbances, as many as possible of these stages lying between genotype and phenotype must be examined.

Using this logic, they determined that to understand how information is translated into dermal ridges, the fingertips of

human embryos should be examined microscopically, using both light and electron microscopes. Hale (1952:151-152) had previously used a light microscope to study human embryo fingertips and defined three developmental stages:

1. Initial phase (70-140mm Crown Rump Length) This is the period in which the primary ridges are established, with these ridges penetrating deeper into the dermal substance.
2. Secondary phase (140-220mm Crown Rump Length) The secondary ridges appear between the primary ridges, occurring as irregularities of contour parallel to the primary ridges.
3. Third phase (220mm Crown Rump Length--) Development of the dermal papillae.

Hirsch and Schweichel (1973) used both light and electron microscopy to observe volar pads and found that the formation of pads on the index and middle finger are visible by the second intra-uterine month and are well defined in shape by the third month. They determined that the ultimate ridge pattern was to a large extent dependent upon the degree of asymmetry in pad formation: symmetrical pads resulting in whorls, asymmetrical pads resulting in loops, weak pad development resulting in arches, pronounced pad development resulting in either whorls or loops. Mulvihill and Smith (1969) hypothesized that the type of pattern was determined by the shape of the volar pad during ridge formation, with ridges developing transversely across lines of stress. According to them, high pads result in whorls, intermediate pads offset to one side result in loops, while low pads result in arches. Their hypothesis also predicts that whorls should be associated with early ridge differentiation and arches with late differentiation relative to pad regression.

Babler (1978) utilized light microscopy in studying fetuses that came from both spontaneous and elective abortions. His findings that patterns were discernible with the earliest ridge development were consistent with those of other researchers. He found that the development of the epidermal ridges occurs first in the basal layer of the epidermis during the tenth or eleventh week of intrauterine life. This development is caused by cell proliferations which form epidermal ridges that project into the dermis. These ridges are referred to as primary ridges and they continue to increase in number by the formation of new ridges between existing ridges. This increase accompanies an increase in the size of the digit and continues until about the seventeenth week. Fingerprint patterns are evident at this time although the ridge patterns are recognizable in the dermal layer much earlier than this. During this stage of formation, the pattern becomes more elaborate, with the number of ridges increasing. It is at this stage that environmental factors and genetic actions such as cell differentiation and control of growth rates find the fetus most susceptible to developmental insult.

Babler found that the spontaneous abortions sample was associated with a higher incidence of arches than that found in the elective abortion sample. His explanation was that there may be stabilizing selection operating on ontogenetic factors which are associated with ridge and pattern formation, one of these factors being developmental timing. Because the volar pads are regressing while the ridges are differentiating, Babler deduces that selection at this

time of early fetal development involves deviations in developmental timing or pad height from a common developmental pathway. He concludes that postnatal dermatoglyphic traits reflect selective pressures on the developing fetus and that dermatoglyphic traits must be viewed as products of developmental processes affecting the entire fetus.

Babler (1978:26) states that:

The prenatal association of dermatoglyphic traits with differential survival suggests that postnatal individual and populational variation in dermatoglyphic patterns may be by-products of varying genetic and environmental factors interacting at an early developmental stage.

The real issue is yet to be addressed; that is, what happens within the cell which results in the difference in phenotype found in Turner syndrome individuals? Jantz and Hunt (1985) hypothesize that sex chromosomes actually control tissue sensitivity to fetal sex steroids and that 45,X females should have a lower hormone sensitivity than normal 46,XX females.

Turner syndrome patients exhibit larger fingertip patterns than control males and females, resulting in larger total ridge counts (Holt and Lindsten 1964). Penrose and Loesch (1967) proposed that the increased TRC may be due to Turner individuals having thinner epidermal ridges with more of them required to cover a pattern. An attempt to explain this phenomenon was made by Penrose (1967:299) when he noted that:

If cells contained many chromosomes there would be more water inside the cells and less outside, in the cavity or in the spaces between the cells, than if the cells contained few chromosomes. An organism

with fewer chromosomes than normal might therefore be relatively oedematous at some early developmental stage, and an organism with more chromosomes be relatively dehydrated.

He assumed that the pads on the fingers and palms of the 45,X fetus would be abnormally large and would require more ridges to cover the surface than on normal fetuses, ridge formation being brought about by a combination of tension along the direction of the ridges and compression at right angles to them.

Probably the most quoted work concerning this issue has been that of Peter Barlow (1973) regarding the influence of inactive chromosomes on human development. This work was a watershed in the study of chromosomal abnormalities because he found that heterochromatic sex chromosomes slow cell division by affecting the mitotic rate. Therefore, 45,X females, lacking the heterochromatic sex chromosomes, show an increased mitotic rate. Barlow surmises that persons with abnormal numbers of sex chromosomes could reach critical developmental milestones with abnormal cell population structures due to the abnormal mitotic rate. Persons with extra sex chromosomes would be expected to exhibit retarded cell division and it has, indeed, been found that these individuals have a decreased birth weight. According to Park et al. (1983), 98% of all 45,X conceptions end in spontaneous abortion, and the 2% who survive to term suffer from genital, cardiac, renal, and dermal abnormalities. Because there is a high in utero mortality rate, the few who are born full term represent survivors of a rigorous prenatal developmental ordeal

and are therefore smaller individuals (Barlow 1973, Bowen and Lee 1969).

Jantz et al. (1981) allude to developmental fields in the finger ridge counts of Turner syndrome patients. The concept of developmental fields deals with the observation that adjacent digits are more similar than digits that are more distant. Siervogel et al. (1978) claim that this phenomenon can be accounted for by developmental gradients from one digit to another, but that developmental fields could represent nothing more than different local environments. All fingers of the same individual presumably have the same genotype but develop a different phenotype, the most likely reason being that a different local environment for each finger interacts with that genotype. By "local environment," Siervogel et al. refer to non-genetic intrauterine conditions which involve differences among digits in nerve and blood supply or in external pressure. Disruption of the normal developmental process, such as in the Turners' sample, could result in changes in the local environment of each finger and could, along with other developmental disruptions, effect changes in the dermal configurations.

Laterality is a subject touched upon by researchers such as Corballis and Morgan (1978), although little has been done regarding Turner syndrome specifically. This would appear to be a fruitful area of study for Turner syndrome since Corballis and Morgan suggest that lateral asymmetries are generally under the control of a left-to-right maturational gradient, although in man it appears that

the growth gradient may favor the right side. Mittwoch (1977) claims that during the fourth month of pregnancy the number of dermal ridges on the right hand of the fetus is higher than the number on the left hand, indicating a gradient that favors the right side. Corballis and Morgan (1978) suggest that if the leading side is damaged or restricted, the gradient may be reversed and this reversal would be relevant to the issue of Turner dermatoglyphics because any deviation of the Turners from the normal controls in directional asymmetry would be indicative of an early developmental insult. They suggest that different sides of the embryo develop in spurts, but they emphasize that little is known about the exact temporal-spatial course of embryonic development.

CHAPTER III

METHODS AND MATERIALS

All individuals used in this study are German and the data were made available by Dr. Richard L. Jantz of The University of Tennessee, Knoxville. The primary sample used was composed of 109 45,X (Turner syndrome) patients obtained from three different German laboratories. Only patients karyotyped as having a "pure" 45,X cell line were used in this analysis; patients exhibiting mosaicism, isochromosomes, ring chromosomes, short arm deletions or other chromosomal abnormalities were eliminated. Eighty of the patients were cases of R. A. Pfeiffer and were counted at the Department of Human Genetics, the University of Lubeck; the prints of 19 patients were collected by Professor Degenhardt at the Institute of Human Genetics, the University of Frankfurt; and the prints of 10 patients were collected by Dr. Stoekenius at the Cytogenetic Laboratory, Barmbeck Hospital, Hamburg.

A sample of 16 Klinefelter syndrome patients was also used for comparison. The prints of seven individuals were collected at Hamburg and the prints of nine individuals were collected at Frankfurt.

The prints of the fingers and palms of all individuals were obtained and counted by Dr. Richard L. Jantz during the summer of 1978 and the ridge counts were made according to standard methods

(Holt 1968). For statistical purposes, each person was represented by a vector of 20 counts (radial and ulnar counts for each digit) and a vector of six counts (c-d, b-c, and a-b ridge counts for each hand).

The control group is from southwestern Germany and was assembled and counted by Heinz Brehme. The sample consists of 147 males and 147 females for the palm counts and 154 males and 151 females for the finger counts. Because the control group is from a particular area in Germany and the Turner and Klinefelter individuals represent several geographic areas within Germany, it may be questionable to compare controls from one area to patients from another area. But Jantz et al. (1981) used the same Turner syndrome and controls samples in their canonical analysis and discriminant function analysis of the finger ridges, and their justification for using those samples in a single study was that the Turner versus control differences should exceed in magnitude any geographical differences among groups. Another possible problem arises with using the Turner sample from the Hamburg laboratory. This sample consists of only 10 individuals and because it is too small a sample for adequate statistical inference and also because it is from a separate geographical area than the other samples, it might be assumed that this could distort the results. But upon plotting the principal component scores and checking for outliers, it was noted that any outliers were not from Hamburg as might be expected. Therefore, the inclusion of the Hamburg sample in this analysis is justified.

Data for all samples were analyzed using the MEANS, PRINCOMP, and CORR Procedures of the SAS Statistical Package and were processed by an IBM Computer at The University of Tennessee Computer Center. The MEANS Procedure yielded means, variances, and standard deviations for all counts, both on the fingers and palms. The PRINCOMP Procedure used a correlation matrix to derive the principal components (eigenvectors), eigenvalues, and proportions of variance accounted for by each eigenvalue for the fingers and palms. The decision was made to use the correlation matrix in this analysis after extracting the principal components for all samples using both the correlation matrix and covariance matrix. The components extracted from both matrices were examined and compared and it was noted that the components extracted using the correlation matrix were more easily interpreted and less ambiguous than the components extracted using the covariance matrix. Roberts and Coope (1975) and Siervogel et al. (1978) performed principal components analyses on the fingers using correlation matrices and their results were similar to those obtained in this analysis. Since the results obtained from the correlation matrix seemed to be the least ambiguous, the decision was made to use the principal components derived from the correlation matrix for the purposes of this analysis. The fingers were analyzed using as variables all 20 counts, the largest counts of each digit, and the absolute counts of each digit. The palms were analyzed using as variables the a-b, b-c, and c-d counts for the palms. All correlation matrices for the fingers and palms are included

in the Appendix (Tables 45-58). The CORR Procedure was used to calculate asymmetry values for homologous digits and also for the corresponding counts on the palms. A correlation matrix was derived using the asymmetry values as variables.

CHAPTER IV

RESULTS AND DISCUSSION

The initial step in this analysis was to inspect the means and variances of the finger and palm ridges for all the samples. These results are presented in Tables 1-8. The Turners exhibited increased variance over the other samples but the decision was made to utilize a correlation matrix for deriving principal components even though this method standardizes the variance, setting all variances equal to one.

Principal components analysis was performed on both the radial and ulnar counts on all fingers, the largest counts on all fingers, and the absolute counts on all fingers, with results presented in Tables 9-28. The principal components analysis for the radial and ulnar counts was performed on all four samples while the largest and absolute counts principal components analysis was performed only on the Turners and the male and female controls.

The results extracted were 20 principal components for the 20 radial and ulnar counts, and 10 principal components each for the largest and absolute counts. All components were examined but in each situation there were several components which were determined to be largely ambiguous and difficult to interpret. For the radial-ulnar count analysis only the first five components were used, while only four components were used for the analysis of the largest and absolute counts principal components.

Table 1. Finger Ridge-Count Means of Turner Syndrome Females (n=109).

Variable *	X (Mean)	S.D.	Variance
LVR	16.6055	6.2849	39.5003
LVU	2.6697	6.3655	40.5195
LIVR	18.1927	6.7666	45.7866
LIVU	6.1651	8.5986	73.9354
LIIIR	15.1376	6.9568	48.3976
LIIIU	2.9450	6.2001	38.4414
LIIR	10.2661	8.5771	73.5674
LIU	9.0826	9.3434	87.2987
LIR	18.5596	6.9847	48.7858
LIU	4.0000	7.8008	60.8519
RVR	17.8165	5.0427	25.4290
RVU	2.6422	5.7663	33.2504
RIVR	17.8257	6.5190	42.4971
RIVU	5.6881	8.3341	69.4574
RIIIR	15.2294	5.8825	34.6043
RIIIU	1.5872	5.1482	26.5039
RIIR	12.0741	8.0393	64.6300
RIIU	7.9907	8.9516	80.1214
RIR	20.5505	7.5798	57.4534
RIU	2.6055	6.1419	37.7226
Total Variance = 1028.7541			

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 2. Finger Ridge-Count Means of Klinefelter Syndrome Males (n=16).

Variance *	X (Mean)	S.D.	Variance
LVR	12.25	4.4647	19.9333
LVU	0.25	1.0000	1.0000
LIVR	16.3750	4.9244	24.2500
LIVU	2.9375	6.0605	36.7292
LIIR	10.5625	5.8762	34.5292
LIUU	2.1250	5.9090	34.9167
LIIR	6.8125	6.2952	39.6292
LIUU	5.5000	8.4617	71.6000
LIR	11.2500	4.8097	23.1333
LIU	2.7500	4.9329	24.3333
RVR	12.1250	4.7592	22.6500
RVU	1.3125	3.6280	13.1625
RIVR	17.3125	7.3368	53.8292
RIVU	9.6250	8.0239	64.3833
RIIR	9.9375	4.4342	19.6625
RIIU	3.5000	6.8993	47.6000
RIIR	5.0625	4.9189	24.1958
RIIU	8.5000	8.1404	66.2667
RIR	13.8750	3.6492	13.3167
RIU	5.5000	8.0911	65.4667
Total Variance = 700.5876			

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 3. Finger Ridge-Count Means of Female Controls (n=151).

Variable*	X (Mean)	S.D.	Variance
LVR	12.4702	4.8665	23.6641
LVU	1.2185	3.6677	13.4519
LIVR	15.2649	6.5071	42.3427
LIVU	4.5033	6.8018	46.2650
LIIR	10.8940	6.2227	38.7220
LIUU	3.1060	6.7242	45.2154
LIIR	7.7417	6.3974	40.9262
LIUU	6.6159	8.2104	67.4115
LIR	14.7020	6.6149	43.7573
LIU	4.9868	7.6516	58.5465
RVR	12.3113	5.0414	25.4158
RVU	1.1656	3.4028	11.5791
RIVR	15.2318	6.3733	40.6192
RIVU	5.2450	7.2194	52.1196
RIIR	11.2252	5.9556	35.4690
RIIU	2.4106	5.7274	32.8036
RIIR	8.5364	6.7644	45.7570
RIIU	7.5430	8.3879	70.3565
RIR	16.9272	5.6416	31.8280
RIU	5.1523	7.8382	61.4366
Total Variance =			827.687

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 4. Finger Ridge-Count Means of Male Controls (n=154).

Variable*	X (Mean)	S.D.	Variance
LVR	14.7143	4.6593	21.7087
LVU	0.6558	2.6551	7.1030
LIVR	17.4935	5.6871	32.3431
LIVU	5.2857	7.5222	56.5845
LIIIR	13.4740	5.7271	32.7999
LIIIU	2.4221	6.0636	36.7684
LIIR	8.7792	7.1174	50.6568
LIIU	7.1169	8.6106	74.1431
LIR	17.3701	6.3575	40.4177
LIU	4.9675	7.7733	60.4238
RVR	14.5714	5.1575	26.5994
RVU	1.3766	3.7330	13.9357
RIVR	17.2078	6.6781	44.5970
RIVU	7.4870	7.7259	59.6894
RIIR	12.2727	5.7613	33.1931
RIIU	3.1558	6.7234	45.2043
RIIR	7.5974	7.7253	59.6800
RIIU	8.5260	8.5964	73.8980
RIR	20.0844	5.8967	34.7706
RIU	7.9870	8.6030	74.0129
Total Variance =			878.5294

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 5. Palmar Ridge-Count Means of Turner Syndrome Females (n=109).

Variable *	X (Mean)	S.D.	Variance
LCD	31.0092	9.6920	93.9351
LBC	28.7339	7.2209	52.1415
LAB	44.8991	6.4002	40.9619
RCD	33.3945	8.4525	71.4448
RBC	29.1468	8.0529	64.8486
RAB	43.7706	5.3292	28.4006
			Total Variance = 351.7325

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

Table 6. Palmar Ridge-Count Means of Klinefelter Syndrome Males (n=16).

Variable*	X (Mean)	S.D.	Variance
LCD	31.9375	6.5876	43.3958
LBC	23.4375	5.5853	31.1958
LAB	39.6250	5.3276	28.3833
RCD	34.8125	4.7359	22.4292
RBC	24.3750	7.6757	58.9167
RAB	38.2500	4.7679	22.7333
			Total Variance = 207.0541

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

Table 7. Palmar Ridge-Count Means of Female Controls (n=147).

Variable*	X (Mean)	S.D.	Variance
LCD	36.4014	6.3209	39.9542
LBC	26.6735	5.7733	33.3310
LAB	42.4762	5.3601	28.7306
RCD	37.8163	6.2197	38.6852
RBC	27.2517	5.8343	34.0390
RAB	41.0068	5.0185	25.1849
Total Variance = 199.9249			

*L=Left, R=Right, A=a triradius, B=b triradius, C=c tri-radius.

Table 8. Palmar Ridge-Count Means of Male Controls (n=147).

Variable*	X (Mean)	S.D.	Variance
LCD	37.8095	6.8360	46.7306
LBC	27.4898	5.4426	29.6125
LAB	43.4490	6.1245	37.5094
RCD	39.4898	5.6983	32.4708
RBC	28.2925	5.8100	33.7563
RAB	42.4762	6.1191	37.4429
Total Variance = 217.5315			

*L=Left, R=Right, A=a triradius, B=b triradius, C=c tri-radius.

Table 9. Eigenvalues and Proportions of Variance for the Radial and Ulnar Finger Counts for Turner Syndrome Females.

Prin. No.*	Eigenvalue	Difference	Proportion	Cumulative
Prin1	7.821641	5.801214	0.391082	0.391082
Prin2	2.020428	0.403522	0.101021	0.492103
Prin3	1.616905	0.411697	0.080845	0.572949
Prin4	1.205209	0.176682	0.060260	0.633209
Prin5	1.028527	0.070026	0.051426	0.684635
Prin6	0.958501	0.047541	0.047925	0.732561
Prin7	0.910960	0.166574	0.045548	0.778109
Prin8	0.744386	0.166431	0.037219	0.815328
Prin9	0.577954	0.074110	0.028898	0.844226
Prin10	0.503844	0.080495	0.025192	0.869418
Prin11	0.423349	0.055127	0.021167	0.890585
Prin12	0.368222	0.013209	0.018411	0.908996
Prin13	0.355014	0.042661	0.017751	0.926747
Prin14	0.312352	0.028708	0.015618	0.942365
Prin15	0.283644	0.045011	0.014182	0.956547
Prin16	0.238633	0.045471	0.011932	0.968478
Prin17	0.193162	0.025892	0.009658	0.978137
Prin18	0.167270	0.009519	0.008364	0.986500
Prin19	0.157751	0.045503	0.007888	0.994388
Prin20	0.112247	.	0.005612	1.000000

*Principal Component Number (Eigenvector).

Table 10. Eigenvectors of the Radial and Ulnar Finger Counts for Turner Syndrome Females.

Variable*	Prin1	Prin2	Prin3	Prin4	Prin5
LVR	0.257446	0.107902	-.211841	0.229055	-.287508
LVU	0.189182	-.024720	0.482887	-.016701	-.250214
LIVR	0.285962	-.020883	-.228960	0.030045	-.220035
LIVU	0.252823	0.005061	0.277056	0.171712	-.031520
LIIIR	0.250956	-.275024	-.172529	-.025995	-.141185
LIIIU	0.211913	0.230381	0.332739	-.038831	0.205170
LIIR	0.216438	-.171577	-.014212	0.041696	0.129783
LIIU	0.218064	0.240342	-.066254	-.272563	-.123728
LIR	0.264952	-.171221	-.021101	-.149639	0.321983
LIU	0.163462	0.394674	-.030862	0.329804	0.159227
RVR	0.238984	0.054653	-.177511	0.207820	-.250267
RVU	0.161932	-.086337	0.515020	0.142525	-.084890
RIVR	0.276622	-.027517	-.240412	0.161467	-.067531
RIVU	0.248868	0.023794	0.177515	-.181246	-.171637
RIIIR	0.251881	-.313856	-.125144	0.047535	0.154876
RIIIU	0.128922	0.342122	0.044484	-.389572	0.205342
RIIR	0.238884	-.208918	0.081876	0.236701	0.227025
RIIU	0.215617	0.258445	-.113135	-.441882	-.167816
RIR	0.205909	-.168989	-.097327	-.253744	0.493588
RIU	0.072282	0.469008	-.116657	0.391996	0.297948

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 11. Eigenvalues and Proportions of Variance for the Radial and Ulnar Finger Counts for Klinefelter Syndrome Males.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative
Prin1	8.300724	4.942167	0.415036	0.415036
Prin2	3.358557	1.476996	0.167928	0.582964
Prin3	1.881561	0.035466	0.094078	0.677042
Prin4	1.846095	0.404476	0.092305	0.769347
Prin5	1.441619	0.422390	0.072081	0.841428
Prin6	1.019229	0.374483	0.050961	0.892389
Prin7	0.644746	0.123723	0.032237	0.924627
Prin8	0.521023	0.142598	0.026051	0.950678
Prin9	0.378426	0.126701	0.018921	0.969599
Prin10	0.251724	0.071120	0.012586	0.982185
Prin11	0.180605	0.087339	0.009030	0.991215
Prin12	0.093265	0.048513	0.004663	0.995879
Prin13	0.044752	0.017256	0.002238	0.998116
Prin14	0.027496	0.017319	0.001375	0.999491
Prin15	0.010177	0.010177	0.000509	1.000000
Prin16	0.000000	0.000000	0.000000	1.000000
Prin17	0.000000	0.000000	0.000000	1.000000
Prin18	0.000000	0.000000	0.000000	1.000000
Prin19	-.000000	0.000000	-.000000	1.000000
Prin20	-.000000	.	-.000000	1.000000

Table 12. Eigenvectors of the Radial and Ulnar Finger Counts for Klinefelter Syndrome Males.

Variable*	Prin1	Prin2	Prin3	Prin4	Prin5
LVR	0.260181	-.104794	-.017804	-.257891	-.177917
LVU	0.157546	0.365944	0.217141	0.143368	-.139601
LIVR	0.266457	-.251099	0.108057	-.030077	0.146722
LIVU	0.173307	0.283164	0.173038	0.261761	0.276901
LIIR	0.216724	-.296040	0.042091	0.207947	-.183428
LIUI	0.166958	0.386646	0.061101	0.194299	-.261391
LIIR	0.163100	-.201621	0.213021	0.376249	-.005978
LIUI	0.204507	-.015013	-.006398	0.354587	-.364698
LIR	0.160215	0.059932	-.235656	0.188790	0.584940
LIU	0.268912	0.230008	-.220107	0.021419	-.110383
RVR	0.277226	-.142414	-.137793	-.183276	-.152366
RVU	0.207160	0.273054	-.038499	-.341928	0.001122
RIVR	0.232040	-.235027	0.107808	-.373822	0.028754
RIVU	0.313332	-.094356	-.022528	-.050672	0.021171
RIIR	0.233122	-.269734	0.233836	0.002689	0.009549
RIUI	0.222185	0.314625	-.064926	-.210030	-.149302
RIIR	0.115178	0.199263	0.487602	-.301808	0.213724
RIUI	0.297134	-.074033	-.000354	0.153004	0.007456
RIR	0.108837	0.000635	-.634405	-.030631	-.037195
RIU	0.276219	0.038087	-.155854	0.082176	0.409040

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 13. Eigenvalues and Proportions of Variance for the Radial and Ulnar Finger Counts for the Female Controls.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative
Prin1	8.277890	6.129526	0.413894	0.413894
Prin2	2.148364	0.665846	0.107418	0.521313
Prin3	1.482518	0.263734	0.074126	0.595439
Prin4	1.218784	0.103021	0.060939	0.656378
Prin5	1.115763	0.319170	0.055788	0.712166
Prin6	0.796592	0.018052	0.039830	0.751996
Prin7	0.778540	0.089466	0.038927	0.790923
Prin8	0.689075	0.102511	0.034454	0.825376
Prin9	0.586564	0.063129	0.029328	0.854705
Prin10	0.523435	0.105018	0.026172	0.880876
Prin11	0.418418	0.082739	0.020921	0.901797
Prin12	0.335678	0.022406	0.016784	0.918581
Prin13	0.313272	0.022670	0.015664	0.934245
Prin14	0.290603	0.072590	0.014530	0.948775
Prin15	0.218012	0.016175	0.010901	0.959675
Prin16	0.201837	0.017488	0.010092	0.969767
Prin17	0.184349	0.032991	0.009217	0.978985
Prin18	0.151358	0.005192	0.007568	0.986553
Prin19	0.146166	0.023386	0.007308	0.993861
Prin20	0.122780	.	0.006139	1.000000

Table 14. Eigenvectors of the Radial and Ulnar Finger Counts for the Female Controls.

Variable *	Prin1	Prin2	Prin3	Prin4	Prin5
LVR	0.253945	-.115771	0.159903	0.034299	-.441228
LVU	0.152782	0.319304	0.177784	0.461045	-.191260
LIVR	0.269727	-.176952	-.074485	-.207669	-.223703
LIVU	0.215358	0.336667	0.005452	0.003405	0.018199
LIIR	0.260677	-.174351	-.263273	0.055715	0.070808
LIUI	0.207452	0.310912	-.220258	-.025506	0.167292
LIIR	0.211221	-.055005	-.083806	0.370521	0.198840
LIUI	0.230553	0.090752	-.133826	-.201445	-.025869
LIR	0.182260	-.358577	0.220987	0.132065	0.232353
LIU	0.188447	0.018189	0.528681	-.155530	0.242151
RVR	0.252810	-.135800	0.125835	0.003027	-.452325
RVU	0.182511	0.358676	0.198505	0.349007	-.165366
RIVR	0.263863	-.160904	-.172981	-.167356	-.265036
RIVU	0.214655	0.279884	-.073385	-.178432	0.118105
RIIR	0.252765	-.190037	-.279825	0.144544	0.100333
RIUI	0.225409	0.252765	-.172333	-.190189	0.240418
RIIR	0.214532	-.071346	-.181296	0.277410	0.177136
RIUI	0.239880	0.069056	-.010454	-.342425	-.027739
RIR	0.206663	-.334015	0.106527	0.173711	0.262290
RIU	0.204082	-.002511	0.472523	-.238242	0.218137

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 15. Eigenvalues and Proportions of Variance for the Radial and Ulnar Finger Counts for the Male Controls.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative
Prin1	7.831142	5.910858	0.391557	0.391557
Prin2	1.920283	0.383915	0.096014	0.487571
Prin3	1.536368	0.106344	0.076818	0.564390
Prin4	1.430024	0.447627	0.071501	0.635891
Prin5	0.982397	0.037637	0.049120	0.685011
Prin6	0.944760	0.196212	0.047238	0.732249
Prin7	0.748548	0.106407	0.037427	0.769676
Prin8	0.642141	0.082104	0.032107	0.801783
Prin9	0.560037	0.094131	0.028002	0.829785
Prin10	0.465906	0.027740	0.023295	0.853080
Prin11	0.438167	0.036059	0.021908	0.874989
Prin12	0.402108	0.022295	0.020105	0.895094
Prin13	0.379813	0.031395	0.018991	0.914085
Prin14	0.348418	0.016276	0.017421	0.931505
Prin15	0.332142	0.063500	0.016607	0.948113
Prin16	0.268641	0.035237	0.013432	0.961545
Prin17	0.233404	0.040893	0.011670	0.973215
Prin18	0.192511	0.014934	0.009626	0.982840
Prin19	0.177577	0.011962	0.008879	0.991719
Prin20	0.165615	.	0.008281	1.000000

Table 16. Eigenvectors of the Radial and Ulnar Finger Counts for the Male Controls.

Variable*	Prin1	Prin2	Prin3	Prin4	Prin5
LVR	0.265594	-.122801	-.188997	-.128577	0.144618
LVU	0.130359	0.477628	0.106272	-.197850	0.236933
LIVR	0.269555	-.202775	-.220934	-.161922	0.142654
LIVU	0.218428	0.261126	-.131597	-.170511	0.091983
LIIR	0.264188	-.167359	0.009676	-.168814	-.158065
LIUI	0.219903	0.253967	-.021931	0.058542	-.475078
LIIR	0.224930	-.070544	0.358011	-.036077	-.256493
LIUI	0.200710	0.147772	-.242639	0.334042	-.057011
LIR	0.231025	-.222768	0.326923	0.146129	0.137858
LIU	0.208513	0.118693	0.184177	0.391253	0.158929
RVR	0.245017	-.123826	-.270546	-.086480	0.170575
RVU	0.121010	0.424020	0.257787	-.181623	0.363892
RIVR	0.230262	-.195960	-.356954	-.214444	0.028651
RIVU	0.216015	0.194073	-.065027	-.097390	0.158160
RIIR	0.251530	-.168365	0.192851	-.200315	-.224832
RIUI	0.233933	0.230447	-.087724	0.103689	-.389645
RIIR	0.214456	-.006539	0.302050	-.310273	-.189109
RIUI	0.228703	0.105597	0.275710	0.354345	0.007985
RIR	0.221054	-.310295	0.231665	0.143165	0.318676
RIU	0.216105	-.065821	0.146068	0.425026	0.055228

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 17. Eigenvalues and Proportions of Variance for the Largest Finger Counts for Turner Syndrome Females.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative
Prin1	6.128638	5.063417	0.612864	0.612864
Prin2	1.065221	0.389078	0.106522	0.719386
Prin3	0.676142	0.096923	0.067614	0.787000
Prin4	0.579219	0.141897	0.057922	0.844922
Prin5	0.437322	0.084757	0.043732	0.888654
Prin6	0.352565	0.109813	0.035257	0.923911
Prin7	0.242753	0.021655	0.024275	0.948186
Prin8	0.221098	0.049656	0.022110	0.970296
Prin9	0.171441	0.045841	0.017144	0.987440
Prin10	0.125601	.	0.012560	1.000000

Table 18. Eigenvectors of the Largest Finger Counts for Turner Syndrome Females.

Variable *	Prin1	Prin2	Prin3	Prin4
LV	0.308608	-.476236	0.286266	0.033208
LIV	0.338279	-.228524	-.265568	-.024713
LIII	0.322154	0.004606	-.507657	0.329825
LII	0.330117	0.168296	-.040434	-.528013
LI	0.315200	0.311936	0.373119	0.096217
RV	0.280676	-.477595	0.385112	0.164185
RIV	0.342306	-.164597	-.119381	0.001156
RIII	0.324672	0.228059	-.340655	0.320966
RII	0.323603	0.143116	-.020290	-.612495
RI	0.268577	0.517344	0.412234	0.310354

*L=Left, R=Right, V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 19. Eigenvalues and Proportions of Variance for the Largest Finger Counts for the Female Controls.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative
Prin1	6.037536	5.030961	0.603754	0.603754
Prin2	1.006576	0.065795	0.100658	0.704411
Prin3	0.940781	0.365194	0.094078	0.798489
Prin4	0.575587	0.104193	0.057559	0.856048
Prin5	0.471394	0.157069	0.047139	0.903187
Prin6	0.314325	0.112349	0.031432	0.934620
Prin7	0.201976	0.027445	0.020198	0.954817
Prin8	0.174531	0.010138	0.017453	0.972270
Prin9	0.164393	0.051490	0.016439	0.988710
Prin10	0.112902	.	0.011290	1.000000

Table 20. Eigenvectors of the Largest Finger Counts for the Female Controls.

Variable *	Prin1	Prin2	Prin3	Prin4
LV	0.308634	-.239789	0.490461	0.136153
LIV	0.348918	-.168080	0.042161	-.306057
LIII	0.331919	-.038560	-.389903	-.245989
LII	0.314011	-.005436	-.256736	0.565870
LI	0.273891	0.627890	0.217373	-.093934
RV	0.309292	-.267798	0.509810	0.099036
RIV	0.338854	-.285603	-.031860	-.378913
RIII	0.322798	-.012436	-.398266	-.214690
RII	0.317650	-.048349	-.232255	0.545119
RI	0.289185	0.602255	0.137851	-.040238

*L=Left, R=Right, V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 21. Eigenvalues and Proportions of Variance for the
Largest Finger Counts for the Male Controls.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative
Prin1	5.705909	4.605170	0.570591	0.570591
Prin2	1.100740	0.336744	0.110074	0.680665
Prin3	0.763995	0.141095	0.076400	0.757064
Prin4	0.622900	0.101531	0.062290	0.819354
Prin5	0.521369	0.164277	0.052137	0.871491
Prin6	0.357092	0.063321	0.035709	0.907200
Prin7	0.293770	0.043168	0.029377	0.936577
Prin8	0.250603	0.042017	0.025060	0.961638
Prin9	0.208585	0.033548	0.020859	0.982496
Prin10	0.175037	.	0.017504	1.000000

Table 22. Eigenvectors of the Largest Finger Counts for the Male Controls.

Variable*	Prin1	Prin2	Prin3	Prin4
LV	0.327155	-.320863	-.048676	0.225429
LIV	0.347601	-.221031	-.249039	-.023899
LIII	0.327083	0.005224	-.208745	-.567901
LII	0.296322	0.195676	0.652712	-.035451
LI	0.291277	0.565831	-.217470	0.121865
RV	0.310662	-.374505	0.026779	0.303200
RIV	0.321062	-.350673	-.109788	0.110899
RIII	0.326882	0.080037	-.058660	-.560570
RII	0.317790	0.079300	0.555097	0.071878
RI	0.291681	0.462376	-.307188	0.431691

*L=Left, R=Right, V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 23. Eigenvalues and Proportions of Variance for the Absolute Finger Counts for Turner Syndrome Females.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative
Prin1	6.176868	5.230240	0.617687	0.617687
Prin2	0.946628	0.169758	0.094663	0.712350
Prin3	0.776870	0.205900	0.077687	0.790037
Prin4	0.570970	0.181376	0.057097	0.847134
Prin5	0.389594	0.028907	0.038959	0.886093
Prin6	0.360688	0.115960	0.036069	0.922162
Prin7	0.244728	0.035851	0.024473	0.946635
Prin8	0.208877	0.026740	0.020888	0.967522
Prin9	0.182137	0.039499	0.018214	0.985736
Prin10	0.142638	.	0.014264	1.000000

Table 24. Eigenvectors of the Absolute Finger Counts for Turner Syndrome Females.

Variable*	Prin1	Prin2	Prin3	Prin4
LACV	0.316246	-.378893	0.359294	-.158664
LACIV	0.344188	-.197664	-.143264	0.060188
LACIII	0.330937	-.112574	-.279390	0.361160
LACII	0.338124	0.085103	-.123152	-.526170
LACI	0.310645	0.357069	0.318826	-.097695
RACV	0.276886	-.385632	0.506254	0.365531
RACIV	0.343136	-.135096	-.213654	0.004895
RACIII	0.303070	0.158320	-.493349	0.354756
RACII	0.344899	0.081680	-.068003	-.462507
RACI	0.236560	0.686481	0.324884	0.284544

*L=Left, R=Right, AC=Absolute Count, V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 25. Eigenvalues and Proportions of Variance for the Absolute Finger Counts for Female Controls.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative
Prin1	6.112058	4.984486	0.611206	0.611206
Prin2	1.127572	0.273641	0.112757	0.723963
Prin3	0.853931	0.247471	0.085393	0.809356
Prin4	0.606460	0.196278	0.060646	0.870002
Prin5	0.410182	0.148389	0.041018	0.911020
Prin6	0.261793	0.077699	0.026179	0.937199
Prin7	0.184094	0.014580	0.018409	0.955609
Prin8	0.169514	0.024856	0.016951	0.972560
Prin9	0.144658	0.014919	0.014466	0.987026
Prin10	0.129739	.	0.012974	1.000000

Table 26. Eigenvectors of the Absolute Finger Counts for the Female Controls.

Variable*	Prin1	Prin2	Prin3	Prin4
LACV	0.298159	0.130321	-.607728	0.199236
LACIV	0.336186	-.104195	-.095819	-.529404
LACIII	0.328185	-.330711	0.187487	-.023728
LACII	0.333921	-.157260	0.133129	0.464796
LACI	0.260423	0.637717	0.238247	-.072696
RACV	0.316979	0.106683	-.571398	0.084607
RACIV	0.328028	-.213566	-.006020	-.548479
RACIII	0.328742	-.271690	0.275624	0.101061
RACII	0.332396	-.117076	0.163562	0.371233
RACI	0.290544	0.535596	0.287397	-.046234

*L=Left, R=Right, AC=Absolute Count, V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 27. Eigenvalues and Proportions of Variance for the Absolute Finger Counts for Male Controls.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative
Prin1	5.987156	4.919379	0.598716	0.598716
Prin2	1.067777	0.366488	0.106778	0.705493
Prin3	0.701290	0.122801	0.070129	0.775622
Prin4	0.578489	0.124532	0.057849	0.833471
Prin5	0.453957	0.115990	0.045396	0.878867
Prin6	0.337967	0.066978	0.033797	0.912664
Prin7	0.270990	0.026378	0.027099	0.939763
Prin8	0.244611	0.047783	0.024461	0.964224
Prin9	0.196828	0.035893	0.019683	0.983907
Prin10	0.160934	.	0.016093	1.000000

Table 28. Eigenvectors of the Absolute Finger Counts for the Male Controls.

Variable*	Prin1	Prin2	Prin3	Prin4
LACV	0.317736	-.315136	0.246841	-.424109
LACIV	0.323154	-.321280	0.006274	0.446204
LACIII	0.326201	-.003828	-.473848	-.109224
LACII	0.328349	0.269778	-.247279	-.206121
LACI	0.289393	0.519020	0.255659	0.018893
RACV	0.301294	-.316812	0.441419	-.420418
RACIV	0.308738	-.345949	0.087003	0.564025
RACIII	0.334630	0.031431	-.403125	-.014403
RACII	0.347481	0.070764	-.186256	-.074090
RACI	0.278979	0.478797	0.434014	0.256296

*L=Left, R=Right, AC=Absolute Count, V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

For the radial and ulnar counts, Prin1 (First Principal Component) accounted for 39% of the variation for the Turners, 42% for the Klinefelters, 41% for the female controls, and 39% for the male controls. Because all loadings were positive and approximately equal, Prin1 was viewed as a general size component. These results were an expected observation since according to Jantz and Parham (1981), a large part of the correlation among a set of 20 finger ridge counts is due to size variation, being consistently at about 40-50% of the variation.

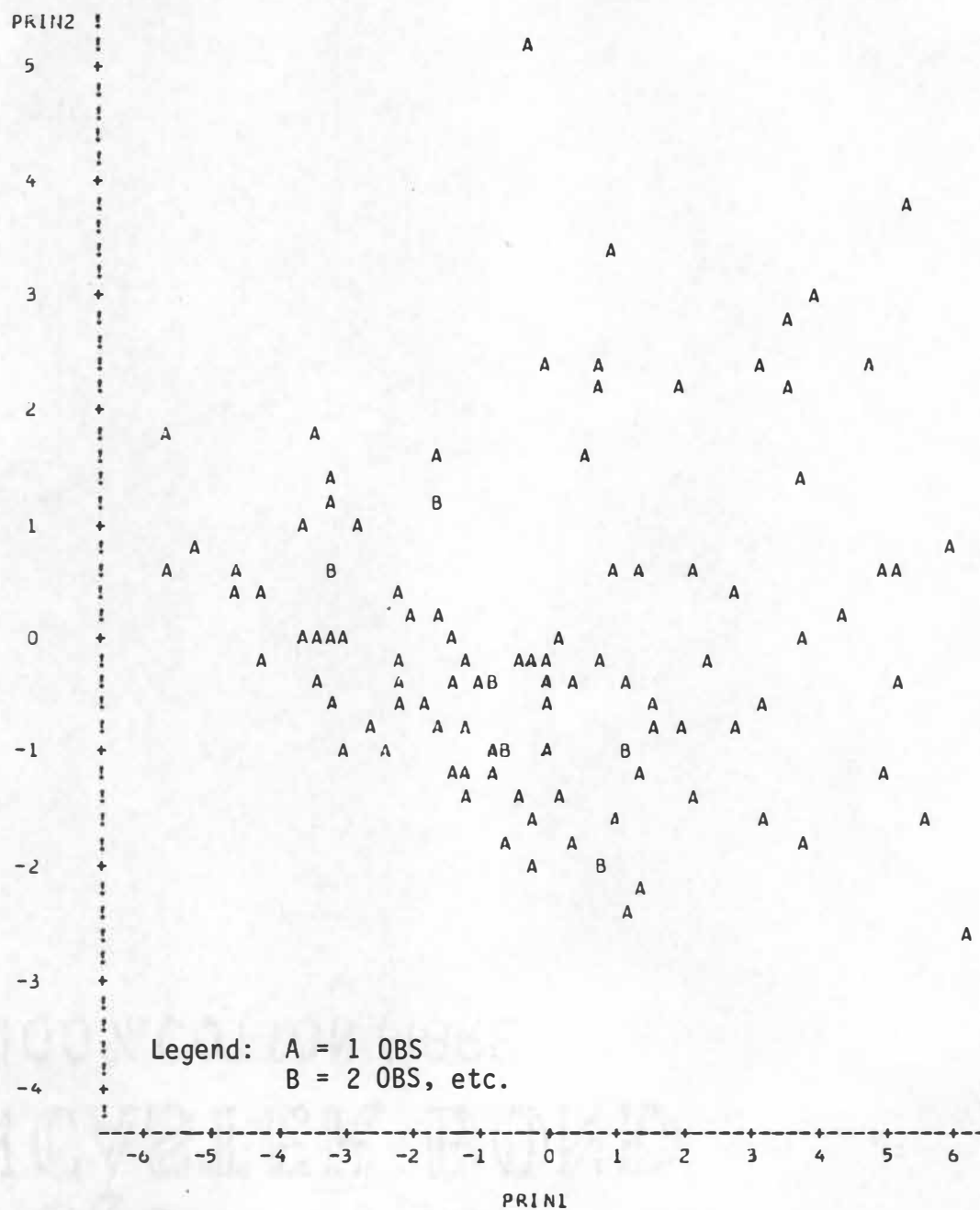
Prin2 (Second Principal Component) for the Turners accounted for 10% of the variation and was a contrast component, contrasting the radial and ulnar sides of the fingers, especially of the left and right thumbs and right digit III. The loadings of digit V were opposite those of the other digits; in this respect the Turners were different from the other samples. Prin2 for the Klinefelters accounted for 17% of the variation and contrasted the radial and ulnar sides of left digits III, IV, and V, and right digits II, III, and V. The Klinefelters showed a different pattern of loadings from the other samples in that although there was a general pattern of high contrast for the radial and ulnar counts, it was not true for all digits. Prin2 for the female controls accounted for 11% of the variation and contrasted the radial and ulnar sides of the fingers. The exception was that of the right thumb, which had both loadings with the same sign. Prin2 for the male controls accounted for 10% of the variation and was largely a contrast component of

the radial and ulnar sides of the digits. The exception was the right thumb, which had both loadings with the same sign. The largest contrasts were on right and left digit V.

Prin2 for all samples was a contrast of the radial and ulnar sides of the digits. The results showed that the male and female controls exhibited the differences as outlined by Jantz and Parham (1981), who found that males show ulnar counts in favor of the right hand and radial counts in favor of the left hand, with females displaying the opposite pattern. They claim that negative correlation between the sides of the digits implies competition between sides of the digit for anlage during volar pad formation. This competition would influence the shape of the pad and therefore the type of pattern formed.

There were differences among the samples in regard to Prin2. Although they all followed the general trend of male-female differences as outlined by Jantz and Parham (1981), there were differences between the Turners and the female controls and differences between the Klinefelters and the male controls. If Prin2 does have biological significance in terms of indicating competition between the sides of the digit for anlage during the developmental process, the differences observed in the Turners and Klinefelter samples should serve to point out a deviation from a normal developmental pathway.

Prin1 and Prin2 scores were plotted against one another for all samples (Figures 1-4). The plots showed a curvilinear relationship with an increase in size exhibiting a concomitant decrease



NOTE: 1 OBS HAD MISSING VALUES

Figure 1. The Plot of General Size and the Radial-Ulnar Contrasts for Turner Syndrome Females.

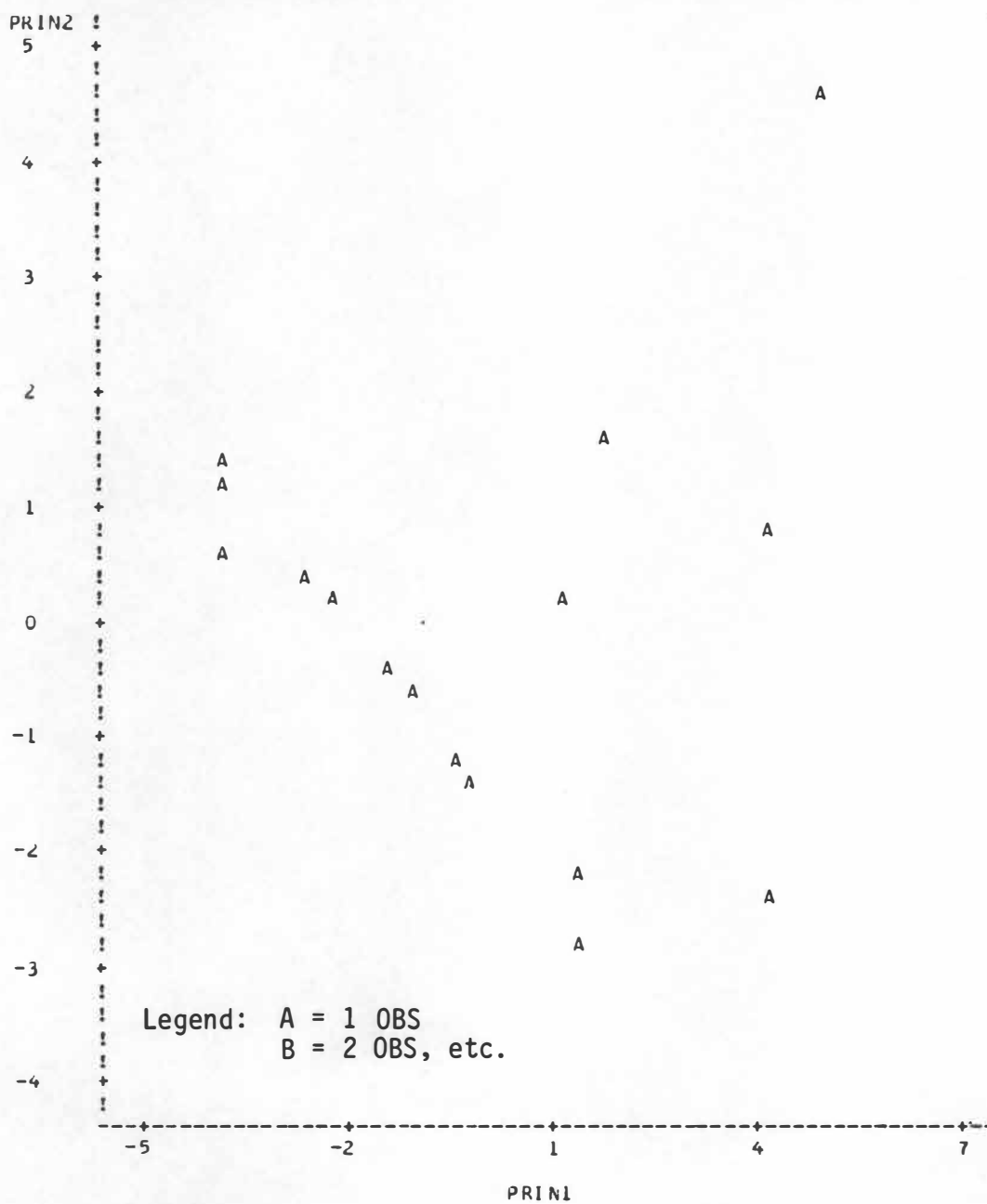


Figure 2. The Plot of General Size and the Radial-Ulnar Contrasts for Klinefelter Syndrome Males.

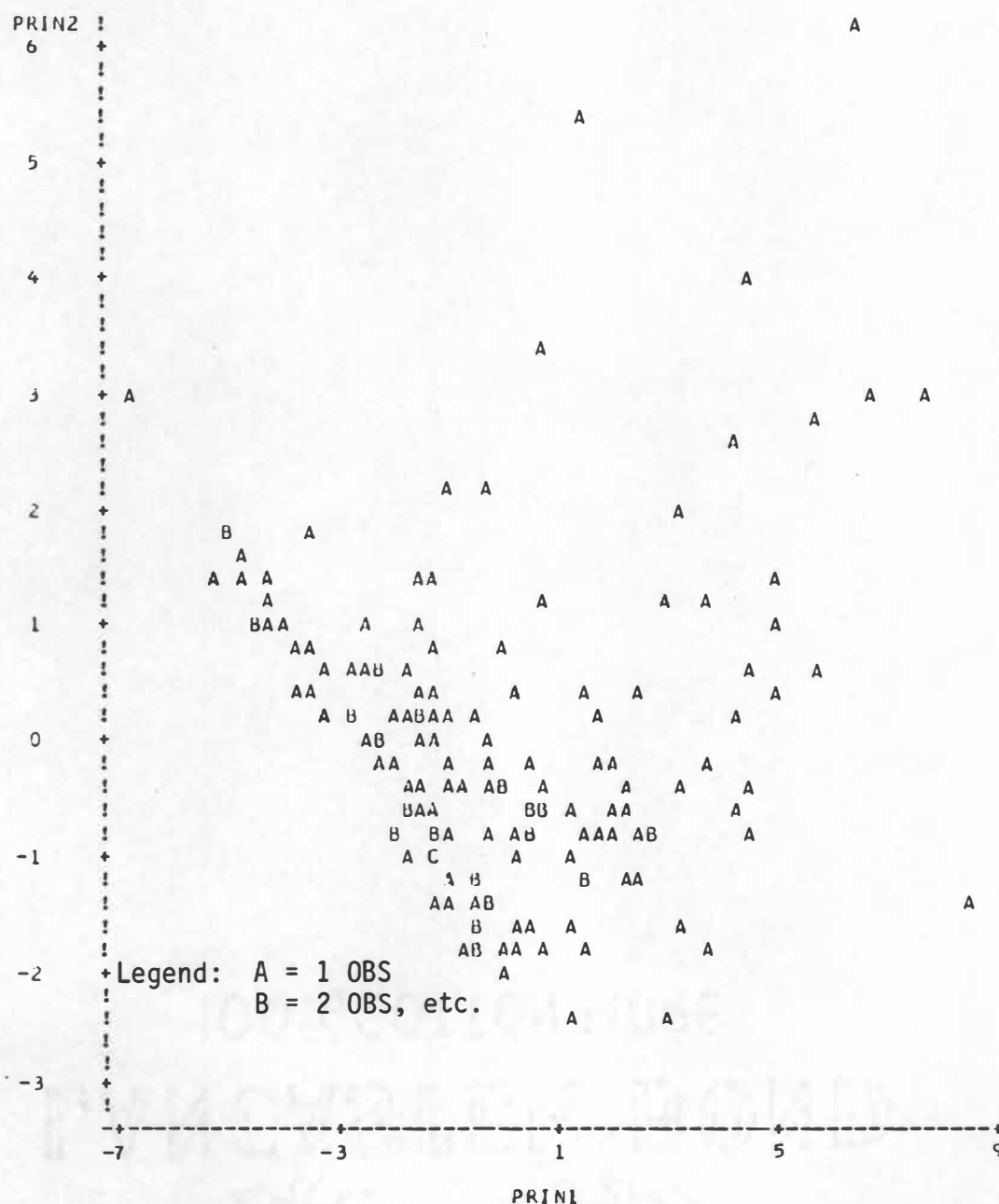


Figure 3. The Plot of General Size and the Radial-Ulnar Contrasts for Female Controls.



Figure 4. The Plot of General Size and the Radial-Ulnar Contrasts for Male Controls.

in the radial-ulnar contrast until a certain size was reached and then a continuing size increase resulted in an increase in the radial-ulnar contrast. Upon looking at Tables 10, 12, 14, and 16 (pages 27, 29, 31, and 33, respectively), it could be seen that the digits with the smallest counts and largest counts showed the largest radial-ulnar contrast for all samples. The strongest relationships were seen in the controls.

The plots of Prin1 and Prin2 for the Turner sample were looked at carefully because the Turners have large patterns on the digits and therefore have large ridge counts. The curvilinear relationship for the Turners did not appear to be as strong as in the female controls.

Prin3 (Third Principal Component) for the Turners accounted for 8% of the variation and was a digit V component which contrasted the sides of the digits. There was a similar contrast for digit III. Prin3 for the Klinefelters accounted for 9% of the variation and was a contrast of right radial II and right radial I. Prin3 for the female controls accounted for 7% of the variation and was largely a thumb component with high loadings on the ulnar side of both thumbs. Also, there were moderately low loadings on the radial sides of digit III. Prin3 for the male controls accounted for 8% of the variation and was a digit II component with contrasting radial counts on right and left digit II.

Prin3 for the Turners was where the importance of digit V was re-emphasized. Also, digit III was seen as an important digit.

It appeared that Prin3 pointed out variations that are divided along lines of sexual differences since Prin3 for the female controls was a thumb component while for the Turners Prin2 was a thumb component. The female controls, like the Turners, showed that digit III was an important digit. Prin3 for the Klinefelters and male controls was a digit II component.

Prin4 (Fourth Principal Component) for the Turners accounted for 6% of the variation and was a thumb component with contrasting loadings on the ulnar and radial sides of the digits. The right hand also showed a contrast of the radial and ulnar sides of digits II and III. Prin4 for the Klinefelters accounted for 9% of the variation and was a digit II component with contrasting loadings on the radial and ulnar sides of left digit II. There were low loadings on the radial side of right digits II, IV, and V. Prin4 for the female controls accounted for 6% of the variation and was a digit II and digit V component. Digits II and V exhibited contrasting loadings on the radial and ulnar sides of both hands. Prin4 for the male controls accounted for 7% of the variation and was a digit II component with contrasting loadings on the radial and ulnar sides of digit II. There were also high loadings on the ulnar sides of both hands.

The differences between the Turner and the control fingers showed up clearly in Prin4 because the control females, unlike the Turners, failed to show an importance on digit V until Prin4. The Klinefelter and control males again emphasized digit II, which seemed

to be largely a difference divided along sexual lines because digit II appeared to be a stronger contributor to variation in the males than in the females.

Prin5 (Fifth Principal Component) was clearly a digit V component for the Turners and the male and female controls. Prin5 for the Turners accounted for 5% of the variation and was a contrast between the radial sides of the thumbs and the radial sides of digit V. Prin5 for the Klinefelters accounted for 7% of the variation and was a thumb component with contrasting loadings on the ulnar and radial sides of the thumb. Prin5 for the female controls accounted for 6% of the variation and was a radial digit V component with low loadings on both hands. Prin5 for the male controls accounted for 5% of the variation and was a digit V component with high loadings on the ulnar side of both digits. There were low loadings on the ulnar side of digit III of both hands.

Since the radial-ulnar contrasts were responsible for a large amount of the variation in the fingers when using all 20 counts, principal components analysis was performed on the largest counts on each digit for all samples. This served to eliminate the radial-ulnar contrasts as contributors to the variation and further partition the remaining variance. This procedure was performed only on the Turner and control samples.

As in the radial-ulnar counts principal components analysis, the largest counts principal components analysis showed that Prin1 was a general size component, accounting for close to 60% of the

variation for all samples. Prin1 accounted for 61% of the variation for the Turners, 60% for the female controls, and 57% for the male controls.

A phenomenon that first appeared at this point in the analysis was that of a gradient, with all samples showing a gradient from digit I to IV, with digit V being variable and independent. This growth relationship across the hands has previously been established although the intensity and expression of the gradient will vary along sexual lines (Hawkinson 1981). Emphasis was again placed on digit V which again makes its appearance as a significant digit, serving to operate independently of the other digits as far as size and growth gradients are concerned for all samples.

Prin2 for the Turners accounted for 11% of the variation and was a contrast between the thumb and digit V on both hands with contrasting loadings on the thumbs and digit V. It exhibited a gradient from digit I to digit V for both hands. Prin2 for the female controls accounted for 10% of the variation and was largely a thumb component with high loadings on both thumbs. Both hands had moderately low loadings on digits IV and V, showing a gradient from digit I to digit V for both hands. Prin2 for the male controls accounted for 11% of the variation and was a digit I, digit IV, and digit V component. There was a gradient from digit I to digit V for both hands.

Prin2 showed a gradient for all samples and with such a gradient there was a large contrast between the loadings for digit V and

digit I. This seemed to indicate the existence of a developmental field in which adjacent digits are more similar to each other than to more distant digits. This developmental field was influencing the variation at the rate of approximately 10-11% for all samples.

Prin3 for the Turners accounted for 7% of the variation and was a contrast of the thumb and digit III for both hands. Prin3 for the female controls accounted for 9% of the variation and was a contrast of digit V and digit III on both hands. Prin3 for the male controls accounted for 8% of the variation and was a contrast of digit II with all the other digits.

Prin3 for the Turners emphasized the importance of the thumbs, contrasting them with digit III. These results differed from those found for the female controls in which Prin3 was a contrast of digits III and V. The Turners and control females presented a dichotomy in results at this point with the middle digit being contrasted to digits on opposite sides of the hand. This may be a significant indication of the developmental differences affecting the Turner sample, such as a deviation in the growth gradient or the developmental field. Prin3 for the male controls was a digit II component, which was predictable because digit II was shown to be an important digit for males on the previous analysis.

Prin4 for the Turners accounted for 6% of the variation and was a contrast of digit II and digit III on both hands. Prin4 for the control females accounted for 6% of the variation and was a digit II and digit IV contrast. Prin4 for the male controls accounted

for 6% of the variation and was a component contrasting digit III and digit V. There was a high loading on the right thumb with no corresponding high value on the left thumb.

Prin4 seemed to be divided along sexual lines because both the Turners and female controls emphasized digit II. Prin4 for the male controls was ambiguous but digit V finally appeared as an important digit. Digit V did not seem to be as important a contributor towards variation in the males as in the females.

The last principal components analysis performed on the fingers was carried out using the absolute ridge counts. Prin1 was a general size component and accounted for approximately 61% of the variation for all the samples, accounting for 62% of the variation for the Turners, 61% for the female controls, and 60% for the male controls. This high percentage was probably due to the radial-ulnar contrasts being eliminated as a source of variation. The male controls exhibited a gradient from digit II to digit V, with the thumbs being independent.

Prin2 for the Turners accounted for 9% of the variation and was a component contrasting digit V and digit I. There was a gradient from digit V to digit I for both hands. Prin2 for the female controls accounted for 11% of the variation and was a thumb component with high loadings on both thumbs. Prin2 for the male controls accounted for 11% of the variation and was a digit I component primarily, but was also a digit IV component, with contrasting loadings between digit I and digits IV and V. There was a gradient from digit I to digit V on both hands, but the gradient on the right hand was not as strong as on the left hand.

Prin2 was where the growth gradient first appears for the Turners, with the largest contrasts being between the thumbs and digit V. This perhaps demonstrated the developmental field theory since the loadings for each digit were more similar to the loadings of adjacent digits than they were to more distant digits.

The female controls still did not exhibit a growth gradient, indicating that this factor was not as important a contributor to the variance in the absolute counts, with Prin2 instead being a thumb component.

Prin3 for the Turners accounted for 8% of the variation and contrasted digits I and V with digit III. Prin3 for the female controls accounted for 9% of the variation and was a digit V component with low loadings on both hands. There was a weak gradient from digit I to digit V on both hands with digit II being out of sequence. Prin3 for the male controls accounted for 7% of the variation and was ambiguous. There were contrasting loadings of right digits I and V with right digit III.

Prin3 became more ambiguous for all the samples with the Turner contrasts of digit III with digits I and V emphasizing the concept of developmental fields. The female samples both showed digit V to be a consistently important digit.

Prin4 for the Turners accounted for 6% of the variation and was a digit II and digit III component with contrasting loadings for digits II and III. Prin4 for the female controls accounted for 6% of the variation and was a component contrasting digits II

and IV. Prin4 for the male controls accounted for 6% of the variation and was a component contrasting digits IV and V.

It was on Prin4 that digits II and III appeared as important digits for the Turners. These digits were consistently found to be more important contributors towards the variance in the males than in the females. Prin4 for the female controls contrasted digits II and IV which was consistent with the developmental field theory while the male control contrast of digits IV and V did not coincide well with this theory.

Principal components analysis was also performed on the palms of all four samples with the variables used being the a-b, b-c, and c-d counts for each hand. Six principal components were extracted and all were interpretable and utilized in this study (Tables 29-32).

Prin1 accounted for 42% of the variation for the Turners, 47% of the variation for the Klinefelters and was a general size component for both. The Turners exhibited an a-b to c-d gradient for both hands while the Klinefelters exhibited an a-b to c-d gradient for the left hand. Prin1 accounted for 51% of the variation for the female controls and 51% of the variation for the male controls. It was a general size component for both samples with the male controls exhibiting an a-b to c-d gradient.

Prin1 showed a growth gradient for all samples except the female controls, but this was not unexpected because the principal components analysis for the female control fingers revealed that growth gradients were not an important contributor to the variance.

Table 29. Eigenvalues, Proportions of Variance, and Eigenvectors of the Palm Counts for the Turner Syndrome Females.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative	Variable*	Prin1	Prin2	Prin3	Prin4	Prin5	Prin6
Prin1	2.495088	0.900325	0.415848	0.415848	LCD	0.505451	0.009431	-.437689	0.360842	-.592105	-.268445
Prin2	1.594763	0.570977	0.265794	0.681642	LBC	0.450085	-.392573	0.346591	-.276816	0.236432	-.625026
Prin3	1.023786	0.624918	0.170631	0.852273	LBA	0.233766	0.608892	0.318596	0.557298	0.377505	-.141453
Prin4	0.398868	0.114453	0.066478	0.918751	RCD	0.451743	0.062618	-.592143	-.230291	0.560798	0.271745
Prin5	0.284415	0.081335	0.047402	0.966153	RBC	0.427175	-.407411	0.405072	0.252617	-.080157	0.645921
Prin6	0.203080	.	0.033847	1.000000	RAB	0.317406	0.552398	0.268482	-.604761	-.360667	0.161898

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

Table 30. Eigenvalues, Proportions of Variance, and Eigenvectors of the Palm Counts for the Klinefelter Syndrome Males.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative	Variable*	Prin1	Prin2	Prin3	Prin4	Prin5	Prin6
Prin1	2.807396	1.163359	0.467899	0.467899	LCD	0.264607	0.604151	0.171061	-.670962	0.290614	0.032792
Prin2	1.644037	0.682281	0.274006	0.741906	LBC	0.438126	0.062872	-.635723	0.274884	0.438166	0.363866
Prin3	0.961756	0.600342	0.160293	0.902198	LBA	0.476698	-.288900	0.430161	-.062386	-.302821	0.639269
Prin4	0.361415	0.214230	0.060236	0.962434	RCD	0.104913	0.654469	0.331254	0.658897	-.129548	-.002428
Prin5	0.147185	0.068975	0.024531	0.986965	RBC	0.533238	0.072031	-.349240	-.104941	-.622854	-.435363
Prin6	0.078210	.	0.013035	1.000000	RAB	0.464154	-.337738	0.387114	0.158738	0.476575	-.517991

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

Table 31. Eigenvalues, Proportions of Variance, and Eigenvectors of the Palm Counts for the Female Controls.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative	Variable*	Prin1	Prin2	Prin3	Prin4	Prin5	Prin6
Prin1	3.088590	1.837841	0.514765	0.514765	LCD	0.454595	-.258580	0.398301	-.242965	-.598587	-.387941
Prin2	1.250749	0.331913	0.208458	0.723223	LBC	0.372045	0.615493	0.027231	0.339372	0.253523	-.550057
Prin3	0.918836	0.567281	0.153139	0.876363	LBA	0.419790	-.260969	-.478700	-.549481	0.443791	-.166248
Prin4	0.351555	0.097290	0.058593	0.934955	RCD	0.380054	-.392043	0.522410	0.334110	0.490746	0.276564
Prin5	0.254266	0.118262	0.042378	0.977333	RBC	0.411002	0.544811	0.106573	-.330677	-.126690	0.630478
Prin6	0.136004	.	0.022667	1.000000	RAB	0.406619	-.188900	-.572007	0.550353	-.351549	0.212862

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

Table 32. Eigenvalues, Proportion of Variance, and Eigenvectors of the Palm Counts for the Male Controls.

Prin. No.	Eigenvalue	Difference	Proportion	Cumulative	Variable*	Prin1	Prin2	Prin3	Prin4	Prin5	Prin6
Prin1	3.036073	1.869911	0.506012	0.506012	LCD	0.412930	0.419837	0.339916	-.609855	-.136272	0.383654
Prin2	1.166162	0.180353	0.194360	0.700373	LBC	0.398253	-.509091	0.300819	0.442280	-.072125	0.539365
Prin3	0.985809	0.640164	0.164301	0.864674	LBA	0.413249	0.056506	-.601296	-.035955	0.650515	0.200033
Prin4	0.345645	0.078757	0.057607	0.922282	RCD	0.354598	0.581114	0.295892	0.569622	0.130122	-.328046
Prin5	0.266888	0.067465	0.044481	0.966763	RCD	0.424048	-.472944	0.268354	-.321708	0.192503	-.619629
Prin6	0.199423	.	0.033237	1.000000	RAB	0.441081	0.001184	-.522343	0.056633	-.706449	-.174145

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

Prin2 for the Turners accounted for 27% of the variation and was an a-b component contrasting the loadings for both hands. Prin2 accounted for 27% of the variation and was an a-b and c-d component contrasting loadings on both hands. There was a gradient from a-b to c-d on both hands. Prin2 for the female controls accounted for 21% of the variation and was a b-c and c-d component with contrasting loadings on each hand. Prin2 for the male controls accounted for 19% of the variation and was a b-c and c-d component with contrasting loadings on each hand.

Prin2 pointed out some basic differences between the Turners and the other groups. The Turners showed Prin2 to be an a-b component while the male and female controls showed Prin2 to be a contrast of the b-c and c-d counts. The Klinefelters showed a deviation from all the groups in that Prin2 exhibited a growth gradient in which c-d was contrasted with a-b.

Prin3 for the Turners accounted for 17% of the variation and was a component in which c-d was contrasted with a-b and b-c. Prin3 for the Klinefelters accounted for 16% of the variation and was a b-c and a-b component with contrasting loadings on b-c and a-b. Prin3 for the female controls was an a-b and c-d component with contrasting loadings on both hands. There was a gradient from the a-b to the c-d counts for both hands. Prin3 for the male controls accounted for 16% of the variation and was mostly an a-b and c-d component with contrasting loadings on both hands. There was a gradient from a-b to the c-d counts on both hands.

Prin3 again showed that the Turners vary not only from the female controls but also from the other two male groups. The Turner Prin3 is a contrast of c-d with a-b and b-c while for the female controls it showed a radial-ulnar growth gradient with resulting contrasts between a-b and c-d. For the Klinefelters, Prin3 was a b-c and a-b contrast as compared to the control males, who exhibited a radial-ulnar growth gradient with resulting a-b and c-d contrasts.

Prin4 for the Turners accounted for 7% of the variation and was an a-b component with contrasting loadings on the left and right hands. Prin4 for the Klinefelters accounted for 6% of the variation and was a c-d component with contrasting loadings on the left and right hands. Prin4 for the female controls accounted for 6% of the variation and was an a-b and c-d component with contrasting loadings on both hands. Prin4 for the male controls accounted for 6% of the variation and was a right-left contrast component for the c-d and b-c counts. Prin4 for the Turners was an a-b component, re-emphasizing the fact that the large a-b count was an important contributor towards variation in the Turner group. In this case there was a contrast between the right and left hands. The Klinefelters also exhibited a right-left contrast, except the counts involved were the c-d counts. Prin4 for the female controls was not an asymmetry component and contrasted the a-b and b-c counts. For the male controls Prin4 appeared to be an asymmetry component since it contrasted the c-d and b-c counts of the left hand with the c-d and b-c counts of the right hand. This component was of

interest because it seems to be an asymmetry component for all samples except the female controls. This appeared to indicate that the female controls were not as asymmetric as the other groups, perhaps being better canalized. This is another way in which the Turners deviated in their development from normal females, the lack of an X chromosome resulting in increased asymmetry.

Prin5 for the Turners accounted for 5% of the variation and was a right-left contrast for the c-d and a-b counts. There was a gradient from a-b to the c-d count for both hands. Prin5 for the Klinefelters accounted for 2% of the variation and was a right-left contrast component for the a-b and b-c counts. Prin5 for the female controls accounted for 4% of the variation and was a contrast of the c-d and a-b counts of each hand. The left hand showed high loadings on the a-b count and low loadings on the c-d count, while the right hand showed high loadings on the c-d count and low loadings on the a-b counts. There was a gradient from the c-d to the a-b counts for the right hand and from the a-b to the c-d counts for the left hand. Prin5 for the male controls accounted for 4% of the variation and was an a-b component which contrasted the a-b counts on both hands. There was a gradient from a-b to c-d on the left hand.

Prin5 for the Turners showed a radial-ulnar growth gradient which also contrasted the c-d and a-b counts of the right hand with the c-d and a-b counts of the left hand. Again, asymmetry appeared to be an important factor in contributing to the variance. Prin5

was also an asymmetry component for the Klinefelters, contrasting the b-c and a-b counts of one hand with the same counts of the other hand. For the female controls, asymmetry finally proved to be a factor contributing to variation in Prin5. In this case, the a-b and c-d counts of one hand were contrasted with the same counts of the other hand. A growth gradient appeared here but was difficult to interpret clearly since the gradient for the right hand was in the opposite direction of the gradient for the left hand. The male controls also showed asymmetry here, contrasting right a-b and left a-b.

Prin6 for the Turners accounted for 3% of the variation and was basically an asymmetry component with contrasting loadings for the right and left hands. The b-c count was the most variable with the highest contrasts. Prin6 for the Klinefelters accounted for 1% of the variation and was an asymmetry component contrasting the loadings for the right and left hands. Prin6 for the female controls accounted for .2% of the variation and was an asymmetry component with contrasting loadings for the right and left hands. Prin6 for the male controls accounted for 3% of the variation and was an asymmetry component with contrasting loadings for the right and left hands.

Prin6 was basically an overall asymmetry component for all the samples, contrasting the left hand with the left hand counts.

It was originally hypothesized that the Turner sample would show a higher directional asymmetry than the control groups. The Turners (Table 33) showed right directional asymmetry consistently

Table 33. Finger Asymmetry for Turner Syndrome Females.

R-L *	=	Variable	N	Mean	Std. Dev.
(RVR-LVR)		ASYM1	109	1.21100917	4.37178113
(RVU-LVU)		ASYM2	109	-0.02752294	5.41851886
(RIVR-LIVR)		ASYM3	109	-0.36697248	4.61611619
(RIVU-LIVU)		ASYM4	109	-0.47706422	7.79553093
(RIIIR-LIIIR)		ASYM5	109	0.09174312	5.05257779
(RIIIU-LIIIU)		ASYM6	109	-1.35779817	5.83178223
(RIIR-LIIR)		ASYM7	108	1.71296296	8.36442280
(RIIU-LIIU)		ASYM8	108	-1.07407407	7.95865919
(RIR-LIR)		ASYM9	109	1.99082569	5.63799185
(RIU-LIU)		ASYM10	109	-1.39449541	6.84892307

*R=Right (First Letter), L=Left, R=Radial (Last Letter),
U=Ulnar, -=Minus.

on the radial side of the fingers, on digits I, II, III and V, with left directional asymmetry predominating and being found on radial and ulnar IV, and ulnar I, II, III, and V. The highest directional asymmetry was found on the thumbs, followed by ulnar III and radial V. The Klinefelters (Table 34) showed a predominantly right directional asymmetry consistently on all the ulnar sides of the digits, plus being found on radial IV and I. Left directional asymmetry was found only on radial II, III, and V. High directional asymmetry was found on the thumbs but the highest was found on ulnar II and IV. The female controls (Table 35) showed a predominantly right directional asymmetry but this asymmetry did not follow the pattern found in the Turners and Klinefelters in that the directional asymmetry did not follow a trend of alternation on the radial and ulnar sides of the digits. Right directional asymmetry was found on ASYM4, ASYM5, ASYM7, ASYM8, ASYM9, and ASYM10. Left directional asymmetry was found on the remaining variables. The male controls (Table 36) showed a predominantly right directional asymmetry and exhibited a pattern of the right directional asymmetry being found on the ulnar sides of all the digits, plus being found on radial I. Left directional asymmetry was found on the radial sides of all digits except radial I.

Comparing the Turners' asymmetry values with those of the female controls, it was seen that the Turners exceeded the females in all but one variable. Also, there was a difference in the direction of the asymmetry, with the Turners showing a predominance of left

Table 34. Finger Asymmetry for Klinefelter Syndrome Males.

R-L*	=	Variable	N	Mean	Std. Dev.
(RVR-LVR)		ASYM1	16	-0.12500000	2.91833286
(RVU-LVU)		ASYM2	16	1.06250000	3.17214439
(RIVR-LIVR)		ASYM3	16	0.93750000	4.82312140
(RIVU-LIVU)		ASYM4	16	6.68750000	8.06406639
(RIIIR-LIIIR)		ASYM5	16	-0.62500000	4.51479051
(RIIIU-LIIIU)		ASYM6	16	1.37500000	5.38980519
(RIIR-LIIR)		ASYM7	16	-1.75000000	8.20975030
(RIIU-LIIU)		ASYM8	16	3.00000000	6.80196050
(RIR-LIR)		ASYM9	16	2.62500000	4.80104155
(RIU-LIU)		ASYM10	16	2.75000000	6.04979338

*R=Right (First Letter), L=Left, R=Radial (Last Letter),
U=Ulnar, -=Minus.

Table 35. Finger Asymmetry for Female Controls.

R-L *	=	Variable	N	Mean	Std. Dev.
(RVR-LVR)		ASYM1	151	-0.15894040	2.82156627
(RVU-LVU)		ASYM2	151	-0.05298013	2.95925234
(RIVR-LIVR)		ASYM3	151	-0.03311258	3.63211090
(RIVU-LIVU)		ASYM4	151	0.74172185	6.08436639
(RIIR-LIIR)		ASYM5	151	0.33112583	3.69634388
(RIIU-LIIU)		ASYM6	151	-0.69536424	5.23067029
(RIIR-LIIR)		ASYM7	151	0.79470199	6.52821352
(RIIU-LIIU)		ASYM8	151	0.92715232	7.32675402
(RIR-LIR)		ASYM9	151	2.22516556	4.34077134
(RIU-LIU)		ASYM10	151	0.16556291	5.43253221

*R=Right (First Letter), L=Left, R=Radial (Last Letter),
U=Ulnar, -=Minus.

Table 36. Finger Asymmetry for Male Controls.

R-L *	=	Variable	N	Mean	Std. Dev.
(RVR-LVR)		ASYM1	154	-0.14285714	3.68786842
(RVU-LVU)		ASYM2	154	0.72077922	3.11751693
(RIVR-LIVR)		ASYM3	154	-0.28571429	4.59712085
(RIVU-LIVU)		ASYM4	154	2.20129870	7.00828629
(RIIR-LIIR)		ASYM5	154	-1.20129870	4.77518076
(RIIU-LIIU)		ASYM6	154	0.73376623	5.75200131
(RIIR-LIIR)		ASYM7	154	-1.18181818	7.07241215
(RIIU-LIIU)		ASYM8	154	1.40909091	7.36944197
(RIR-LIR)		ASYM9	154	2.71428571	4.33063911
(RIU-LIU)		ASYM10	154	3.01948052	7.40029215

*R=Right (First Letter), L=Left, R=Radial (Last Letter),
U=Ulnar, -=Minus.

directional asymmetry while the control females showed a predominantly right directional asymmetry. The patterning of asymmetry was different between the Turners and female controls. The Turners showed a pattern of asymmetry in which there was a trend towards having alternating directional asymmetry, with right directional values being on the radial sides and left directional values on the ulnar sides. The initial asymmetry of the volar pads which resulted in the various patterns must be influenced by environmental conditions or genetic factors to the extent that the radial sides of the pads followed a right to left maturational gradient while the ulnar sides followed a left to right maturational gradient. This pattern differed from the female controls in that the controls exhibited a pattern of left directional asymmetry for the digits on the ulnar side of the hand which reverses to a right directional asymmetry for the digits on the radial side of the hands. This again pointed out not only the importance of digit V, but also its relative independence for the females. Both the Turners and female controls showed high right directional asymmetry for the radial thumb while the Turners showed a high left directional asymmetry for the ulnar thumb. This served to point out the importance and also the independence of the thumbs during the developmental process.

Comparing the Turners with the Klinefelters, the Klinefelters exceeded the Turners in all but one variable in directional asymmetry. Another difference between the groups was that the Klinefelters showed a predominantly right directional asymmetry, which was the

expected normal pattern of development. Both showed the thumbs to have a high right directional asymmetry and to be independent.

Comparing the Turners with the male controls, the male controls substantially exceeded the Turners in asymmetry values on six of the measurements. The males followed the expected pattern of development as outlined by Jantz and Parham (1981) in that the radial counts will exhibit left directional asymmetry and the ulnar counts will exhibit right directional asymmetry. Also evident was the high right directional asymmetry of the thumb. The Turners differed from the other groups in that the radial thumb asymmetry value showed a right directional asymmetry. The ulnar asymmetry value showed a left directional asymmetry. This perhaps reflected yet another developmental difference between the Turners and controls in that the Turners deviate somewhat from the expected lateralization.

The next step in this analysis was to look at the results of the correlation matrix formed from the asymmetry values for the fingers. Each group had a few asymmetry values which were correlated either positively or negatively with several other of the asymmetry values. The Turner correlation matrix (Table 37) showed that the asymmetry values which had the highest number of correlations with other asymmetry values were ASYM3, which was correlated positively with ASYM1, ASYM5, ASYM7, and ASYM9, and negatively correlated with ASYM4, ASYM6, and ASYM8. ASYM8 was positively correlated with ASYM2, ASYM4, and ASYM6, and negatively correlated with ASYM7. The Klinefelter correlation matrix (Table 38) showed that the asymmetry value

Table 37. Correlation Matrix of Finger Asymmetry Values for Turner Syndrome Females.

Variable	Correlation Coefficients / Prob > R Under H0:RHO=0									
	ASYM1	ASYM2	ASYM3	ASYM4	ASYM5	ASYM6	ASYM7	ASYM8	ASYM9	ASYM10
ASYM1	1.00000 0.0000									
ASYM2	0.07959 0.4107	1.00000 0.0000								
ASYM3	0.33101 0.0004	0.01218 0.9000	1.00000 0.0000							
ASYM4	-0.10298 0.2866	0.09570 0.3222	-0.21384 0.0256	1.00000 0.0000						
ASYM5	0.25146 0.0083	0.02343 0.8089	0.31072 0.0010	-0.14604 0.1297	1.00000 0.0000					
ASYM6	0.06981 0.4707	0.06708 0.4883	0.07728 0.4244	0.15182 0.1151	-0.10069 0.2975	1.00000 0.0000				
ASYM7	0.14753 0.1276	-0.15719 0.1042	0.20181 0.0362	-0.30589 0.0013	0.09862 0.3099	-0.26676 0.0053	1.00000 0.0000			
ASYM8	-0.15334 0.1131	0.27240 0.0043	-0.10999 0.2571	0.42834 0.0001	-0.12743 0.1888	0.26183 0.0062	-0.55304 0.0001	1.00000 0.0000		
ASYM9	0.12292 0.2029	0.14699 0.1272	0.18843 0.0497	0.01802 0.8525	0.17783 0.0643	0.05988 0.5362	0.03875 0.6905	-0.09976 0.3043	1.00000 0.0000	
ASYM10	0.22855 0.0168	0.17910 0.0624	-0.04064 0.6748	0.00112 0.9907	0.10942 0.2574	0.16195 0.0925	-0.01634 0.8667	0.06738 0.4884	0.08623 0.3726	1.00000 0.0000

Table 38. Correlation Matrix of Finger Asymmetry Values for Klinefelter Syndrome Males.

Variable	Correlation Coefficients / Prob > R Under H0:RHO=0/N=16									
	ASYM1	ASYM2	ASYM3	ASYM4	ASYM5	ASYM6	ASYM7	ASYM8	ASYM9	ASYM10
ASYM1	1.00000 0.0000									
ASYM2	-0.03511 0.8973	1.00000 0.0000								
ASYM3	0.32622 0.2175	0.50573 0.0457	1.00000 0.0000							
ASYM4	0.13987 0.6054	0.43604 0.0913	0.45026 0.0801	1.00000 0.0000						
ASYM5	-0.38581 0.1400	0.18445 0.4942	0.04095 0.8803	-0.37012 0.1582	1.00000 0.0000					
ASYM6	-0.00106 0.9969	0.82518 0.0001	0.52413 0.0372	0.64249 0.0073	-0.00890 0.9739	1.00000 0.0000				
ASYM7	-0.36869 0.1600	0.27327 0.3058	0.25128 0.3478	-0.41966 0.1056	0.63042 0.0088	0.05650 0.8354	1.00000 0.0000			
ASYM8	0.23173 0.3878	0.43565 0.0917	0.32514 0.2192	0.32816 0.2147	-0.00651 0.9809	0.60554 0.0129	0.01671 0.9510	1.00000 0.0000		
ASYM9	0.19627 0.4663	0.01477 0.9567	0.38471 0.1412	0.22579 0.4004	-0.12533 0.6437	0.07020 0.7961	-0.00592 0.9826	-0.23681 0.3772	1.00000 0.0000	
ASYM10	0.29642 0.2649	0.12245 0.6514	0.06340 0.8156	0.11171 0.6804	0.11838 0.6624	0.15845 0.5578	-0.17449 0.5181	0.66423 0.0050	-0.51758 0.0400	1.00000 0.0000

that had the highest number of correlations with other asymmetry values is ASYM6, which was correlated positively with ASYM2, ASYM4, and ASYM8. All of these asymmetry values were from the ulnar sides of the digits. There were no negative correlations with ASYM6. The female control correlation matrix (Table 39) showed that the female controls exhibited fewer correlations between asymmetry values than the Turners and Klinefelters. ASYM8 was positively correlated with ASYM4 and ASYM6, which were the ulnar side of digits IV and III. There was a negative correlation between ASYM8 and ASYM7, which was the radial side of the same digit. The male control correlation matrix (Table 40) showed that two variables exhibited correlations with other variables. ASYM7 was positively correlated with ASYM3 which was also a radial side variable. ASYM7 was negatively correlated with ASYM4, ASYM8 (which was the ulnar side of the same digit), and ASYM10 (which was the ulnar side of the adjacent digit). ASYM8 was negatively correlated with ASYM3, ASYM7 (which was the radial side of the same digit), and ASYM10 (which was the ulnar side of the adjacent digit). ASYM10 was positively correlated with ASYM4, ASYM8 (which was the ulnar side of the same digit), and ASYM9 (which was the radial side of the same digit). ASYM10 was negatively correlated with ASYM4 (which was the radial side of the adjacent digit).

These values, in all samples, were correlated positively with values that were on the same side of the digits as the digit in question and negatively correlated with values that were on the

Table 39. Correlation Matrix of Finger Asymmetry Values for Female Controls.

Variable	Correlation Coefficients / Prob > R Under H0:RHO=0/N=151									
	ASYM1	ASYM2	ASYM3	ASYM4	ASYM5	ASYM6	ASYM7	ASYM8	ASYM9	ASYM10
ASYM1	1.00000 0.0000									
ASYM2	0.05088 0.5350	1.00000 0.0000								
ASYM3	0.08795 0.2829	0.01720 0.8339	1.00000 0.0000							
ASYM4	0.08264 0.3131	0.02478 0.7626	-0.03448 0.6743	1.00000 0.0000						
ASYM5	-0.07418 0.3653	0.04428 0.5893	0.11056 0.1765	-0.07384 0.3676	1.00000 0.0000					
ASYM6	-0.00392 0.9619	0.03120 0.7037	0.00650 0.9369	0.11205 0.1708	0.01544 0.8508	1.00000 0.0000				
ASYM7	0.03369 0.6814	0.00772 0.9251	0.05763 0.4821	-0.08745 0.2857	0.26613 0.0010	0.01824 0.8241	1.00000 0.0000			
ASYM8	0.00524 0.9491	0.04318 0.5986	-0.14940 0.0671	0.26502 0.0010	-0.13966 0.0872	0.28083 0.0005	-0.37344 0.0001	1.00000 0.0000		
ASYM9	0.00893 0.9134	-0.14023 0.0859	0.02035 0.8041	-0.00233 0.9774	-0.07781 0.3423	-0.02036 0.8040	0.02352 0.7744	0.08059 0.3253	1.00000 0.0000	
ASYM10	-0.00393 0.9618	0.10215 0.2120	0.00501 0.9513	0.15499 0.0574	-0.11795 0.1492	0.03411 0.6776	-0.11784 0.1496	0.09946 0.2243	-0.08047 0.3260	1.00000 0.0000

Table 40. Correlation Matrix of Finger Asymmetry Values for Male Controls.

Variable	Correlation Coefficients / Prob > R Under H0:RHO=0/N=154									
	ASYM1	ASYM2	ASYM3	ASYM4	ASYM5	ASYM6	ASYM7	ASYM8	ASYM9	ASYM10
ASYM1	1.00000 0.0000									
ASYM2	-0.09388 0.2468	1.00000 0.0000								
ASYM3	0.07969 0.3259	-0.14652 0.0698	1.00000 0.0000							
ASYM4	0.09014 0.2663	0.10340 0.2019	-0.05541 0.4949	1.00000 0.0000						
ASYM5	0.07852 0.3330	0.15470 0.0554	0.04679 0.5645	-0.03022 0.7098	1.00000 0.0000					
ASYM6	0.07029 0.3863	0.10408 0.1989	0.03641 0.6540	0.03976 0.6244	-0.06264 0.4402	1.00000 0.0000				
ASYM7	-0.01980 0.8075	0.00954 0.9065	0.17188 0.0331	-0.23411 0.0035	-0.00477 0.9532	-0.08715 0.2825	1.00000 0.0000			
ASYM8	-0.01347 0.8683	0.10145 0.2106	-0.16186 0.0449	0.10419 0.1985	-0.04575 0.5732	0.14506 0.0727	-0.38756 0.0001	1.00000 0.0000		
ASYM9	0.07437 0.3594	0.07732 0.3405	0.07171 0.3768	-0.00111 0.9891	-0.13681 0.0907	0.05150 0.5259	0.00576 0.9435	0.15442 0.0559	1.00000 0.0000	
ASYM10	0.05040 0.5348	0.05520 0.4966	0.00650 0.9362	0.29091 0.0003	0.01879 0.8171	0.14446 0.0739	-0.18713 0.0201	0.28760 0.0003	0.20065 0.0126	1.00000 0.0000

opposite side of the digit as the digit in question. These correlations were usually on the same or adjacent digits. The one digit that appeared consistently was digit II, which appeared in all other forms of analysis as a significant digit, especially for the males. The biological significance of this finding is unclear, but probably is related to maturational gradients or developmental fields. It is undoubtedly significant that the two most asymmetric samples, the Turners and the male controls, had the highest number of correlated asymmetry values.

The palmar asymmetry was looked at in the same manner as in the fingers. All samples exhibited right directional asymmetry on ASYM1 and ASYM2 and left directional asymmetry on ASYM3. The Turners (Table 41) and Klinefelters (Table 42) showed a higher directional asymmetry than the male and female controls (Tables 43-44) for ASYM1. The Klinefelters exhibited a higher directional asymmetry on ASYM2 than the other samples, while the Turners showed an even lower directional asymmetry than the male and female controls. On ASYM3 the female controls showed a higher directional asymmetry than the other samples, followed by the Klinefelters, Turners, and male controls.

The initial observation was that for all samples the b-c and c-d counts exhibited right directional asymmetry and the a-b exhibited left directional asymmetry. This was contrary to the expected findings if you take the expectations of Corballis and Morgan (1978) literally; that is, there should be a right to left maturation gradient,

Table 41. Palmar Asymmetry Among Turner Syndrome Females (n=109).^a

Variable	Variable*		
	ASYM1	ASYM2	ASYM3
R-L	(RCD-LCD)	(RBC-LBC)	(RAB-LAB)
X	2.3853	0.4128	-1.1284
S.D.	7.1930	5.3128	5.1282
ASYM1	1.0000 0.0000	-0.1968 0.0402	0.0774 0.4237
ASYM2	-0.1968 0.0402	1.0000 0.0000	-0.1554 0.1067
ASYM3	0.0774 0.4237	-0.1554 0.1067	1.0000 0.0000

^aCorrelation Coefficients/Prob > (R) under H₀:RHO=0

*RCD-LCD=Right c-d Minus Left c-d, RBC-LBC=Right b-c Minus Left b-c, RAB-LAB=Right a-b Minus Left a-b.

Table 42. Palmar Asymmetry Among Klinefelter Syndrome Males (n=16).^a

Variable	Variable*		
	ASYM1	ASYM2	ASYM3
R-L	(RCD-LCD)	(RBC-LBC)	(RAB-LAB)
X	2.8750	0.9375	-1.3750
S.D.	5.2265	4.5088	2.4187
ASYM1	1.0000 0.0000	-0.3936 0.1315	0.2123 0.4300
ASYM2	-0.3935 0.1315	1.0000 0.0000	-0.4118 0.1129
ASYM3	0.2123 0.4300	-0.4119 0.1129	1.0000 0.0000

^aCorrelation Coefficients/Prob > (R) under $H_0: \rho = 0$.

*RCD-LCD=Right c-d Minus Left c-d, RBC-LBC=Right b-c Minus Left b-c, RAB-LAB=Right a-b Minus Left a-b.

Table 43. Palmar Asymmetry Among Female Controls (n=147).^a

Variable	Variable*		
	ASYM1	ASYM2	ASYM3
R-L	(RCD-LCD)	(RBC-LBC)	(RAB-LAB)
X	1.4150	0.5782	-1.4694
S.D.	4.5764	3.6750	4.1003
ASYM1	1.0000 0.0000	-0.2726 0.0008	0.0444 0.5934
ASYM2	-0.2726 0.0008	1.0000 0.0000	-0.2760 0.0007
ASYM3	0.0444 0.5934	-0.2760 0.0007	1.0000 0.0000

^aCorrelation Coefficients/Prob > (R) under H₀:RHO=0.

*RCD-LCD=Right c-d Minus Left c-d, RBC-LBC=Right b-c Minus Left b-c, RAB-LAB=Right a-b Minus Left a-b.

Table 44. Palmar Asymmetry Among Male Controls (n=147).^a

Variable	Variable *		
	ASYM1	ASYM2	ASYM3
R-L	(RCD-LCD)	(RBC-LBC)	(RAB-LAB)
X	1.6803	0.8027	-0.9728
S.D.	5.1338	3.9650	4.4751
ASYM1	1.0000 0.0000	-0.2501 0.0022	-0.0476 0.5668
ASYM2	-0.2501 0.0022	1.0000 0.0000	-0.0618 0.4568
ASYM3	-0.0462 0.5668	-0.0618 0.4568	1.0000 0.0000

^aCorrelation Coefficients/Prob > (R) under $H_0: \rho_{H0}=0$.

*RCD-LCD=Right c-d Minus Left c-d, RBC-LBC=Right b-c Minus Left b-c, RAB-LAB=Right a-b Minus Left a-b.

in which case all of the counts would be expected to be larger on the right hand. But since this does not appear to be true, even in the controls, perhaps a reversal of the growth gradient occurs at some point in the developmental process.

The most asymmetric of the samples were the Klinefelters. The Turners showed a higher asymmetry value on the c-d count than either of the control groups. This finding could best be explained by remembering that this area would be most affected by the abnormal growth and development experienced by the underlying bone structure of the Turners. The b-c count for all the samples appeared to be the most stable, or the least asymmetric, with the highest asymmetry being found on the male control samples. The most unexpected results were that the Turners were not the most asymmetric sample for the a-b count. The only group less asymmetric than the Turners was the male control group, the Klinefelter and female controls both having higher asymmetry values.

Overall, it was difficult to state which group was the most asymmetric since different samples showed increased asymmetry on different variables.

Upon looking at the correlation matrix for all the samples (Tables 41-44), it was seen that all except the Klinefelters exhibited a negative correlation between the b-c and c-d asymmetry values. This was not an unexpected finding because the asymmetry values for the c-d counts were the highest and the asymmetry values for the b-c counts were the lowest. This correlation indicated that

there may be a relationship for the Turners and the male and female controls between the development of these areas of the hand, which is unrelated to the a-b count and independent. This is true except for the female controls, which showed a negative correlation between the b-c and a-b values.

The female controls exhibited the highest degree of correlation. The Turners were more similar to the male controls as far as asymmetry correlations were concerned, showing a deviation from the normal female developmental pathway.

According to Jantz and Webb (1980), the X and Y chromosomes will alter dermatoglyphic asymmetry, with the Y chromosome having a greater influence than the X chromosome. This is why the male controls and Klinefelters often exhibited higher asymmetry values on the fingers and palms than the Turners and female controls. Also, the sex chromosomes play an important role in the lateralization of the body. Jantz and Parham (1981) claim that the sex differences in directional asymmetry follow the lines of major axis variation and are interpretable as differences in growth gradients affecting the whole body.

Another reason for observable differences between males and females was that in the 15-75mm crown-rump range, the male embryo is advanced over the female in the development of the hand skeleton and remains advanced up to the time of the appearance of calcified bone tissue (Garn et al. 1974).

CHAPTER V

CONCLUSIONS

The results obtained should be compared with the hypotheses presented in the Introduction. Assuming that Turner syndrome females experience prenatal developmental stress due to the lack of an X chromosome, this stress will be reflected in the dermal ridge system of the fingers and palms. The expected differences were put forth in four hypotheses predicting that Turners in contrast to controls will exhibit:

1. Increased total variance in the ridge counts for the fingers and palms.
2. Increased directional asymmetry.
3. Changes in growth gradients.
4. Deviation in lateralization.

Hypothesis 1 is supported because the Turners showed a higher total variance for the fingers and palms than any of the other groups. The results obtained from the principal components in this analysis were similar to those obtained for the radial and ulnar counts principal components in the analyses by Jantz and Hawkinson (1980) and Roberts and Coope (1975): the first principal component was a general size component and the second principal component was a radial-ulnar contrast. Siervogel et al. (1978) claim that because similar results are obtained by several independent studies, these findings must necessarily have biological significance, this significance being the presence of developmental fields.

Hypothesis 2 is concerned with directional asymmetry and the Turners show the predicted increase in directional asymmetry for the fingers. The results for the palms are not as clear because the Turners do not show the highest directional asymmetry on all the variables.

Hypothesis 3 is concerned with changes in growth gradients. This hypothesis is not easily evaluated because all samples exhibited growth gradients. The female controls seemed to be the least affected by growth gradients of all the samples, with the Turners failing to exhibit marked changes or deviations in growth gradients when contrasted with the other samples. Interestingly, the principal components analysis which revealed the growth gradients also revealed evidence for developmental fields. Growth gradients are inferential evidence of developmental fields, but the components extracted for all samples showed the importance and independence of the thumbs and the importance of digits II and V. These results were also shown by Roberts and Coope (1975) and Jantz et al. (1981). Jantz et al. found that for discriminant function analysis that digit V was a strongly contributing digit for discerning Turner-control differences. They claim that the differences between Turners and normal controls are patterned along the lines of developmental fields.

Hypothesis 4 is concerned with changes in Turners in lateralization. As expected, Turners deviate from the expected right-to-left maturational gradient because the left directional asymmetry values on the fingers predominate, indicating an earlier development of

the left side in Turners. Another interesting result is that the radial and ulnar sides of the fingers are apparently under the control of different maturational gradients.

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- Alvesalo, Lassi and Markku Kari
 1977 Sizes of deciduous teeth in 47,XYY males. American Journal of Human Genetics 29:486-489.
- Babler, William J.
 1978 Prenatal selection and dermatoglyphic patterns. American Journal of Physical Anthropology 48:21-28.
- Barlow, Peter
 1973 The influence of inactive chromosomes on human development. Humangenetik 17:105-136.
- Bocian, Maureen, Eva Krmpotic, Katarina Szego, and Ira M. Rosenthal
 1971 Somatic stigmata of Turner's syndrome in a patient with 46,XXq-. Journal of Medical Genetics 8:358-363.
- Boczkowski, Krzysztof, Margareto Mikhelsen, and Hanne Poulsen
 1978 Turner syndrome with rare karyotypes. Clinical Genetics 13:409-414.
- Borgaonkar, Digamber and Emilie Mules
 1970 Comments on patients with sex chromosome aneuploidy: dermatoglyphs, parental ages, Xg^a blood group. Journal of Medical Genetics 7:345-350.
- Bowen, Peter and Catherine S. N. Lee
 1969 Spontaneous abortion. American Journal of Obstetrics and Gynecology 104:973-983.
- Corballis, Michael and Michael J. Morgan
 1978 On the biological basis of human laterality. I. Evidence for a maturational left-right gradient. The Behavioral and Brain Sciences 2:261-269.
- Cummins, Harold and Charles Midlo
 1961 Finger Prints, Palms and Soles. Dover Publications, New York.
- Farman, Naziha, Digamber S. Borgaonkar, and Bernadette Zaczek
 1979 Dermatoglyphic studies in Turner syndrome. In Birth Defects: Original Article Series, Volume XV, Number 6, pp. 609-620. The National Foundation.

- Ferguson-Smith, Malcolm A.
 1965 Karyotype-phenotype correlations in gonadal dysgenesis and their bearing on the pathogenesis of malformations. Journal of Medical Genetics 2:142-155.
- Garn, Stanley M., Alphonse R. Burdi, and William J. Babler
 1974 Male advancement in prenatal hand development. American Journal of Physical Anthropology 41:353-360.
- Garn, Stanley M., Alphonse R. Burdi, William J. Babler, and Sara Stinson
 1975 Early prenatal attainment of adult metacarpal-phalangeal rankings and proportions. American Journal of Physical Anthropology 43:327-332.
- Garn, Stanley M. and Christabel G. Rohmann
 1962 X-Linked inheritance of developmental timing in man. Nature 196:695-696.
- Grace, H. J., D. K. Quinlan, and W.E.B. Edge
 1973 45,X lymphocyte karyotype in a fertile woman. American Journal of Obstetrics and Gynecology 115:279-282.
- Haddad, Heskel M. and Lawson Wilkins
 1959 Congenital anomalies associated with gonadal aplasia. Pediatrics 23:885-902.
- Hale, Alfred R.
 1952 Morphogenesis of volar skin in the human fetus. American Journal of Anatomy 91:147-173.
- Hawkinson, Cleone Hart
 1981 Dermatoglyphic variability in Armenian fingertips and palms: a directional asymmetry approach to identify developmental stress. Unpublished M.A. Thesis, Department of Anthropology, University of Tennessee, Knoxville.
- Hirsch, W. and J. U. Schweichel
 1973 Morphological evidence concerning the problem of skin ridge formation. Journal of Mental Deficiency Research 17:58-72.
- Holt, Sarah B.
 1968 The Genetics of Dermal Ridges. Charles C. Thomas, Springfield, Illinois.
- Holt, Sarah B. and J. Lindsten
 1964 Dermatoglyphic anomalies in Turner's syndrome. Annals of Human Genetics 28:87-100.

- Jantz, Richard L. and Cleone H. Hawkinson
1980 Components of racial variation in finger ridge-counts. American Journal of Physical Anthropology 52:139-144.
- Jantz, Richard L. and D. R. Hunt
1985 The influence of sex chromosomes on finger dermatoglyphic patterns. Unpublished manuscript, Department of Anthropology, University of Tennessee, Knoxville.
- Jantz, Richard L. and K. R. Parham
1981 Some developmental implications of size corrected finger ridge-count correlations. American Journal of Physical Anthropology 54:236.
- Jantz, Richard L., G. C. Ranyard, and D. W. Owsley
1981 Finger ridge-count variation in 45,X Turner's syndrome. Human Genetics 57:376-379.
- Jantz, Richard L. and R. S. Webb
1980 The influence of sex chromosomes and race on asymmetry of finger ridge-counts. American Journal of Physical Anthropology 52:241.
- Loesch, Danuta Z.
1971 Genetics of dermatoglyphic patterns on palms. Annals of Human Genetics 34:277-293.
- Loesch, Danuta Z.
1983 Quantitative dermatoglyphics, classification, genetics and pathology. Oxford Monographs on Medical Genetics, No. 10. Oxford University Press, Oxford.
- Miller, James R.
1973 Dermatoglyphics. Journal of Investigative Dermatoglyphics 60:435-442.
- Mittwoch, Ursula
1977 To be right is to be born male. New Scientist 73:74-76.
- Mulvihill, John J. and David W. Smith
1969 The genesis of dermatoglyphics. The Journal of Pediatrics 75:579-589.
- Nielsen, J., Margit Fischer, and Ursula Friedrich
1973 Mental retardation in Turner's syndrome. Journal of Mental Deficiency Research 17:227-230.
- Okajima, M.
1975 Development of dermal ridges in the fetus. Journal of Medical Genetics 12:243-250.

Park, Elizabeth

1976a Cortical bone measurements in Turner's syndrome. American Journal of Physical Anthropology 46:455-462.

1976b Radiological anthropometry of the hand in Turner syndrome. American Journal of Physical Anthropology 46:463-470.

Park, Elizabeth, John D. Bailey, and Carol A. Cowell

1983 Growth and maturation of patients with Turner's syndrome. Pediatric Research 17:1-7.

Patten, Bradley M.

1968 Human Embryology. McGraw-Hill Book Company, New York.

Penrose, L. S.

1963 Finger-Prints, palms and chromosomes. Nature 197:933-938.

Penrose, L. S.

1967 Finger-Print pattern and the sex chromosomes. The Lancet 1:298-300.

Penrose, L. S. and Danuta Loesch

1967 A study of dermal ridge width in the second (palmar) interdigital area with special reference to aneuploid states. Journal of Mental Deficiency Research 11:36-42.

Preus, Marilyn and F. Clarke Fraser

1972 Dermatoglyphics and syndromes. American Journal of Diseases of Children 124:933-943.

Reed, T., A. Reichmann, and C. G. Palmer

1977 Dermatoglyphic differences between 45,X and other chromosomal abnormalities of Turner syndrome. Human Genetics 36:13-23.

Roberts, D. F. and E. Coope

1975 Components of variation in a multifactorial character: a dermatoglyphic analysis. Human Biology 47:169-188.

Rothhammer, Francisco, Elena Llop, and James V. Neel

1982 Dermatoglyphic characters and physique: a correlation study. American Journal of Physical Anthropology 57:99-101.

Saldana-Garcia, P.

1977 A dermatoglyphic study of the thenar/first interdigital area of the palm in females and males with sex chromosomal abnormalities. Journal of Mental Deficiency Research 21:127-131.

- Saldana-Garcia, P.
1979 Dermatoglyphics in sex chromosome anomalies. Journal of Mental Deficiency Research 23:91-104.
- Siervogel, R. M., A. F. Roche, and E. M. Roche
1978 Developmental fields for digital dermatoglyphic traits as revealed by multivariate analysis. Human Biology 50:541-556.
- Stough, Thomas R. and J. Rodman Seely
1969 Dermatoglyphics in medicine. Clinical Pediatrics 8:32-41.
- Summit, Robert L.
1969 Turner syndrome and Noonan's syndrome. The Journal of Pediatrics 74:155-156.
- Townsend, Grant, Birgit Leth Jensen, and Lassi Alvesalo
1984 Reduced tooth size in 45,X (Turner syndrome) females. American Journal of Physical Anthropology 65:367-371.
- Turner, H. H.
1938 Syndrome of infantilism, congenital webbed neck, and cubitus valgus. Endocrinology 23:566-574.
- White, Beverly J. and Stephen J. Marx
1978 Dermatoglyphic and radiographic findings in a mother and daughter with pseudohypothyroidism. Clinical Genetics 13:359-368.

APPENDIX

Table 45. Correlation Matrix of Radial and Ulnar Finger Counts for Turner Syndrome Females.

Variable*	LVR	LVU	LIVR	LIVU	LIIIR	LIIIU	LIIIR	LIIU	LIR	LIU	RVR	RVU	RIVR	RIVU	RIIIR	RIIIU	RIIR	RIIU	RIR	RIU
LVR	1.0000																			
LVU	0.2613	1.0000																		
LIVR	0.6657	0.2753	1.0000																	
LIVU	0.3981	0.5017	0.4841	1.0000																
LIIIR	0.4828	0.2681	0.6819	0.4158	1.0000															
LIIIU	0.3321	0.4252	0.3405	0.5352	0.2378	1.0000														
LIIIR	0.3991	0.2375	0.4838	0.3672	0.4362	0.1985	1.0000													
LIIU	0.4080	0.4033	0.4880	0.3935	0.3203	0.4174	0.0702	1.0000												
LIR	0.4496	0.3646	0.5170	0.4412	0.5310	0.3358	0.5168	0.3608	1.0000											
LIU	0.4216	0.2099	0.2795	0.3045	0.1397	0.3882	0.2047	0.3639	0.2281	1.0000										
RVR	0.7213	0.2688	0.5206	0.3702	0.4413	0.2950	0.3166	0.3809	0.3806	0.3172	1.0000									
RVU	0.2199	0.6042	0.2233	0.4379	0.2072	0.3841	0.3109	0.0582	0.3330	0.1455	0.2763	1.0000								
RIVR	0.5646	0.2556	0.7577	0.5164	0.5694	0.2814	0.4171	0.4577	0.4906	0.3409	0.5849	0.2064	1.0000							
RIVU	0.4283	0.3828	0.5280	0.5939	0.4637	0.4858	0.4641	0.3473	0.4445	0.2295	0.3309	0.3869	0.4270	1.0000						
RIIIR	0.3679	0.2544	0.5527	0.4693	0.7073	0.3081	0.4534	0.3215	0.5789	0.1411	0.4488	0.1944	0.5949	0.4315	1.0000					
RIIIU	0.2360	0.0735	0.2019	0.2353	0.0973	0.4839	0.1872	0.3168	0.1793	0.2248	0.2200	0.0499	0.1855	0.3167	0.0513	1.0000				
RIIR	0.3614	0.3710	0.4381	0.5360	0.4933	0.3881	0.4936	0.3189	0.5369	0.2312	0.3918	0.3077	0.5134	0.3522	0.6047	0.0976	1.0000			
RIIU	0.4821	0.3003	0.5072	0.2352	0.3007	0.2863	0.3487	0.6241	0.4366	0.3355	0.3481	0.1535	0.4056	0.5300	0.1987	0.4137	0.1156	1.0000		
RIR	0.3065	0.1917	0.3562	0.2430	0.3976	0.2777	0.3356	0.3351	0.7032	0.1297	0.2962	0.2503	0.4272	0.2494	0.5401	0.1771	0.3749	0.3392	1.0000	
RIU	0.1878	-0.0610	0.1884	0.1627	-0.1183	0.2472	0.0405	0.1802	0.0519	0.5383	0.1906	0.0112	0.2279	0.0549	-0.0638	0.1941	0.0409	0.1972	0.0168	1.0000

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 46. Correlation Matrix of Radial and Ulnar Finger Counts for Klinefelter Syndrome Males.

Variable*	LVR	LVU	LIVR	LIVU	LIIR	LIUIU	LIIR	LIUIU	LIR	LIU	RVR	RVU	RIVR	RIVU	RIIR	RIUIU	RIIR	RIUIU	RIR	RIU
LVR	1.0000																			
LVU	0.1045	1.0000																		
LIVR	0.6747	-0.0203	1.0000																	
LIVU	0.1337	0.5748	0.2533	1.0000																
LIIR	0.4364	0.0652	0.6235	0.0422	1.0000															
LIUIU	0.2211	0.8067	0.0349	0.6704	0.0938	1.0000														
LIIR	0.0848	0.2621	0.4433	0.1395	0.7798	0.0509	1.0000													
LIUIU	0.4818	0.3309	0.4368	0.3205	0.4552	0.5133	0.3536	1.0000												
LIR	0.1428	0.1525	0.4011	0.4557	0.1527	0.1536	0.2218	0.0950	1.0000											
LIU	0.5267	0.5000	0.3581	0.4521	0.2766	0.6873	0.1057	0.6037	0.4468	1.0000										
RVR	0.8016	0.1611	0.6521	0.1598	0.6147	0.2317	0.2389	0.3923	0.1995	0.5097	1.0000									
RVU	0.3982	0.5650	0.1945	0.2496	-0.0182	0.4210	0.0290	0.0619	0.2206	0.6789	0.3721	1.0000								
RIVR	0.6528	-0.0477	0.7586	-0.0040	0.5384	-0.0902	0.2583	0.1348	0.0808	0.2897	0.7568	0.4118	1.0000							
RIVU	0.6988	0.2451	0.7782	0.3710	0.7061	0.2738	0.5304	0.3682	0.3792	0.5836	0.7677	0.5196	0.6884	1.0000						
RIIR	0.5834	0.1842	0.7644	0.0619	0.6488	-0.0200	0.5823	0.4788	0.2008	0.2278	0.5785	0.1671	0.6994	0.5614	1.0000					
RIUIU	0.4264	0.5991	0.1943	0.3819	0.1143	0.6557	0.0576	0.2010	0.1848	0.7914	0.4203	0.8989	0.3023	0.5937	0.0207	1.0000				
RIIR	0.3149	0.4845	0.2164	0.4563	-0.1258	0.3116	-0.0577	-0.0841	0.0782	0.1820	0.1221	0.4770	0.3707	0.1847	0.3272	0.3585	1.0000			
RIUIU	0.6273	0.2457	0.7251	0.5142	0.5442	0.3146	0.5041	0.6649	0.3337	0.5777	0.6453	0.3555	0.5006	0.7951	0.5864	0.4166	0.1107	1.0000		
RIR	0.2476	0.0091	0.0436	-0.0938	0.1621	0.0997	-0.1085	0.1511	0.3817	0.4500	0.4770	0.2549	0.1136	0.2738	0.0448	0.2277	-0.4229	0.2065	1.0000	
RIU	0.4208	0.2801	0.5739	0.5894	0.3470	0.2468	0.3370	0.3447	0.7675	0.6665	0.5402	0.4871	0.4464	0.6767	0.4655	0.4275	0.2420	0.7429	0.4177	1.0000

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 47. Correlation Matrix of Radial and Ulnar Finger Counts for Female Controls.

Variable*	LVR	LVU	LIVR	LIVU	LIIR	LIIU	LIR	LIU	LIR	LIU	RVR	RVU	RIVR	RIVU	RIIR	RIIU	RIIR	RIIU	RIR	RIU
LVR	1.0000																			
LVU	0.3518	1.0000																		
LIVR	0.6087	0.1599	1.0000																	
LIVU	0.3087	0.4456	0.4018	1.0000																
LIIR	0.4730	0.2067	0.6410	0.3202	1.0000															
LIIU	0.2915	0.3534	0.3495	0.5399	0.3648	1.0000														
LIR	0.3861	0.2687	0.3573	0.2696	0.5342	0.3668	1.0000													
LIU	0.4185	0.2605	0.4661	0.4230	0.4405	0.4941	0.2061	1.0000												
RVR	0.4011	0.0915	0.4258	0.1533	0.3978	0.0933	0.3307	0.2645	1.0000											
RVU	0.3921	0.2374	0.3532	0.3402	0.2311	0.2255	0.2477	0.2738	0.3592	1.0000										
RIVR	0.8383	0.2901	0.6273	0.3306	0.4750	0.2629	0.3959	0.4056	0.3978	0.3675	1.0000									
RIVU	0.3879	0.6520	0.2235	0.5442	0.2178	0.3917	0.3502	0.3278	0.1020	0.3137	0.3460	1.0000								
RIIR	0.5891	0.1470	0.8412	0.4105	0.6290	0.3653	0.3676	0.4814	0.3742	0.2624	0.6372	0.2192	1.0000							
RIIU	0.2784	0.2946	0.4229	0.6248	0.3891	0.5168	0.3185	0.3341	0.1361	0.3008	0.3384	0.3959	0.4155	1.0000						
RIR	0.4595	0.2044	0.5866	0.2821	0.8166	0.3403	0.5032	0.4480	0.4143	0.2328	0.4371	0.2389	0.6114	0.3184	1.0000					
RIU	0.3383	0.2807	0.3536	0.4959	0.4416	0.6577	0.3428	0.4871	0.1402	0.3115	0.3029	0.3399	0.3743	0.5630	0.4222	1.0000				
RIR	0.3535	0.2145	0.3913	0.3200	0.4684	0.3347	0.5091	0.4667	0.3066	0.2688	0.3814	0.2950	0.4338	0.2913	0.5969	0.3259	1.0000			
RIU	0.4912	0.2076	0.5210	0.3700	0.4632	0.3679	0.3555	0.6105	0.2430	0.3458	0.4782	0.3026	0.4629	0.4807	0.3963	0.5648	0.2874	1.0000		
RIR	0.4312	0.1570	0.4649	0.2049	0.4996	0.2002	0.4121	0.2713	0.7602	0.3464	0.4326	0.0795	0.4126	0.1818	0.4832	0.2566	0.4000	0.3011	1.0000	
RIU	0.4009	0.1987	0.4202	0.3054	0.3303	0.2169	0.2959	0.3314	0.3750	0.7542	0.3748	0.3322	0.3352	0.3590	0.2859	0.3219	0.2348	0.4605	0.3238	1.0000

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 48. Correlation Matrix of Radial and Ulnar Finger Counts for Male Controls.

Variable*	LVR	LVU	LIVR	LIVU	LIIR	LIUU	LIIR	LIUU	LIR	LIU	RVR	RVU	RIVR	RIVU	RIIR	RIIU	RIIR	RIIU	RIR	RIU
LVR	1.0000																			
LVU	0.1963	1.0000																		
LIVR	0.6319	0.1337	1.0000																	
LIVU	0.4010	0.3867	0.4342	1.0000																
LIIR	0.5680	0.2013	0.6512	0.3546	1.0000															
LIUU	0.3654	0.3702	0.3233	0.3925	0.4175	1.0000														
LIIR	0.3919	0.1572	0.3539	0.2283	0.4557	0.3718	1.0000													
LIUU	0.3371	0.2342	0.3278	0.3440	0.3294	0.4356	0.1201	1.0000												
LIR	0.3721	0.1395	0.4642	0.2277	0.4974	0.2784	0.4724	0.3193	1.0000											
LIU	0.3192	0.2796	0.2822	0.3234	0.3289	0.3590	0.3368	0.4615	0.4413	1.0000										
RVR	0.7222	0.1561	0.5782	0.3794	0.4683	0.2863	0.3402	0.3479	0.2772	0.3035	1.0000									
RVU	0.2039	0.5689	0.1186	0.3013	0.1221	0.2280	0.2312	0.1277	0.1257	0.2716	0.1130	1.0000								
RIVR	0.5876	0.1069	0.7347	0.3573	0.5197	0.2900	0.2390	0.3598	0.2924	0.1696	0.5763	0.0118	1.0000							
RIVU	0.3607	0.2986	0.4594	0.5778	0.3165	0.3547	0.3517	0.2404	0.2727	0.2606	0.4009	0.3161	0.3444	1.0000						
RIIR	0.4853	0.1445	0.5311	0.3443	0.6545	0.4049	0.5519	0.2507	0.5424	0.3391	0.4404	0.1888	0.4443	0.2839	1.0000					
RIIU	0.3883	0.2861	0.3634	0.4547	0.4177	0.5996	0.4146	0.4186	0.2725	0.3424	0.3542	0.2458	0.3441	0.4487	0.3617	1.0000				
RIIR	0.3781	0.2466	0.3458	0.4032	0.4647	0.3550	0.5485	0.2285	0.4175	0.2563	0.3159	0.2929	0.3453	0.3174	0.5493	0.3249	1.0000			
RIIU	0.4457	0.1928	0.4656	0.3825	0.3545	0.4323	0.3127	0.6332	0.3181	0.3896	0.4378	0.1708	0.3818	0.3588	0.2431	0.5222	0.1019	1.0000		
RIR	0.4415	0.0459	0.5037	0.1999	0.4683	0.1586	0.4145	0.2452	0.7527	0.3597	0.3743	0.1084	0.3542	0.2489	0.4339	0.1985	0.3666	0.3409	1.0000	
RIU	0.3877	0.0175	0.3314	0.2321	0.3081	0.3247	0.4728	0.2927	0.4309	0.5957	0.3949	0.1172	0.2222	0.4040	0.3307	0.4160	0.2395	0.4397	0.4864	1.0000

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I, R=Radial (Last Letter), U=Ulnar.

Table 49. Correlation Matrix of the Largest Finger Counts for Turner Syndrome Females.

Variable*	LV	LIV	LIII	LII	LI	RV	RIV	RIII	RII	RI
LV	1.0000									
LIV	0.7131	1.0000								
LIII	0.5453	0.6967	1.0000							
LII	0.5182	0.6217	0.5658	1.0000						
LI	0.5301	0.5407	0.5447	0.6112	1.0000					
RV	0.7591	0.5260	0.4595	0.4641	0.4232	1.0000				
RIV	0.6357	0.7916	0.6330	0.6326	0.5671	0.6055	1.0000			
RIII	0.4285	0.5944	0.7526	0.6407	0.5882	0.4673	0.6261	1.0000		
RII	0.5216	0.6033	0.5652	0.7724	0.6184	0.4554	0.6179	0.5875	1.0000	
RI	0.3318	0.4017	0.4353	0.5330	0.7031	0.3214	0.4728	0.5840	0.4935	1.0000

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 50. Correlation Matrix of the Largest Finger Counts for the Female Controls.

Variable*	LV	LIV	LIII	LII	LI	RV	RIV	RIII	RII	RI
LV	1.0000									
LIV	0.6245	1.0000								
LIII	0.4868	0.6528	1.0000							
LII	0.5000	0.5916	0.6283	1.0000						
LI	0.4380	0.5034	0.4501	0.4548	1.0000					
RV	0.8401	0.6338	0.4661	0.4721	0.4329	1.0000				
RIV	0.5834	0.8618	0.6735	0.5647	0.4143	0.6382	1.0000			
RIII	0.4757	0.5980	0.8163	0.5879	0.4405	0.4534	0.6314	1.0000		
RII	0.4942	0.6073	0.6039	0.7021	0.4182	0.5188	0.5867	0.6118	1.0000	
RI	0.4504	0.5208	0.5040	0.4765	0.7863	0.4449	0.4299	0.5046	0.4962	1.0000

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 51. Correlation Matrix of the Largest Finger Counts for the Male Controls.

Variable*	LV	LIV	LIII	LII	LI	RV	RIV	RIII	RII	RI
LV	1.0000									
LIV	0.6358	1.0000								
LIII	0.5737	0.6610	1.0000							
LII	0.4463	0.4585	0.4617	1.0000						
LI	0.3778	0.4669	0.5084	0.4969	1.0000					
RV	0.7225	0.5977	0.4761	0.4451	0.3214	1.0000				
RIV	0.6111	0.7819	0.5180	0.4270	0.3686	0.6009	1.0000			
RIII	0.5189	0.5783	0.6887	0.5239	0.5563	0.5184	0.5098	1.0000		
RII	0.5314	0.5219	0.5045	0.6936	0.4757	0.4963	0.5297	0.5216	1.0000	
RI	0.4439	0.5077	0.4704	0.4330	0.7546	0.3993	0.3915	0.4608	0.4676	1.0000

*L=Left, R=Right (First Letter), V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 52. Correlation Matrix of the Absolute Finger Counts for the Turner Syndrome Females.

Variable*	LV	LIV	LIII	LII	LI	RV	RIV	RIII	RII	RI
LACV	1.0000									
LACIV	0.6686	1.0000								
LACIII	0.6023	0.7258	1.0000							
LACII	0.6255	0.6757	0.6002	1.0000						
LACI	0.5753	0.5597	0.5552	0.6226	1.0000					
RACV	0.7090	0.5594	0.5212	0.4407	0.4565	1.0000				
RACIV	0.6048	0.8069	0.6840	0.6748	0.5516	0.5460	1.0000			
RACIII	0.4117	0.5940	0.7117	0.6091	0.4921	0.3896	0.6323	1.0000		
RACII	0.6383	0.6508	0.6195	0.8218	0.6474	0.4887	0.7113	0.6105	1.0000	
RACI	0.2904	0.3872	0.3766	0.4498	0.6392	0.3352	0.3946	0.4419	0.4700	1.0000

*L=Left, R=Right (First Letter), AC=Absolute Counts, V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 53. Correlation Matrix of the Absolute Finger Counts for the Female Controls.

Variable*	LACV	LACIV	LACIII	LACII	LACI	RACV	RACIV	RACIII	RACII	RACI
LACV	1.0000									
LACIV	0.5655	1.0000								
LACIII	0.4945	0.6668	1.0000							
LACII	0.5336	0.5913	0.7119	1.0000						
LACI	0.4384	0.4611	0.3424	0.4297	1.0000					
RACV	0.8217	0.6349	0.4999	0.5814	0.4605	1.0000				
RACIV	0.4870	0.8095	0.6792	0.5724	0.3836	0.5909	1.0000			
RACIII	0.4767	0.6071	0.8060	0.6814	0.3956	0.4840	0.6549	1.0000		
RACII	0.5048	0.5996	0.6121	0.7844	0.4409	0.5707	0.6218	0.6958	1.0000	
RACI	0.4637	0.5902	0.4459	0.5053	0.8307	0.4859	0.4693	0.4810	0.5365	1.0000

*L=Left, R=Right (First Letter), AC=Absolute Counts, V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 54. Correlation Matrix of the Absolute Finger Counts for the Male Controls.

Variable*	LACV	LACIV	LACIII	LACII	LACI	RACV	RACIV	RACIII	RACII	RACI
LACV	1.0000									
LACIV	0.6227	1.0000								
LACIII	0.5994	0.5879	1.0000							
LACII	0.5087	0.4892	0.6277	1.0000						
LACI	0.4406	0.4376	0.5062	0.6225	1.0000					
RACV	0.7382	0.5670	0.4594	0.4825	0.3989	1.0000				
RACIV	0.5729	0.7502	0.5301	0.4824	0.3536	0.5710	1.0000			
RACIII	0.5434	0.5975	0.7447	0.6495	0.5210	0.5151	0.5615	1.0000		
RACII	0.5818	0.6323	0.6409	0.7772	0.5441	0.5651	0.5752	0.6677	1.0000	
RACI	0.3945	0.4037	0.4294	0.5418	0.7153	0.4161	0.4365	0.4861	0.5403	1.0000

*L=Left, R=Right (First Letter), AC=Absolute Counts, V=Digit V, IV=Digit IV, III=Digit III, II=Digit II, I=Digit I.

Table 55. Correlation Matrix of the Palm Counts for the Turner Syndrome Females.

Variable*	LCD	LBC	LBA	RCD	RBC	RAB
LCD	1.0000					
LBC	0.3608	1.0000				
LBA	0.1856	-.0238	1.0000			
RCD	0.6936	0.2866	0.1324	1.0000		
RBC	0.3657	0.7632	0.0147	0.1949	1.0000	
RAB	0.2532	0.1278	0.6313	0.2571	0.0593	1.0000

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

Table 56. Correlation Matrix of the Palm Counts for the Klinefelter Syndrome Males.

Variable*	LCD	LBC	LBA	RCD	RBC	RAB
LCD	1.0000					
LBC	0.2363	1.0000				
LBA	0.1418	0.2859	1.0000			
RCD	0.6172	0.0512	-.0426	1.0000		
RBC	0.4079	0.8139	0.5433	0.1103	1.0000	
RAB	0.0536	0.3311	0.8910	-.0745	0.4927	1.0000

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

Table 57. Correlation Matrix of the Palm Counts for the Female Controls.

Variable*	LCD	LBC	LBA	RCD	RBC	RAB
LCD	1.0000					
LBC	0.2947	1.0000				
LBA	0.4868	0.2450	1.0000			
RCD	0.7338	0.1988	0.3755	1.0000		
RBC	0.4541	0.7996	0.3435	0.2355	1.0000	
RAB	0.4179	0.3346	0.6897	0.3241	0.2970	1.0000

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

Table 58. Correlation Matrix of the Palm Counts for the Male Controls.

Variable*	LCD	LBC	LBA	RCD	RBC	RAB
LCD	1.0000					
LBC	0.3015	1.0000				
LBA	0.3435	0.2913	1.0000			
RCD	0.6783	0.2208	0.3102	1.0000		
RBC	0.4034	0.7536	0.3545	0.1982	1.0000	
RAB	0.3790	0.3812	0.7328	0.3213	0.4080	1.0000

*L=Left, R=Right, A=a triradius, B=b triradius, C=c triradius.

VITA

Maxine J. Miller was born in Carthage, Missouri, on August 28, 1948. She attended Carthage Senior High School, Carthage, Missouri, where she was a member of the National Honor Society and graduated in the top 10% of her class in 1966. She entered Missouri Southern State College, Joplin, Missouri, and was graduated cum laude in 1970 with a B.S. in Biology. Following a hiatus of nine years in which she traveled, lived in several different cities across the United States, and reared two daughters, she returned to Graduate School at The University of Tennessee, Knoxville, where she will receive an M.A. with a major in Anthropology in December, 1985.

She has two daughters, Myra Lynn Flitcroft, age 11, and Anna Louise Flitcroft, age 9.