REVIEW OF LITERATURE
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PIONEER WORKERS

The study of asymmetrical expression of dermatoglyphic traits particularly on palm and fingers, has attracted the anthropologists for a considerable time. In the beginning of the twentieth century Poll (1914), while dealing with the data of Galton (1892), Cevadilla and Benassi (1908-1909) and Flaco (1908), pointed out that the frequency of symmetrical patterns on the homologous digits of both hands are more frequent than the frequency which would be expected by chance. The potential contributions in this subfield of dermatoglyphic research, came from the studies of Gruneberg (1928), Newman (1928; 1930), Henckel (1933; 1934), Meyer-Heydenhagen (1934), Krichmaier (1935), Poll (1938), Dankmeijer and Renes (1938; 1940), Cummins and Midlo (1943) Renes (1946), and Holt (1954). It has already been mentioned in the previous chapter that asymmetry, particularly of the fluctuating type, develops when there is a gross failure in the buffering system or canalization of an individual mechanism, responsible for developing symmetrical expression on paired structures. Thus, the degree and intensity of FA usually differ within and between the individual for a particular trait depending upon the stress caused by environmental or genetical factors which disturb the ontogenic development of an organism. This fact prompted the scientists to undertake studies that would help them understand the relationship between fluctuating asymmetry and stress.
ASYMMETRY STUDIES ON ANIMALS

The results of a series of experiments carried out to this end (Harrison 1958; Riesenfeld 1973; Siegel and Smookler 1973; Siegel and Doyle 1975a, b, c; Siegel et al.; 1977; Siegel et al., 1977; Doyle et al, 1977; Sciulli et al., 1979; Mooney et al, 1985) showed that various types of environmental stress such as heat, cold, audiogenic, protein deprivation, teratogenic or behavioral modification can lead to varied degrees of asymmetry in the long bones or in the dentition of the domestic mouse or laboratory rat. Besides exogenous factors, several studies focused also on the relationship between the degree of asymmetry and the pressure of endogenous factors such as inbreeding (Sumner and Huestis 1921; Bader 1965; Sakai and Shimamato 1965; Boesiger 1973; Zakharov 1981; Vrijenhoek and Leman 1982; Graham and Felley 1985) or selection pressure (Mather 1953; Waddington 1960). The results of all these studies unequivocally showed that Van Vallen's (1962) "Fluctuating Asymmetry" or Waddington's (1957) developmental "Noise' is the outcome of stress which influenced the normal developmental pathways of an organism during the prenatal period.

The only available study on the asymmetry of dermatoglyphic characters in higher primate has so far been reported by Newell- Moris (1982). Dermatoglyphic prints of the macaque were studied by the author to test the hypothesis that the phenotypic asymmetry is the outcome of "developmental decanalization". It emerged from the
study that the foetus as well as the offspring of macaque show greater dermatoglyphic asymmetry as individuals less exposed to environmental stress.

ASYMMETRY STUDIES ON HUMAN BEINGS

To understand the relative role of heredity and environment in the etiology of asymmetry, human biologists have laid maximum stress on human dental and other morphometric traits.

Suarez (1974) studied the dentition of the Neanderthal teeth and reported that they were more asymmetric than in the modern homosapiense and he attributed this difference to technological advancement. The study conducted by Doyle and Johanston (1977) on the Eskimo and Pueblon teeth, where they compared their data with Ohio whites emphasized that Eskimo and Pueblon showed comparatively greater degree of asymmetric teeth than the Ohio whites, as they were less exposed to environmental stress. In this connection the study of Perzigian (1977) is of special interest. He has studied fluctuating dental asymmetry among three different population groups who were the representatives of three different technological strata i.e. hunting and gathering stage (Indian Knoll group), agricultural stage (Cambell and Larson Polled) and a group (Hamann-Todd) exposed to modern technology. His study revealed an inverse relationship between the degree of asymmetry and the level of technological development. The result of Harris and Neweeia (1980) also supported Perzigian's findings.
To examine the popular contention that the asymmetry reflects disturbed developmental homeostasis Barden (1980a) worked among two groups of mentally retarded non-Mongol samples. Sample A consisted of persons with mental deficiencies due to prenatal disturbances and sample B consisted of persons with mental retardation due to birth injury or neonatal causes. His results showed a greater dental asymmetry among the children of sample A, that is, those who had experienced relatively greater environmental hazards during their prenatal development.

Livshits and Kobyliansky, (1988) compared asymmetric differences of anthropometric traits between preterm (born between 26-29 weeks) and term babies. From their observations they hypothesized that all the preterm babies were the outcome of inhospitable intra-uterine environmental condition which not only cut short their perinatal age but also influenced their organogenesis process which they reflected through a higher degree of asymmetry. Malina and Buschang (1984) also reported an increased anthropometric asymmetry among mentally retarded individuals compared with the control.

Besides exogenous, there are also several studies which were undertaken to understand the relationship between asymmetric level and endogenous stress such as inbreeding and chromosomal aberration. The results of several studies (Niswander and Chung 1965; Bailit et al, 1970) showed a
high level of asymmetry values for the teeth in inbred populations as compared to the outbred ones. According to the authors the only plausible explanation behind this difference was a greater degree of homozygosity in the inbred population, which was the most vulnerable factor for developing higher degree of asymmetry. However, no marked difference between inbred and outbred populations in regard to this trait was reported by Rosenzweig and Smith (1971). A linear increment in the dental asymmetry associated with Down's patients and patients with the XO condition (Garn et al, 1970; Shapiro 1970, 1975; Barden 1980 b) has been reported. This positive correlation with disturbed chromosomal condition and increased fluctuating asymmetry leads to the conclusion that the polygenic system may buffer developmental process against environmental insults while the deleterious genes may reduce the buffering below a threshold level and resultant reduction in the stability of normal developmental pathway which reflects an "amplified developmental instability". The results of Webb's (1977) study showed a similar trend of asymmetric response in dermatoglyphic and dental traits, which implied that these two traits may develop and grow under similar controlling genetic factors. Although almost all studies on asymmetry in dental traits have supported the stress hypothesis Smith et al, (1980) have tried to negate the stress hypothesis even in the absence of a clear cut conclusion from their study.
Baume and Crawford (1980) observed that dental discrete asymmetry followed a population line rather than a ecological line and for this reason they felt a genetic component could not be excluded. However, Townsend and Brown (1980) did not find any significant genetic component in the expression of fluctuating dental asymmetry.

The systematic qualitative study of human dermatoglyphic asymmetry began in 1954. It was Holt (1954) who first demonstrated in her family study, where she took 50 British families consisting of 254 males and 240 females, that dextral dominance in regard to finger ridge count was 63.4% among males and 66.7% among females. She also reported that 32.68% of males and 28.33% of females had more ridges on their left hand and 3.94% of males and 5.00% of females had equal counts on both hands. She found also a high correlation between right and left hand (0.94±0.01) in females. She used right minus left to measure the asymmetry of ridge count and reported that all correlations between sib-sib, parent-child and twin-co-twin were insignificant. Based on this finding her conclusion was that asymmetry in ridge counts was due to environmental factors and lacked any genetic component.

To examine Holt's (1954) observation, Singh (1970) studied the heritable nature of finger ridge count asymmetry among 150 Australian families and found the heritability among male children, female children and all
children (combined sex) to be 35%, 23% and 5% respectively whereas the heritability which was estimated from parent-child correlations ranged from 20% to 44%. The relatively low heritability among the sex undifferentiated children suggested, that the degree of asymmetry is somehow influenced by sex. However, Singh concluded that asymmetry of finger ridge counts has a significant hereditary component although most of the observed asymmetry may be due to the effect of environment and chance. Rothhammer et al., (1973) studied dermatoglyphic characters among Yanomama Indians - a tribal population, and stated that the asymmetry of ridge-counts is the result of "developmental indeterminancy".

Jantz (1975) strongly opposed the findings of Holt (1954) and Rothhammer et al, (1973) and propounded that the expression of asymmetry is governed by the inherent factor which markedly differs in different ethnic stocks. The experiment from which his observation emerged was based on three ethnic groups - two Europeans, four Africans and one Polynesian group all comprising 956 males and 754 females. The results showed that all four Negro populations exhibited the lowest $\sqrt{A^2}$ (a measure of finger ridge count asymmetry) value whereas the European population showed the greatest asymmetry and the third group i.e. the Polynesian population showed an intermediate value. The same trend of asymmetry was exhibited by the females in the three ethnic stocks. The pairwise comparison to understand the magnitude of population differences showed that one African group
(Pygmies) and the Polynesians (Easter Islanders) significantly differ from each other and also from the rest of the populations in respect of the total ridge counts. It is relevant to remember Holt's (1954) comments on the genetics of asymmetry that the degree of asymmetry largely depends on environmental factor rather than the hereditary component. Even then it is quite hard to accept that the results showing consistent asymmetry among the African Negroes of whom two were tribal populations and the American Negroes are the out come of similar environmental stress. To explain the possible mechanism behind the relatively low ridge counts and asymmetric values among African populations that have experienced a relatively higher environmental stress in the form of scarcity of food, low nutrition and high prevalence of disease, Jantz (1975) stated that it may be due to the presence of higher number of hetrozygote alleles, responsible for lower ridge counts and low asymmetry or it may be a selective advantage to those who have a greater chance to be exposed a greater degree of environmental stress. Finally, the author concluded that the ethnic trend of dermatoglyphic asymmetry has some genetic basis rather than the ecological one.

The range of finger ridge count heritability was estimated between 0.06 and 0.10 among Hawaii Islanders by Mi and Rashad (1977). They reported a range of heritability for finger pattern was observed 0.10 for simple arches and 0.26 for ulnar loops. The bimanual
difference for finger patterns showed that the Hawaiian population has more whorls on right hand than the left. The regression values of midparent and child for whorl, loop and arches have shown a significant result among all five out of six population groups and suggest a possible genetic component for bimanual differences in dermatoglyphic characters, at least, in digital traits. The nature of inheritance of asymmetry of qualitative dermatoglyphical traits has been studied by Kolski and Salvat (1978a,b,c). They have taken four types of finger tip patterns i.e. whorl, loop (radial and ulnar) and arch of monozygotic and dyzygotic Belgian twins. For all four traits they have found a high statistically significant result. Based on their findings, they have hypothesized the existence of hereditary factor for the transmission of asymmetrical dermatoglyphic traits.

Bener (1979) studied 539 Polish families to correlate the hereditary factor with finger ball patterns. He reported a highest mean value for ulnar loops on digit I in males whereas the distribution of mean values for the same trait showed the trend I<IV<V<III<II in the combined sexes which supports Holt's (1949; 1958) and Mavalwala's (1963) findings for the finger ridge count trait. In the male the bimanual difference in asymmetry for ulnar loop component is highest on index finger followed by thumb, middle, little and ring finger whereas in the female, except ring and little finger the rest of the sequence is the same.
Further, it was found that digits IV and V of both hands have a higher correlation between all relatives for the radial loop component. However, it was also reported that the father-son correlation was lesser than the father-daughter correlation. Father-son and mother-daughter correlations were always lesser than the father-daughter and mother-son correlations but a comparatively low correlation among midparent-daughter than the midparent-son was a somewhat unusual finding. Again brother-brother correlation was greater than the sister-sister correlation and parent-child correlation value was greater than the sib-sib correlation. A small but positive correlation result was obtained from the correlation between the relatives for bimanual difference indicating a significant genetic component for ulnar and radial loops of finger tips. However, Bener (1979) did not find any sex linkage with asymmetry. Bener and Erk (1979) also studied the same Polish sample which included one thousand individuals (515 males and 485 females) to determine the role of heredity in asymmetry. The purpose of their study was three fold - first, to determine the distribution of whorl pattern on specific finger tips, second, to compare the frequencies of occurrence of whorl in males and females and finally to determine whether asymmetry of these dermatoglyphic pattern elements is genetically controlled. It was reported in their study that whorls occur most frequently on digit IV on both hands and the difference for the mean values of
occurrence of the said trait between males and females was insignificant. Finally, a positive coefficient of correlation between parent and child and within the sibs was observed which clearly demonstrated a significant genetic component in the asymmetrical occurrence of whorls.

The hereditary nature of finger ridge count asymmetry was also reported by Martin et al., (1982) where they have applied joint regression analysis, a method to examine genotype and environmental interaction developed by Yates and Cochran (1938) and modified by Perkins and Jinks (1968). The results of their study showed that the three types of asymmetry measures i.e. the difference between left hand and right hand, heterogeneity of regression and heterogeneity of remainder are mostly the outcome of environmental influences but there are certain genetic variations also particularly among males. Their findings support the previous observations of Singh (1970) and Loesch and Swiatkowska (1978). They also reported that the degree of asymmetry for left vs. right differs from finger to finger which further supports Jantz's (1979) observation.

Loesch and Martin (1982) used two types of asymmetry, signed difference between right and left representing unidirectional and absolute difference between right and left representing ambidirectional asymmetry in finger ridge counts. Their data consisted of 221 pairs of twins of which 110 (60 males; 50 females) were monozygotic and 111
(62 males; 49 females) were dizygotic, originally collected by Loesch (1979). Additional 80 pairs of opposite sex full-siblings (FSO) were also included in the study. The greatest difference between absolute and signed difference was noticed on digits II and III which supports the earlier observation of Singh (1968) and Jantz (1979). The distribution of signed and absolute differences showed significant deviation. The distribution of absolute differences were all positively skewed among both male and female but for signed indices females showed positive skewness. In males, except digits IV and V all fingers showed positive skewness whereas digits IV and V showed a significant negative skewness. The correlations between signed and absolute differences for two asymmetric indices on individual fingers showed highest value on thumb in both sexes (male 66%; female 57%). In males besides the thumb, digit II also showed significant positive correlation whereas rest of digits showed a significant negative correlation. In case of females, except digit I and IV all digits showed non-significant results. The genetic analysis revealed a relatively higher heritability for the total signed difference than the individual finger difference. A similar result was also obtained on individual finger ridge counts and total ridge counts which indicates a strong genetic base. The estimated range of heritability for signed asymmetry was 0.43 for digit V and 0.10 for digit III in case of male and for female it was
from 0.38 on digit III to 0 on finger II. Although the heritability differs considerably among fingers it is always higher in males than females. Sexual difference in the heritability of directional asymmetry, particularly on digits I, II and V were noticed but none was observed except in digit V with respect to absolute asymmetry. The estimated overall heredity ($h^2$) was found to be 0.28 ± 0.07. As a whole the study suggests that genetical factors in directional asymmetry are more important in males than in females and the presence of inter-relationship of asymmetry on fingers may have a genetical rather than an environmental basis. Finally, the authors concluded their study with the remark that the origin of asymmetry can not solely be attributed to Waddington's (1957) concept of developmental 'noise' particularly for dermatoglyphic traits of man.

Malhotra and Sengupta (1985) studied absolute and fluctuating asymmetry among 411 Hatkar, a seminomad community of Maharashtra utilizing two digital ridge count traits - TFRC and AFRC. Their study revealed that digits I and IV of the right hand showed a maximum of 63.26% and minimum of 44.04% individuals those who shows R>L values in respect of TFRC whereas digit IV and I showed a highest of 42.58% and a lowest of 26.76% individuals those showing R<L values for the same trait in the left hand. The highest number of individuals having equal number of count on both hands was exhibited by digit II (17.52%) and the lowest by
digit I (9.98%). While dealing with AFRC, they found that digit I scored the highest proportion of individuals having higher counts on right hand (66.18%) whereas the digit III showing lowest (39.42%) proportion of individuals. The number of individuals showing equal ridge counts on both sides was found to be highest (14.89%) on digit II and lowest on digit I (5.84%). When AFRC was considered the highest mean absolute difference was seen in digit I (6.64%) and the lowest in digit V (4.07%). The results for absolute asymmetry have shown that the distribution of absolute right-left differences on all digits irrespective of TFR or AFRC deviates significantly from normality which supports the observation made by Loesch and Martin (1982). The highest mean value of directional asymmetry in terms of TRC was observed in digit I (1.97q0.01) and the lowest in digit IV (-0.13q0.01). In case of ARC the digits I and IV showed a highest of 3.43q0.17 and a lowest of 0.08q0.003 mean. The comparison of data on the Hatkar with those on the American, Asian and African showed that the Hatkar are more asymmetric than the Japanese, Waskia and the American Black but less than the British, Poles and the American whites, which supports the findings of Jantz (1975, 1979) and Harvey and Singh (1980).

Fluctuating asymmetry of dermatoglyphic traits was also used by Adams and Niswander (1967) to understand the relationship of polygenic system and developmental instability caused by environmental stress among
congenitally deformed individuals. An increment in the fluctuating asymmetry among propositi with familiar background of cleft lip and palate, compared with non-familiar propositi was observed. Finally, they commented that polygenic system buffers the development of an organism against environmental influences; the substitution of genes in one of these systems lowers developmental stability and thereby increases the probability of occurrence of Cleft Lip (Palate) and concomitantly of increased fluctuating asymmetry. Polani and Polani (1969) studied dermatoglyphic asymmetry among 27 subjects, those who had normal cells and cells trisomic for chromosome number 21 and 16 subjects with 45X cells and cells with a presumptive isochromosome for the long arm of X chromosome. One hundred male and females were also considered as control those who had normal cells. Finger ridge count and angle atd were considered in this study. It appeared that the dermatoglyphic traits among mosaics were more asymmetric than in the normal controls. In general, the variability of the total values of the two dermatoglyphic traits increased or decreased, as between the normal control and the non-mosaic subjects, while the variability of the mosaic subjects was nearer that of the normal controls. By contrast the difference between hands showed the greatest variability in the mosaic subjects, while the non-mosaic chromosomally abnormal control, though they tended to be more variable than the normal controls, were intermediate between these and mosaics. The findings of
Adams and Niswander (1967) were supported by Woolf and Gians (1976, 1977) who used angle atd, finger pattern and finger ridge counts for measuring FA among propositi with cleft lip q palate, their normal sibs and normal parents for familial and sporadic cases. However, in contrast with previous research findings (Johanston and Penrose 1966; Morton and Niswander 1967; Polani and Polani 1969; Woolf and Gians 1976, 1977) which supported the observations of Adams and Niswander, the findings of Owseley (1978) showed a slightly different result.

Jantz (1979) studied asymmetric variation on 15 samples of different ethnic origin throughout the world, where he found Europeans and West Asians characterized by high asymmetry and the African populations by low asymmetry whereas the East Asian and probably those from Oceania tended to occupy an intermediate position. Basing on his observation Jantz commented that the variation in dermatoglyphic asymmetry in the diverse racial groups follows a particular racial pattern and this patterning of population line suggested a genetic rather than an environmental basis for such variation which in turn suggested that the degree of developmental stability in different populations may be under genetic control. Later, Jantz's observation was also supported by Harvey and Singh (1980).

Chakraborty and Malhotra (1981) conducted a study among 20 different nomadic population groups, collectively
described as "Dhangars" with a considerable variation in their economy although all of them share a common eco-climatic set up. They have used Jantz $\sqrt{A^2}$ measure to estimate asymmetry on three dermatoglyphic traits which were total finger count (TFRC), all total finger ridge counts (ATFRC) and pattern intensity index (PII). They have reported that among all 20 castes group, the three different dermatoglyphic parameters (TFRC, ATFRC and PII) showed significant variations. The asymmetry and interdigital diversity ($S/\sqrt{5}$) measures also showed significant variation in almost all cases but the pattern of variations of asymmetry and interdigital diversity was not always in congruence with genetic dissimilarities while the trait-values themselves showed a general congruence. Considering their findings the workers support Jantz's (1975) observation and remark that the genetic component can not be eliminated for the expression of dermatoglyphic asymmetry.

To judge inter-population variation, Chakraborty et al, (1982) used finger ridge count asymmetry ($\sqrt{A^2}$) and interdigital diversity ($S/\sqrt{5}$) among nine endogamous groups (three were tribal and rest were caste) of Maharashtra. The three traits used in the study were absolute ridge count (ARC), total ridge count (TRC) and pattern intensity index (PII). It appeared from their study that all three tribal groups possessed relatively low mean for ARC and TRC compared with caste groups. Asymmetry's value for the
traits ARC and TRC was found highest among Bhils whereas highest asymmetric value for the trait PII was found in a caste group along with the Bhil. Lowest asymmetry was observed among Maratha (7.00), Katkari (12.74) and Brahmin (0.67) for the traits TRC, ARC and PII respectively. The value of asymmetry showed two non-significant positive correlations with the trait TRC and one statistically non-significant negative correlation for the trait PII. For the trait ARC, the correlation was always significant. As a whole both the asymmetry and interdigital diversity values computed for ARC and TRC showed certain degree of within group heterogeneity which suggests a possible genetic control for the trait.

Jantz and Webb (1982) studied the trend of fluctuating asymmetry of palmar a-b ridge count among 38 population samples, broadly of European, African, Amerindians and Asian origin. Pooling sex and ranking the groups by increasing value of fluctuating asymmetry they observed the following trend: Africans < Asians < Europeans < Amerindians. The ranking is the same for each sex, except that in females the Asians and Europeans reverse their position. In both sexes the most clearly discernible feature was that the African population had higher correlations than the other groups. This finding is supported by Jantz's (1975, 1977, 1979) observation for finger ridge counts. Another, less marked consistency is that, Amerindians have lower correlation than the other
groups. The Amerindian population shows the highest degree of racial admixture and they also represent varying degrees of geographical diversification. Despite the racial admixture and geographical heterogeneity, the native American sample presented lowest within group variation compared with the other three racial samples, which suggests that the observed low correlation among them is not an accidental phenomenon but rather is a biological character. The existence of variation among geographical groups negates the exogenous stress hypothesis which alone is responsible for the intergroup variation in asymmetry and in turn strongly provides evidence that the magnitude of fluctuating asymmetry has a genetic component at least for the a-b ridge count.

The pattern of intra-individual variation in the extent of asymmetry was discussed by Malhotra et al, (1991). The variation in the ridge count asymmetry among different dermatoglyphic areas was measured among three population groups - Hatkar of Maharashtra (200 adult males), Vadabalija males (167) and Females (164) of Puri, Orissa. It emerged from the study that the observed pattern of variation in the mean asymmetry in different dermatoglyphic pattern areas is strikingly consistent in the three population groups which, in turn, suggests a common biological mechanism among the three populations. It was also reported that the thumb and the palmar interdigital areas a-b, b-c and c-d showed an elevated level of
asymmetry compared with other areas and were more sensitive to developmental stress.

Fluctuating asymmetry could be a useful tool to measure the environmental stress as described by Livshits and Kobyliansky (1987), who in their study used sixty seven dermatoglyphic traits along with five anthropometric traits on a sample of two hundred and fifty Israeli males. They found that individuals who were at the centre (average q 0.67 SD) of the morphological trait distribution (and therefore perhaps more heterozygous at loci determining the traits) have reduced FA in their ridge counts, which showed a general agreement with their hypothesis that fluctuating asymmetry for dermatoglyphical traits as well as diversity and variability characters of dermatoglyphics would exhibit higher values in homozygous groups than the heterozygous ones. Their findings also support previous finding (Niswander and Chung 1965; Perzigian 1977; Soule 1979; Soule and Cuzin-Roudy 1982; Leamy 1984; Leary et al; 1984) that fluctuating asymmetry tends to increase with inbreeding or with increasing homozygosity of the sample. Mating differential and its possible consequence on bilaterally distributed dermatoglyphic trait was also discussed by Mukherjee (1990a). Five different dermatoglyphic traits were used from six Indian populations who practiced different level of consanguinity and the results were compared with out-bred samples. It was observed that bilateral correlation, which is a negative
measure of asymmetry (Jantz 1982), was greater and bilateral variances of the five dermatoglyphic traits were lower among the high inbreeding classes. This finding led the author to hypothesize that the sources (genetic and/or epigenetic) of bilateral correlations and bilateral variances for these traits must be related to homozygosity of individuals. However, this finding showed a general agreement with Kobyliansky and Livshits (1986) and Clark et al, (1986) but was in disagreement with those of Palmer and Stroebeck (1986) and Livshits and Kobyliansky (1987).

Handedness and asymmetry were studied by Micle et al., (1978) who have reported that the asymmetry has certain degree of correlation with the handedness. In their study they found a relatively lower degree of asymmetry exhibited by sinistral individuals rather than persons who were right-handers.

To trace the possible relationship between the functional and morphological asymmetry Karev (1993) compared two types of functional asymmetries i.e. arm folding and hand clasping with the person's morphological asymmetrical trait i.e. the asymmetrical feature of dermatoglyphic characters. The study revealed that out of twenty morphological - asymmetrical traits, six showed significant results between right and left folders and only two traits between right and left claspers. However, comparisons of the ulnar and radial counts between right and left folders and between right and left claspers showed no
significant difference which in turn suggested that the person who differ in two functional asymmetries differ also in some of the asymmetries of ridge counts but not in the ridge count themselves.

The influence of sex-chromosomes and race on individual asymmetry of finger ridge counts were studied by Jantz and Webb (1980b). In their study they considered four normal racial groups (American White, American Black, German and Blacks from Angola) and two aneuploid (Turner's and Klinefelter's Syndrome) groups. They reported a distinctive asymmetrical pattern in all racial groups and also found that both the X and Y sex chromosomes have alteration power in directional asymmetry with the latter chromosome having greater influence.

The results of Goodson and Meier (1986) showed a sexual difference in the six dermatoglyphic characters, which they have considered for bilateral asymmetry. It was reported that males are more asymmetric than females which may be due to the poor canalization system among males against environmental perturbation.

Recently Jantz and Brehme (1993) made an attempt to understand the asymmetrical expression of Palmar interdigital ridge counts (a-b, b-c and c-d) in terms of sex influence. Earlier studies in the same direction had shown that the directional asymmetry of finger patterns (Jantz and Hunt 1986), finger ridge counts (Jantz 1978) as
well as other developmental asymmetries (Mittwoch and Mahadevaiah 1980) were strongly related with the sex chromosome complement. Their (Jantz and Brehme 1993) study revealed that the female have greater values for directional asymmetry which is more pronounced on the left palm. Another major finding on directional asymmetry is a negative correlation between inter-digital ridge count b-c Vs c-d and a-b. The results of fluctuating asymmetry have shown a distinctive trend in the magnitude of asymmetry in three inter-digital areas i.e. the highest fluctuating asymmetry was observed in c-d followed by a-b. The least asymmetric expression of b-c counts are might be the outcome of early maturation of ridges on the second inter-triradial area which in turn gets less exposure to the prenatal disturbances as suggested by the authors.

Arrieta et al., (1993) postulated that the fluctuating asymmetry of palmar a-b ridge count shows the least genetical response rather than a greater influence of the environmental factors, which is relatively more prominent in the male. In general the volar pad of interdigital area II usually takes more time for the completion of ridge formation compared with the finger thus allowing a greater exposure to the intra-uterine environmental factors. Moreover this process is relatively slow in the male which might be because of the presence of Y chromosome (Barlow 1973, Netley and Rovet 1982) or due to the elevation of the level of the hormone testosterone. Whatsoever the factors
involved in the delaying of the maturation of palmar II inter-digital ridges, the result based on a study of twins (Arrieta et al., 1993) showed that environmental prenatal factors have a greater impact on the fluctuating asymmetry of the a-b ridge count particularly in the male.

Malhotra et al, (1985) observed a trend of decreases in the mean and variance of finger ridge count asymmetry with increasing of age. They have also observed a consistent decrease in the tail of the distribution of asymmetry values from younger to the older generations. This finding enabled them to hypothesize that it is the force of natural selection which gradually eliminates lethal genes from a population, that is, genes which are supposed to be responsible for a relatively greater degree of asymmetric expression in the concerned individual. It follows from this that nature will only select those individuals who are 'more fit' in terms of lower number of lethal genes which expressed their activity through a lesser degree of asymmetry.

To strengthen the "Age Model" Malhotra (1987) again studied fluctuating asymmetry among 69 population groups and found a distinctive racial trend. The author has tried to explain the different trends of asymmetry in the three broad racial stocks with the help of the age model. According to him a relatively higher value of asymmetry in the European population is due to the persistence of
deleterious genes through a relatively low mortality profile, particularly at the childhood age. Conversely, a slow and continuous natural force gradually eliminates 'less fit' individuals in the African population through their high death rate at childhood, more specifically at infant stage. Inadequate medical facilities accelerate this elimination process. Malhotra's 'Age Model' was examined by Reddy et al. (1991) who worked among the Vadde's of Andhra Pradesh. Their sample consisted of 796 Vadde's (365 males and 431 females) ranging in age from 6 months to 85 years and above. This "single breeding unit" was isolated from the modern influences and lived in natural conditions with almost no modern medical facilities which was reflected by their child mortality rate (30%) in the year of investigation. It was observed that both types of asymmetrical measures i.e. $A_1$ (absolute asymmetry values of total finger ridge counts summed over 5 digits) and $A_2$ (absolute R-L values with R+L values for total ridge count) did not show a consistent decrease in the mean asymmetry with increase in age nor was there a consistency in the trend between sexes. No trend of reduction in the tail of distribution was seen from younger generation to older age groups. The r-values obtained between age and asymmetry within different age groups or in the total samples were all rather small and close to zero. The r-square value obtained from regression analysis, in both males and females was almost zero, suggesting a virtually complete absence of age influence on fluctuating asymmetry.
Although the results of their study do not support Malhotra's "Age Model", they have concluded their study with the remark that a composite index of asymmetry containing information from a number of dermatoglyphic characters, rather than that based on a single character is necessary to assess the possible association of age and fluctuating asymmetry which will be applicable in the children below 5 years age, the period when the canalization mechanism is likely to be completed.

Jantz and Webb (1982) reported that the canalization process (individual buffering system against stress) of an individual is closely linked with the expression of asymmetry of dermatoglyphic character, at least, for the a-b ridge count of palm. They have observed that the magnitude of fluctuating asymmetry is higher on both extreme ends of a-b ridge count compared with values which are closer to the mean or fit value.

Chowdhury (1991) has tried to show that the "stressful life due to economic condition" could be a major factor for developing greater dermatoglyphic asymmetry among the Shipi, a small breeding isolate (1294 individuals) of Himachal Pradesh. The mean of Jantz $\sqrt{A^2}$ value, and the asymmetric value for ridge count TFRC and ATFRC were scored highest among Shipi, compared with Bodh or Swangla. Like Shipi, the Bodh and Swangla are also endogamous units but have a greater well-off economic life than the Shipi.
Very recently Bogel et al., (1994) examined the "placental proximity effect" on the asymmetry of palmar a-bridge count among 314 MZ twins with the known type of placenta. Their study revealed a comparatively higher degree of within pair asymmetry variance (6.69) among MZ twin pairs with monochorionic placenta than the MZ twins (4.96) of dichorionic type. Again, the within pair variance was found greater (6.36) among MZ dichorionic twins with fused placenta, compared with the same type of twins (3.71) with a separate placenta. A similar pattern of greater variability in dichorionic fused versus dichorionic separate placentas was also found among 121 same sex DZ twins. Finally, they have commented that the observed differences among twins with different placentation, in terms of absolute asymmetry, could be the result of greater inter-uterine competition between co-twins (Corey et al., 1976), variations in vascular communication, or underlying embryological differences resulting from the different timing of the splitting of egg in MZ twins.

The trend of dermatoglyphic asymmetry of finger and palmar areas has been studied by many workers (Kumbnani 1962, 1963, 1964; Prabha 1963; Mathrani 1963; Kumari 1965; Gupta 1966; Sapra 1967-68; Sen 1968; Bhasin 1969; Indira 1969-70; Jayapradha 1972.) in the context of Indian populations such as Brahmin and Muslim of Rajasthan, Kashmir Pandit, Shahs of Kumaon, Rana Thukur of UP, Brahmin and Kanet of Shimla Hill, Kashmiris, Newar of Nepal, Brahmin of Kullu and Nepalis & Jat.

As far as our knowledge goes, the only available dermatoglyphic asymmetry study among the Bengali Brahmin was one by Chattopadhyay and Das Sharma (1969). In their study they have found that the highest level of asymmetry for fingr pattern was in digits II and I among males whereas among females digits I & II both showed highest asymmetric values and digit V showed the lowest value. The trend of occurrence of symmetrical combinations among males was III> IV> V> I> II and among females it was V> IV> III> I> II. Considering all digits, they found a statistically significant asymmetric value for thumb irrespective of sex which was 2.05 among males and 2.94 among females.