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Journal Title: ACTA ANTHROPOGENETICA

Volume: 4 **Issue:** 1-2

Month/Year: 1980 **Pages:** 1-27

Article Author: Bhasin MK, Malik SL, Grewal MS,
Singh IP, Sudarsha

Article Title: Effect of natural background
radiation on dermatoglyphic traits.

Imprint: RAPID: -4319148

ILL Number: -4319148



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Effect of Natural Background Radiation on Dermatoglyphic Traits

M.K. BHASIN¹, S.L. MALIK,¹ M.S. GREWAL,² INDERA P. SINGH,¹
K.J. SUDARSHAN¹, N. KOCHUPILLAI² AND I.C. VERMA²

1. Department of Anthropology, University of Delhi, Delhi, India.
2. All India Institute of Medical Sciences, New Delhi, India.

Key words

Dermatoglyphics. Radiation. Indian population.

Abstract

Long term exposure to natural background radiation could cause gross abnormalities in individuals and at the population level. Studies conducted on the coastal Kerala population which is known to be receiving fifteen times the normal permissible dose of radiation support this. This study aims at understanding the deviations, if any, in the normal human variation as a result of such high natural radiation. A detailed quantitative and qualitative dermatoglyphic study was done on two communities i.e. Hindus and Christians, living separately in the radiation area. The significant differences were observed between control and exposed groups with regard to d-t ridge count, distance c-t and angle aid. The susceptibility of the axial triradius to environmental disturbances is discussed.

Introduction

The long term effects of chronic doses of natural radiation are known to cause disturbances in certain hereditary factors^{4 13 27} and in some human quantitative traits.^{3 7 8}

An area of high natural background radiation is detected on the southwest coast of India in the Kerala State.^{6 11 27} The penetrating rays emitted by thorium which is present in the monazite occurring in the soil of area, is believed to be causing genetic effects.¹⁴ The inhabitants of this area receive a dose of 0.2 mR per hour (1500 mR/year) which is fifteen times more than the average normal dose of radiation.²⁴

Assessing the possible long-term effects of the background radiation in this area, Kochupillai *et al*¹⁸ reported greater abortion rate among women (109/1000 pregnancies as compared to 64.5/1000 pregnancies in control population), higher incidence of severe mental retardation (0.93/1000

pregnancies as compared to 0.17/1000 pregnancies in controls) and increased chromosomal alterations (such as rings, deletions etc). For example, the frequency of Down's Syndrome is 1 in 1,076 live births in this zone while it is 1 in 1,215 live births in India.²⁶ Similar findings were reported in a Brazilian population, living in an area of high natural background radioactivity⁴. Grewal *et al*¹³ reported high incidence of Down's Syndrome, severe mental subnormality and limb malformations. They have also reported higher incidence of chromosomal aberrations and higher incidence of non-tasters in the radiation group as compared to the controls. Investigation of Kochupillai *et al*¹⁸ does not reveal any high incidence of nodular lesions or neoplasms in this area. Ahuja *et al*³ observed lower variance in six quantitative characters of dermatoglyphics in the exposed group.

This study aims at understanding further, the mutational effects of high levels of radiation on some dermatoglyphic variables.

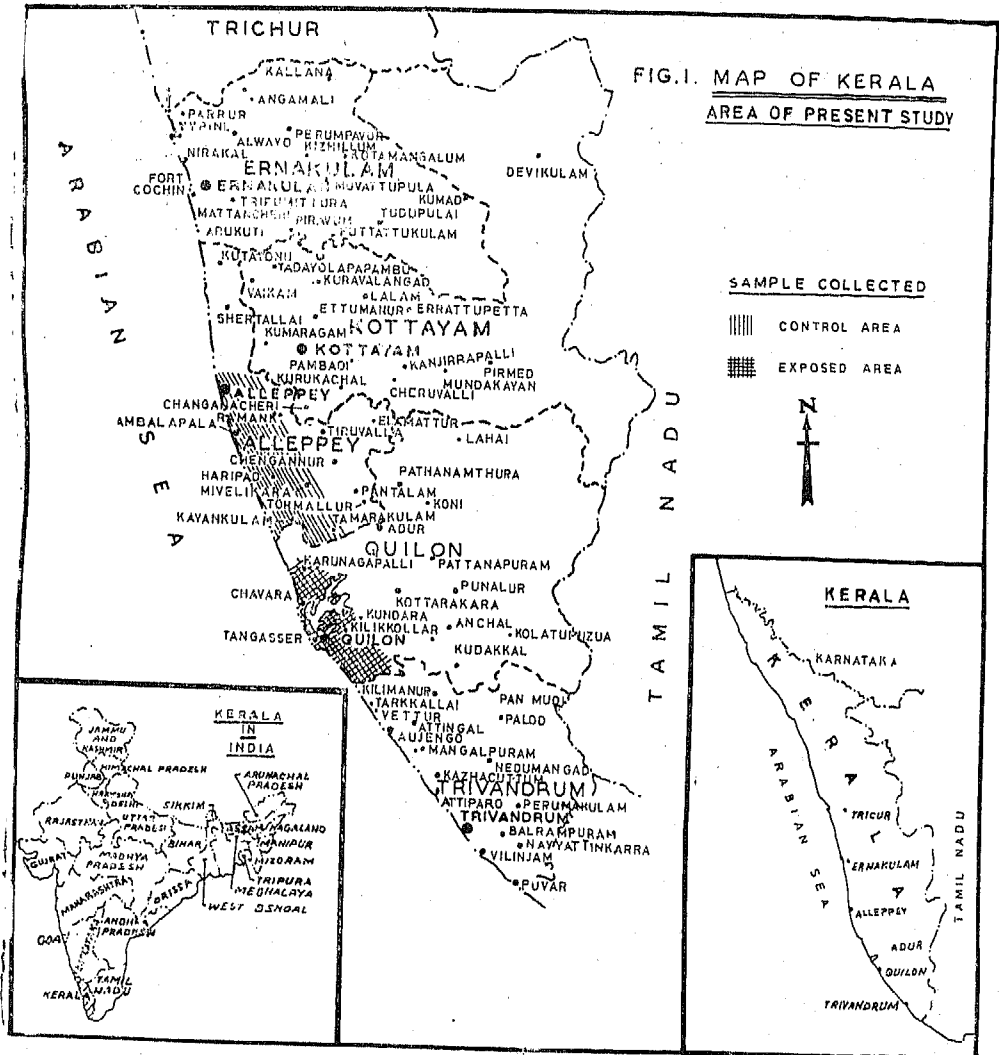
Material and Methods

Area and Population

The area surveyed was the southernmost one fifth of the Chavara-Neendakara strip, with a population of 12,936, with the highest exposure risk in the entire coastal region.¹² The Hindus form the majority (72 per cent)

Table I. Sample size

| Groups | Sex | Sample size |
|----------------------|--------|-------------|
| <i>Control group</i> | | (139) |
| Hindu | Male | 45 |
| Hindu | Female | 44 |
| Christian | Male | 25 |
| Christian | Female | 25 |
| <i>Exposed group</i> | | (79) |
| Hindu | Male | 20 |
| Hindu | Female | 21 |
| Christian | Male | 14 |
| Christian | Female | 24 |



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whereas Christians and Muslims are in minority (26 and 2 percent respectively). The Hindu sample was drawn from the village of Puthenthura and the Christian sample from Karithura receiving normal radiation (i.e. 100 mR Yr⁻¹). The sample size of the exposed and control groups of Hindus and Christians in both the sexes is shown in Table I.

The control samples of the Hindus and Christians were collected from Purakkadi and Punnapara villages in Aleppy district respectively. Hindus constitute 60 per cent of the population (total population approximating 6,000) of control area whereas 25.8 per cent and 14.2 per cent are Christians and Muslims respectively.¹⁹ Both the exposed and control groups belong to the fishermen community known as, Arayas and their age, sex and ethnic structures are similar.

Fingerball patterns, individual finger ridge counts, palmar patterns on different configurational areas, angle atd, palmar ridge counts (a-b, b-c, c-d, a-d and d-t) and main line formulae were analysed according to the scheme proposed by Penrose²¹; c-t distance¹⁶ and D-termination⁹ were also taken into consideration.

In the present study only adult subjects were chosen in order to eliminate biases that arise out of age differences in some of the characters considered here.

Results

Fingerball dermatoglyphics

The variation in the fingerball pattern frequencies of whorls, loops and arches in control and exposed groups of Hindu and Christian males and females is presented in Table II, and values of the test of significance among these groups are presented in Table III.

The bimanual frequency of whorls is invariably high in the control group, whereas the frequency of arches is high in the exposed group in both Hindus and Christians, irrespective of sex. There is a lower frequency of loops in all the exposed groups with the exception of Christian males. The control and exposed groups show statistically significant differences in finger patterns only among Christian males; in other groups the difference is statistically not significant at 5% probability level.

The individual digital ridge counts for the control and exposed groups are represented in Tables IV, V, VI and VII. The ridge counts between control and exposed groups do not vary significantly except occasionally, as in case of the V finger of the right hand in Hindu males and IV finger of the left hand in Christian females; in both the cases the exposed groups show low mean ridge-count.

Table II. Finger patterns

| Groups | Area | Side | Loops | | | | | | | | | | Total |
|------------------|--------------|------|--------|-------|-------|-------|--------|------|-------|-------|--------|-------|-------|
| | | | Whorls | | Ulnar | | Radial | | Total | | Arches | | |
| | | | No. | % | No. | % | No. | % | No. | % | No. | % | |
| Hindu male | Control (45) | R | 118 | 52.44 | 97 | 43.11 | 2 | 0.89 | 99 | 44.00 | 8 | 3.56 | 225 |
| | | L | 117 | 52.00 | 95 | 42.22 | 3 | 1.33 | 98 | 43.55 | 10 | 4.25 | 225 |
| | | R+L | 235 | 52.22 | 192 | 42.67 | 5 | 1.11 | 197 | 43.78 | 18 | 4.00 | 450 |
| | Exposed (20) | R | 49 | 49.00 | 47 | 47.00 | 0 | 0.00 | 47 | 47.00 | 4 | 4.00 | 100 |
| | | L | 40 | 40.00 | 55 | 55.00 | 0 | 0.00 | 55 | 55.00 | 5 | 5.00 | 100 |
| Hindu female | Control (44) | R+L | 89 | 44.50 | 102 | 51.00 | 0 | 0.00 | 102 | 51.00 | 9 | 4.50 | 200 |
| | | R | 100 | 45.45 | 109 | 49.55 | 1 | 0.45 | 110 | 50.00 | 10 | 4.54 | 220 |
| | | L | 109 | 49.55 | 103 | 46.32 | 3 | 1.36 | 106 | 48.18 | 5 | 2.27 | 220 |
| | Exposed (21) | R+L | 209 | 47.50 | 212 | 48.18 | 4 | 0.91 | 216 | 49.09 | 15 | 3.41 | 440 |
| | | R | 42 | 40.00 | 58 | 55.24 | 1 | 0.95 | 59 | 56.19 | 4 | 3.21 | 105 |
| Christian male | Control (25) | L | 41 | 39.05 | 55 | 52.32 | 4 | 3.81 | 59 | 56.19 | 5 | 4.76 | 105 |
| | | R+L | 83 | 39.52 | 113 | 53.81 | 5 | 2.38 | 118 | 56.19 | 9 | 4.29 | 210 |
| | | R | 61 | 48.80 | 61 | 48.80 | 2 | 1.60 | 63 | 50.40 | 1 | 0.80 | 125 |
| | Exposed (14) | L | 63 | 50.40 | 57 | 45.60 | 3 | 2.40 | 60 | 48.00 | 2 | 1.60 | 125 |
| | | R+L | 124 | 49.60 | 118 | 47.20 | 5 | 2.00 | 123 | 49.20 | 3 | 1.20 | 250 |
| Christian female | Control (25) | R | 35 | 50.00 | 26 | 37.14 | 2 | 2.86 | 28 | 40.00 | 7 | 10.00 | 70 |
| | | L | 31 | 44.29 | 33 | 47.14 | 1 | 1.43 | 34 | 48.57 | 5 | 7.14 | 70 |
| | | R+L | 66 | 47.14 | 59 | 42.14 | 3 | 2.14 | 62 | 44.29 | 12 | 8.57 | 140 |
| | Exposed (24) | R | 52 | 41.60 | 68 | 54.40 | 1 | 0.80 | 69 | 55.20 | 4 | 3.00 | 125 |
| | | L | 55 | 44.00 | 62 | 49.60 | 4 | 3.20 | 66 | 52.80 | 4 | 3.20 | 125 |
| Exposed (24) | R+L | 107 | 42.80 | 130 | 52.00 | 5 | 2.00 | 135 | 54.00 | 8 | 3.20 | 250 | |
| | R | 38 | 31.67 | 73 | 60.83 | 2 | 1.67 | 75 | 62.50 | 7 | 5.83 | 120 | |
| | L | 38 | 31.67 | 73 | 60.83 | 2 | 1.67 | 75 | 62.50 | 7 | 5.83 | 120 | |
| | | R+L | 76 | 31.67 | 146 | 60.83 | 4 | 1.67 | 150 | 62.50 | 14 | 5.83 | 240 |

Effect of natural background radiation on dermatoglyphic traits

Table III. Chi square values between exposed and control groups for the distribution of whorls, loops and arches.

| Group | χ^2 | Probability | Remarks |
|------------------|----------|--------------|-----------------|
| Hindu Male | 3.3150 | 0.20>P>0.10 | Non-significant |
| Hindu Female | 4.3041 | 0.20>P>0.10 | Non-significant |
| Christian Male | 12.8176 | 0.01>P>0.001 | Significant |
| Christian Female | 0.4803 | 0.80>P>0.070 | Non-significant |

Table IV. Finger ridge count

Hindu Male

| Side | Digit | Control group Mean \pm S.E. Variance (45) | Exposed group Mean \pm S.E. Variance (20) | F-ratio | t-test |
|-------|-------|--|--|---------|--------|
| Right | I | 19.49 \pm 0.95 40.57 | 20.82 \pm 1.87 70.56 | 0.576 | 0.592 |
| | II | 13.98 \pm 1.00 45.56 | 13.65 \pm 1.22 29.92 | 1.526 | 0.196 |
| | III | 14.72 \pm 0.84 32.26 | 14.88 \pm 1.26 31.80 | 1.017 | 0.100 |
| | IV | 17.91 \pm 0.67 20.34 | 16.41 \pm 1.22 29.92 | 0.681 | 1.001 |
| | V | 15.51 \pm 0.59 15.76 | 12.29 \pm 2.02 9.06 | 1.748 | 3.395* |
| Left | I | 16.21 \pm 0.87 34.45 | 17.82 \pm 1.27 32.71 | 1.051 | 0.978 |
| | II | 13.56 \pm 0.84 32.37 | 14.59 \pm 1.4 39.69 | 0.816 | 0.587 |
| | III | 13.70 \pm 0.95 41.21 | 15.29 \pm 1.16 26.93 | 1.530 | 1.002 |
| | IV | 17.30 \pm 0.84 32.37 | 17.77 \pm 1.23 30.25 | 1.069 | 0.290 |
| | V | 15.42 \pm 0.62 17.55 | 14.47 \pm 0.92 17.22 | 1.023 | 0.795 |

(*denotes significance)

Table V. Finger ridge count

Hindu Female

| Side | Digit | Control group Mean±S.E. Variance (44) | Exposed group Mean±S.E. Variance (21) | F-ratio | t-test |
|-------|-------|--|--|---------|--------|
| Right | I | 17.68±0.99 43.29 | 17.76±1.36 39.31 | 1.100 | 0.060 |
| | II | 14.46±0.98 43.03 | 13.00±1.37 39.56 | 1.085 | 0.860 |
| | III | 15.66±0.93 38.68 | 14.24±1.36 38.93 | 0.993 | 0.859 |
| | IV | 18.66±0.97 41.60 | 17.86±1.22 31.47 | 1.317 | 0.513 |
| | V | 14.82±0.76 25.40 | 14.10±0.75 11.90 | 2.137* | 0.676 |
| Left | I | 17.39±0.94 39.43 | 17.86±1.61 54.46 | 0.724 | 0.252 |
| | II | 14.57±0.92 37.82 | 13.62±1.58 52.99 | 0.714 | 0.516 |
| | III | 15.50±0.71 22.46 | 16.19±1.52 48.58 | 0.461 | 0.411 |
| | IV | 18.07±0.75 24.90 | 17.95±1.43 43.29 | 0.576 | 0.071 |
| | V | 14.57±0.52 12.18 | 13.05±0.90 17.05 | 0.714 | 1.456 |

(*denotes significance)

Table VI. Finger ridge count

Christian Male

| Side | Digit | Control group Mean \pm S.E. Variance (25) | Exposed group Mean \pm S.E. Variance (14) | F-ratio | t-test |
|-------|-------|--|--|---------|--------|
| Right | I | 24.00 \pm 0.00 25.00 | 23.00 \pm 1.66 38.81 | 0.643 | 0.481 |
| | II | 17.83 \pm 1.19 35.76 | 14.25 \pm 2.29 73.96 | 0.484 | 1.287 |
| | III | 18.30 \pm 0.82 14.89 | 14.83 \pm 1.77 43.95 | 0.385 | 1.655 |
| | IV | 19.26 \pm 1.06 28.09 | 14.58 \pm 1.24 21.62 | 1.303 | 0.390 |
| | V | 17.57 \pm 0.80 16.08 | 16.08 \pm 1.66 38.68 | 0.415 | 0.748 |
| Left | I | 22.35 \pm 0.95 22.84 | 23.58 \pm 1.67 39.18 | 0.587 | 0.600 |
| | II | 18.09 \pm 1.24 38.81 | 15.41 \pm 1.70 40.44 | 0.962 | 1.187 |
| | III | 17.09 \pm 1.19 35.88 | 16.41 \pm 1.98 55.35 | 0.646 | 0.270 |
| | IV | 21.13 \pm 0.92 21.52 | 18.83 \pm 2.04 58.62 | 0.368 | 0.953 |
| | V | 18.87 \pm 0.71 12.88 | 16.75 \pm 0.88 10.89 | 1.188 | 1.751 |

Table VII. Finger ridge count

Christian Female

| Side | Digit | Control group Mean±S.E. Variance (25) | Exposed group Mean±S.E. Variance (24) | F-ratio | t-test |
|-------|-------|--|--|---------|--------|
| Right | I | 18.67±1.44 52.12 | 16.73±1.44 49.98 | 1.043 | 0.957 |
| | II | 15.71±1.16 34.10 | 14.62±1.49 53.14 | 0.642 | 0.587 |
| | III | 15.08±1.04 27.14 | 14.00±1.41 48.02 | 0.565 | 0.627 |
| | IV | 18.46±0.95 22.75 | 15.58±1.35 44.08 | 0.516 | 1.772 |
| | V | 14.83±0.97 23.91 | 12.23±1.24 37.08 | 0.664 | 1.684 |
| Left | I | 16.29±1.16 33.98 | 15.85±1.61 62.09 | 0.548 | 0.228 |
| | II | 15.08±1.22 37.45 | 13.92±1.63 63.84 | 0.587 | 0.579 |
| | III | 15.12±1.37 40.32 | 14.65±1.49 53.58 | 0.752 | 0.244 |
| | IV | 19.25±0.97 23.61 | 14.73±1.31 41.08 | 0.575 | 2.823* |
| | V | 14.54±1.02 26.41 | 12.73±1.09 28.62 | 0.924 | 1.221 |

(*denotes significance)

Table VIII. Values of coefficient of correlation between different dermatoglyphic variables
Male Fingers (Hindu)

| | Right hand | | | | | Left hand | | | | |
|-----|------------|-------|-------|-------|-------|-----------|------|-------|-------|---------------|
| | I | II | III | IV | V | I | II | III | IV | V |
| I | | .402 | .370 | .350 | .245 | .544 | .279 | .283 | .234 | .123 |
| II | .495 | | .681 | .522 | .350 | .450 | .775 | .613 | .652 | .458 |
| III | .416 | .835 | | .540 | .259 | .337 | .791 | .724 | .647 | .449 |
| IV | .669 | .680 | .666 | | .691 | .598 | .502 | .452 | .578 | .372 |
| V | .049 | .117 | .245 | .426 | | .465 | .293 | .393 | .473 | .393 |
| I | .834 | .628 | .631 | .756 | -.024 | | .507 | .240 | .299 | .186 |
| II | .537 | .647 | .648 | .716 | .065 | .640 | | .589 | .561 | .296 |
| III | .579 | .813 | .742 | .717 | .040 | .761 | .769 | | .630 | .478 |
| IV | .730 | .523 | .551 | .830 | .182 | .793 | .481 | .701 | | .386 |
| V | -.031 | -.353 | -.209 | -.027 | .338 | -.158 | .019 | -.203 | -.121 | |
| | | | | | | | | | | Control group |

Exposed group

Table IX. Values of coefficient of correlation between different dermatoglyphic variables
Female Fingers (Hindu)

| | Right hand | | | | | Left hand | | | | |
|-----|------------|------|------|------|------|-----------|------|------|------|---------------|
| | I | II | III | IV | V | I | II | III | IV | V |
| I | | .656 | .671 | .721 | .609 | .655 | .640 | .679 | .649 | .694 |
| II | .637 | | .653 | .691 | .625 | .445 | .728 | .636 | .723 | .670 |
| III | .596 | .761 | | .693 | .527 | .281 | .512 | .540 | .487 | .446 |
| IV | .344 | .509 | .682 | | .674 | .515 | .599 | .693 | .784 | .603 |
| V | .338 | .581 | .477 | .448 | | .421 | .677 | .620 | .584 | .625 |
| I | .839 | .625 | .612 | .343 | .178 | .435 | .529 | .533 | .655 | |
| II | .456 | .772 | .706 | .539 | .572 | .488 | .631 | .663 | .642 | |
| III | .534 | .652 | .672 | .743 | .306 | .578 | .752 | .775 | .494 | |
| IV | .659 | .572 | .529 | .504 | .477 | .633 | .510 | .621 | .518 | |
| V | .092 | .223 | .319 | .312 | .511 | .031 | .383 | .242 | .221 | Control group |

Exposed
group

Table XI. Values of coefficient of correlation between different dermatoglyphic variables
Female Fingers (Christian)

| | Right hand | | | | | Left hand | | | | |
|-----|------------|------|------|-------|------|-----------|------|------|------|---------------|
| | I | II | III | IV | V | I | II | III | VI | V |
| I | | .483 | .430 | .038 | .524 | .826 | .290 | .665 | .520 | .663 |
| II | .687 | | .504 | -.073 | .247 | .356 | .341 | .345 | .161 | .304 |
| III | .673 | .862 | | .320 | .518 | .298 | .486 | .386 | .350 | .453 |
| IV | .726 | .712 | .736 | | .615 | .133 | .186 | .276 | .565 | .491 |
| V | .708 | .664 | .614 | .681 | | .422 | .420 | .518 | .531 | .567 |
| I | .856 | .715 | .766 | .691 | .663 | | .216 | .679 | .599 | .796 |
| II | .731 | .800 | .779 | .843 | .722 | .731 | | .639 | .296 | .263 |
| III | .675 | .729 | .753 | .777 | .689 | .669 | .831 | | .665 | .690 |
| IV | .669 | .624 | .649 | .779 | .581 | .693 | .324 | .809 | | .692 |
| V | .138 | .409 | .324 | .278 | .338 | .245 | .398 | .395 | .477 | |
| | | | | | | | | | | Control group |

Exposed group

Though the coefficients of correlation of ridge-counts of different fingers vary, no particular trend of difference between control and exposed groups is observed. This, to some extent, indicates that the natural radiation of the Kerala coastal region is neither sufficient to disperse the uniformity of ridge-count nor it is able to deviate the relationship between the ridge-counts of different fingers by affecting any finger in particular. We are, of course, well aware of our small sample size.

Palmar dermatoglyphics

The distributions of mainline formulae are presented in Table XII, alongwith the chi-square values for differences between the control and exposed groups. Both the male and female Hindu controls have low frequency of 11. 9. 7 and 7. 5. 5—types of main line formulae than those of exposed group, however not reaching the significance level (at 5% level of probability) when the four categories (11.9.7.-, 9.7.5.-, 7.5.5.-, and 'rest') are considered. The frequency of different main line formulae varies to lesser extent among Christian males. Among the Christian females, control group has markedly lower frequency of 9.7.5.-, and higher frequency of 7.5.5.- than the exposed group but statistically these differences are also not significant at 5% level of probability.

The distribution of D line openings is presented in Table XIII. Like the main line formulae, among Hindu males and females, line D- terminations in positions 11 and 7 are more prevalent in control group than in the exposed, whereas D line opening at position 9 is more frequent in exposed group, but the differences between the two groups are statistically not significant (at 5% probability level).

In pattern types in hypothenar area (Table XIV) the Hindus (both male and female) do not show any significant variation in control and exposed groups. While Christian males show the same trend, the females show significant difference in frequency of patterns at hypothenar area—the frequency being significantly higher in exposed group.

At the thenar/I interdigital area the differences in the frequency of occurrence of patterns and open fields are statistically non-significant, between control and exposed groups. Similarly the differences are not significant with respect to the occurrence of patterns at II, III and IV interdigital areas, except in IV interdigital area, where Christian females show statistically significant difference between control and exposed groups.

Variation in interdigital ridge-counts (a-b, b-c, c-d, a-d and d-t), angle atd, and distance c-t has been presented for both right and left palms for both control and exposed groups along with comparisons, in Tables XV, XVI, XVII and XVIII. Among male Hindus, d-t ridge-count of both

Table XII. Main line formulae

| Main line formulae | Hindu | | | | | | Christian | | | | | | χ^2 |
|--------------------|---------------|---------------|---------------|---------------|--------------|---------------|---------------|--------------|---------------|--------------|---------------|---------------|---------------------|
| | Control | | | Exposed | | | Control | | | Exposed | | | |
| | R | L | R+L | R | L | R+L | R | L | R+L | R | L | R+L | |
| <i>Male</i> | | | | | | | | | | | | | |
| 11,9,7,— | 16 (35.55) | 8 (17.78) | 24 (26.67) | 11 (55.00) | 2 (10.00) | 13 (32.50) | 14 (56.00) | 8 (32.00) | 22 (44.00) | 6 (42.86) | 5 (25.71) | 11 (39.29) | Hindu 3.2016 |
| 9,7,5,— | 8 (17.78) | 9 (20.00) | 17 (18.89) | 1 (5.00) | 6 (30.00) | 7 (17.50) | 5 (20.00) | 4 (16.00) | 9 (18.00) | 3 (21.43) | 2 (14.29) | 5 (17.86) | Christian 0.2407 |
| 7,5,5,— | 5 (11.11) | 6 (13.33) | 11 (12.22) | 5 (25.00) | 4 (20.00) | 9 (22.50) | 2 (8.00) | 5 (20.00) | 7 (14.00) | 1 (7.14) | 3 (21.43) | 4 (14.29) | |
| Rest | 16 (35.55) | 22 (48.80) | 38 (42.22) | 3 (15.00) | 8 (40.00) | 11 (27.50) | 4 (16.00) | 8 (32.00) | 12 (24.00) | 4 (28.57) | 4 (28.57) | 8 (22.57) | |
| <i>Female</i> | | | | | | | | | | | | | |
| 11,9,7,— | 13 (29.55) | 7 (15.91) | 20 (22.73) | 8 (38.10) | 9 (42.86) | 17 (40.48) | 7 (28.00) | 7 (28.00) | 14 (28.00) | 8 (33.33) | 5 (20.83) | 13 (27.08) | Hindu 5.9381 |
| 9,7,5,— | 7 (15.91) | 11 (25.00) | 18 (20.45) | 3 (14.29) | 1 (4.77) | 4 (9.52) | 2 (8.00) | 7 (28.00) | 9 (18.00) | 5 (20.83) | 10 (41.67) | 15 (31.25) | Christian 2.1991 |
| 7,5,5,— | 8 (16.18) | 9 (20.45) | 17 (18.32) | 2 (9.52) | 4 (33.33) | 9 (21.43) | 4 (16.00) | 6 (24.00) | 10 (20.00) | 2 (8.33) | 2 (8.33) | 4 (8.33) | |
| Rest | 16 (36.36) | 17 (38.64) | 33 (37.50) | 8 (38.10) | 4 (19.05) | 12 (28.57) | 12 (48.00) | 5 (20.00) | 17 (34.00) | 9 (37.50) | 7 (29.17) | 16 (33.33) | |

(*Probability at 5% level; NS=Non-significant)

Table XIII. Line D distribution

| D-line opening | Hindu | | | | | | Christian | | | | | | χ^2 |
|----------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------------|
| | Control | | | Exposed | | | Control | | | Exposed | | | |
| | R | L | R+L | R | L | R+L | R | L | R+L | R | L | R+L | |
| <i>Male</i> | | | | | | | | | | | | | |
| 11 | 25 (55.55) | 13 (28.88) | 38 (42.22) | 13 (65.00) | 5 (25.00) | 18 (45.00) | 15 (60.00) | 11 (44.00) | 26 (52.00) | 8 (57.14) | 6 (42.86) | 14 (50.00) | Hindu 0.9661 |
| 9 | 15 (33.33) | 23 (51.11) | 38 (42.22) | 2 (10.00) | 11 (55.00) | 13 (32.50) | 7 (28.00) | 9 (36.00) | 16 (32.00) | 4 (28.57) | 5 (35.71) | 9 (32.14) | Christian 0.0508 |
| 7 | 5 (11.11) | 9 (20.00) | 14 (15.55) | 5 (25.00) | 4 (20.00) | 9 (22.50) | 3 (12.00) | 5 (20.00) | 8 (16.00) | 2 (14.29) | 3 (21.43) | 5 (17.86) | |
| <i>Female</i> | | | | | | | | | | | | | |
| 11 | 18 (40.91) | 14 (31.82) | 32 (36.36) | 8 (38.10) | 9 (42.86) | 17 (40.48) | 9 (36.00) | 8 (32.00) | 17 (34.00) | 11 (45.83) | 7 (29.17) | 18 (37.50) | Hindu 0.7020 |
| 9 | 15 (34.09) | 21 (47.73) | 36 (40.91) | 9 (42.86) | 5 (23.81) | 14 (33.33) | 9 (36.00) | 9 (36.00) | 18 (36.00) | 10 (41.67) | 15 (62.50) | 25 (52.08) | |
| 7 | 11 (25.00) | 9 (20.45) | 20 (22.73) | 4 (19.05) | 7 (33.33) | 11 (26.19) | 7 (28.00) | 8 (32.00) | 15 (30.00) | 3 (12.50) | 2 (8.33) | 5 (10.41) | Christian 6.3649 |

(*Probability at 5% level; NS=Non-significant)

Table XIV. Patterns in various palmar regions

| Palmar patterns | Hindu | | | | | | Christian | | | | | | χ^2 |
|---------------------|---------|---------|---------|---------|---------|---------|-----------|---------|---------|---------|---------|---------|-----------|
| | Control | | | Exposed | | | Control | | | Exposed | | | |
| | R | L | R+L | R | L | R+L | R | L | R+L | R | L | R+L | |
| <i>Hypothenar :</i> | | | | | | | | | | | | | |
| <i>(Male)</i> | | | | | | | | | | | | | |
| Pattern | 13 | 15 | 28 | 5 | 8 | 13 | 9 | 19 | 18 | 5 | 4 | 9 | Hindu |
| | (28.89) | (33.33) | (31.11) | (25.00) | (40.00) | (32.50) | (36.00) | (36.00) | (36.00) | (35.71) | (28.57) | (32.14) | 0.024 |
| Open field | 32 | 30 | 62 | 15 | 12 | 27 | 16 | 16 | 32 | 9 | 10 | 19 | Christian |
| | (71.11) | (66.67) | (68.89) | (75.00) | (60.00) | (67.50) | (64.00) | (64.00) | (64.00) | (64.29) | (71.43) | (67.86) | 0.1180 |
| <i>(Female)</i> | | | | | | | | | | | | | |
| Pattern | 23 | 24 | 47 | 8 | 8 | 16 | 3 | 11 | 14 | 10 | 15 | 25 | Hindu |
| | (52.27) | (54.55) | (53.40) | (38.10) | (38.10) | (38.10) | (12.00) | (44.00) | (28.00) | (41.67) | (62.50) | (52.08) | 2.669 |
| Open field | 21 | 20 | 41 | 13 | 13 | 26 | 22 | 14 | 36 | 14 | 9 | 23 | Christian |
| | (47.73) | (45.45) | (46.51) | (61.90) | (61.90) | (61.90) | (88.00) | (56.00) | (72.00) | (58.55) | (37.50) | (47.92) | 5.9286 |
| <i>Thenar/I :</i> | | | | | | | | | | | | | |
| <i>(Male)</i> | | | | | | | | | | | | | |
| Pattern | 7 | 10 | 17 | 2 | 2 | 4 | 6 | 8 | 14 | 5 | 2 | 7 | Hindu |
| | (15.56) | (22.92) | (18.89) | (10.00) | (10.00) | (10.00) | (24.00) | (32.00) | (28.00) | (35.71) | (14.29) | (25.00) | 1.615 |
| Open field | 38 | 35 | 73 | 18 | 18 | 36 | 19 | 17 | 36 | 9 | 12 | 21 | Christian |
| | (84.44) | (77.78) | (81.11) | (90.00) | (90.00) | (90.00) | (76.00) | (68.00) | (72.00) | (64.29) | (85.71) | (75.00) | 0.0820 |
| <i>(Female)</i> | | | | | | | | | | | | | |
| Pattern | 5 | 11 | 16 | 5 | 2 | 7 | 2 | 1 | 3 | 4 | 3 | 7 | Hindu |
| | (11.36) | (25.00) | (18.18) | (23.81) | (9.52) | (16.67) | (8.00) | (4.00) | (6.00) | (16.67) | (12.00) | (14.58) | 0.0451 |
| Open field | 39 | 33 | 72 | 16 | 19 | 35 | 23 | 24 | 47 | 20 | 21 | 41 | Christian |
| | (88.64) | (75.00) | (81.82) | (76.19) | (90.48) | (83.30) | (92.00) | (96.00) | (94.00) | (83.35) | (87.50) | (85.42) | 1.969 |
| <i>II :</i> | | | | | | | | | | | | | |
| <i>(Male)</i> | | | | | | | | | | | | | |
| Pattern | 21 | 5 | 26 | 9 | 4 | 13 | 7 | 3 | 10 | 6 | 3 | 9 | Hindu |
| | (46.67) | (11.11) | (28.89) | (45.00) | (20.00) | (32.50) | (28.00) | (12.00) | (20.00) | (42.86) | (21.43) | (32.14) | 0.172 |
| Open field | 24 | 40 | 64 | 11 | 16 | 27 | 18 | 22 | 40 | 8 | 11 | 19 | Christian |
| | (53.33) | (88.89) | (71.11) | (55.00) | (80.00) | (62.50) | (72.00) | (88.00) | (80.00) | (57.14) | (72.57) | (67.56) | 1.436 |
| <i>(Female)</i> | | | | | | | | | | | | | |
| Pattern | 9 | 6 | 15 | 6 | 3 | 9 | 12 | 1 | 13 | 4 | 1 | 5 | Hindu |
| | (20.45) | (13.64) | (17.05) | (28.57) | (14.29) | (21.43) | (48.00) | (4.00) | (26.00) | (16.67) | (4.17) | (10.42) | 0.363 |
| Open field | 35 | 38 | 73 | 15 | 18 | 33 | 13 | 24 | 37 | 20 | 23 | 43 | Christian |
| | (79.55) | (86.36) | (82.95) | (71.43) | (85.71) | (78.57) | (52.00) | (96.00) | (74.00) | (83.33) | (95.83) | (89.58) | 0.220 |
| <i>III :</i> | | | | | | | | | | | | | |
| <i>(Male)</i> | | | | | | | | | | | | | |
| Pattern | 31 | 24 | 55 | 14 | 9 | 23 | 17 | 16 | 33 | 8 | 8 | 16 | Hindu |
| | (68.89) | (53.53) | (61.11) | (70.00) | (45.00) | (57.50) | (68.00) | (64.00) | (66.00) | (57.14) | (57.14) | (57.14) | 0.150 |
| Open field | 14 | 21 | 35 | 6 | 11 | 17 | 8 | 9 | 17 | 6 | 6 | 12 | Christian |
| | (31.11) | (46.67) | (38.89) | (30.00) | (55.00) | (42.50) | (32.00) | (36.00) | (34.00) | (42.86) | (42.86) | (42.86) | 0.603 |
| <i>(Female)</i> | | | | | | | | | | | | | |
| Pattern | 22 | 20 | 42 | 12 | 11 | 23 | 14 | 10 | 24 | 14 | 11 | 25 | Hindu |
| | (50.00) | (45.45) | (47.73) | (57.14) | (52.38) | (54.76) | (56.00) | (40.00) | (48.00) | (58.33) | (45.83) | (52.08) | 0.563 |
| Open field | 22 | 24 | 46 | 9 | 10 | 19 | 11 | 15 | 26 | 10 | 13 | 23 | Christian |
| | (50.00) | (54.55) | (52.27) | (42.56) | (47.62) | (45.24) | (44.00) | (60.00) | (52.00) | (41.67) | (54.17) | (47.92) | 0.163 |
| <i>IV :</i> | | | | | | | | | | | | | |
| <i>(Male)</i> | | | | | | | | | | | | | |
| Pattern | 34 | 40 | 74 | 14 | 18 | 32 | 18 | 21 | 39 | 12 | 12 | 24 | Hindu |
| | (75.56) | (88.89) | (82.28) | (70.00) | (90.00) | (80.00) | (72.00) | (84.00) | (78.00) | (85.71) | (85.71) | (85.71) | 0.090 |
| Open field | 11 | 5 | 16 | 6 | 2 | 8 | 7 | 4 | 11 | 2 | 2 | 4 | Christian |
| | (24.44) | (11.11) | (17.77) | (30.00) | (10.00) | (20.00) | (28.00) | (16.00) | (22.00) | (14.29) | (14.29) | (14.29) | 0.688 |
| <i>(Female)</i> | | | | | | | | | | | | | |
| Pattern | 34 | 38 | 72 | 15 | 16 | 31 | 21 | 23 | 44 | 16 | 18 | 34 | Hindu |
| | (77.27) | (86.36) | (81.82) | (71.43) | (76.19) | (73.81) | (84.00) | (92.00) | (88.00) | (66.67) | (78.00) | (70.85) | 1.108 |
| Open field | 10 | 6 | 16 | 6 | 5 | 11 | 4 | 2 | 6 | 8 | 6 | 14 | Christian |
| | (22.73) | (13.64) | (18.18) | (28.57) | (23.87) | (26.19) | (16.00) | (8.00) | (12.00) | (33.33) | (25.00) | (29.17) | 4.443 |

(*Probability at 5% level; NS=Non-significant, S=Significant)

Table XV. Interdigital ridge counts, angle atd and distance c-t
Male Palm (Hindu)

| Side | Variable | Control group Mean \pm S.E. Variance | Exposed group Mean \pm S.E. Variance | F-ratio | t-test |
|--------------|--------------|--|--|---------|--------|
| <i>Right</i> | | | | | |
| | a—b | 32.95 \pm 0.75 25.60 | 34.24 \pm 1.23 30.50 | 0.846 | 0.824 |
| | b—c | 24.31 \pm 0.86 33.75 | 22.24 \pm 0.89 15.92 | 2.120 | 1.543 |
| | c—d | 31.33 \pm 0.58 15.52 | 33.59 \pm 1.10 24.40 | 0.639 | 1.666 |
| | a—d | 69.41 \pm 1.49 100.20 | 70.18 \pm 2.46 121.00 | 0.828 | 0.246 |
| | d—t | 90.92 \pm 1.68 126.78 | 102.06 \pm 2.31 106.70 | 1.189 | 3.608* |
| | angle atd | 38.77 \pm 0.64 18.74 | 35.12 \pm 0.52 5.52 | 3.398* | 4.070* |
| | distance c—t | 7.59 \pm 0.13 0.82 | 8.01 \pm 0.03 0.16 | 5.035* | 2.406* |
| <i>Left</i> | | | | | |
| | a—b | 34.21 \pm 0.75 25.50 | 35.53 \pm 0.93 17.55 | 1.453 | 1.020 |
| | b—c | 23.29 \pm 0.85 32.60 | 23.12 \pm 0.89 15.84 | 2.053 | 0.432 |
| | c—d | 32.59 \pm 0.76 26.11 | 34.00 \pm 0.92 17.05 | 1.529 | 1.091 |
| | a—d | 72.10 \pm 1.32 78.32 | 68.00 \pm 1.97 77.61 | 1.010 | 1.601 |
| | d—t | 91.13 \pm 1.79 144.48 | 104.71 \pm 2.32 108.16 | 1.335 | 4.279* |
| | angle atd | 40.31 \pm 0.76 26.52 | 35.41 \pm 0.64 8.35 | 3.172* | 4.523* |
| | distance c—t | 7.46 \pm 0.12 0.74 | 8.07 \pm 0.10 0.20 | 3.667* | 3.426* |

(*denotes significance)

Table XVI. Interdigital ridge counts, angle atd and distance c-t
Female Palm (Hindu)

| Side | Variable | Control group Mean \pm S.E. Variance | Exposed group Mean \pm S.E. Variance | F-ratio | t-test | |
|--------------|--------------|--|--|---------------------------|--------|-------|
| <i>Right</i> | a-b | 34.38 \pm 0.67 20.07 | 33.91 \pm 1.04 23.04 | 0.874 | 0.382 | |
| | b-c | 24.67 \pm 0.83 30.91 | 23.59 \pm 0.95 19.18 | 1.613 | 0.849 | |
| | c-d | 31.55 \pm 0.75 24.90 | 34.91 \pm 1.10 25.80 | 0.965 | 2.529* | |
| | a-d | 76.41 \pm 1.21 64.48 | 72.55 \pm 2.45 126.11 | 0.511 | 1.432 | |
| | d-t | 92.35 \pm 1.50 99.00 | 96.86 \pm 3.45 249.95 | 0.396 | 1.217 | |
| | angle atd | 39.55 \pm 0.60 16.08 | 40.96 \pm 1.74 32.37 | 0.497 | 1.033 | |
| | distance c-t | 7.16 \pm 0.09 0.36 | 6.86 \pm 0.21 0.98 | 0.371 | 1.315 | |
| | <i>Left</i> | a-b | 35.00 \pm 0.82 29.70 | 35.65 \pm 0.80 13.61 | 2.186* | 0.039 |
| | | b-c | 24.52 \pm 0.77 26.11 | 24.55 \pm 0.80 13.61 | 0.973 | 0.016 |
| | | c-d | 33.79 \pm 0.75 25.00 | 35.39 \pm 1.30 35.76 | 0.699 | 1.211 |
| a-d | | 74.81 \pm 1.01 45.42 | 71.77 \pm 2.65 147.86 | 0.308 | 1.087 | |
| d-t | | 90.12 \pm 2.09 192.37 | 99.41 \pm 2.96 184.41 | 1.043 | 2.579* | |
| angle atd | | 41.62 \pm 0.72 23.23 | 41.05 \pm 1.22 31.69 | 0.653 | 0.396 | |
| distance c-t | | 6.97 \pm 0.11 0.60 | 6.85 \pm 0.19 0.82 | 0.736 | 0.544 | |

(*denotes significance)

Table XVII. Interdigital ridge counts, angle atd and distance c-t
Male Palm (Christian)

| Side | Variable | Control group Mean \pm S.E. Variance | Exposed group Mean \pm S.E. Variance | F-ratio | t-test |
|--------------|--------------|--|--|---------|--------|
| <i>Right</i> | | | | | |
| | a—b | 35.48 \pm 1.09 29.81 | 39.31 \pm 1.33 24.80 | 1.201 | 2.139* |
| | b—c | 24.39 \pm 1.25 39.18 | 24.92 \pm 1.45 29.59 | 1.327 | 0.266 |
| | c—d | 32.00 \pm 1.02 26.31 | 31.77 \pm 1.70 40.44 | 0.651 | 0.112 |
| | a—d | 73.48 \pm 1.92 92.73 | 65.31 \pm 2.54 90.25 | 1.027 | 2.467* |
| | d—t | 92.39 \pm 1.45 52.99 | 101.92 \pm 4.99 349.31 | 0.132 | 1.765 |
| | angle atd | 39.65 \pm 1.75 76.73 | 40.69 \pm 2.05 58.82 | 1.305 | 0.371 |
| | distance c—t | 7.90 \pm 0.14 0.54 | 7.55 \pm 0.33 1.53 | 0.353 | 0.906 |
| <i>Left</i> | | | | | |
| | a—b | 36.91 \pm 0.83 17.55 | 39.00 \pm 1.86 48.58 | 0.361 | 0.983 |
| | b—c | 24.83 \pm 1.12 31.47 | 25.31 \pm 1.27 22.84 | 1.378 | 0.273 |
| | c—d | 32.52 \pm 1.18 34.81 | 34.15 \pm 1.37 26.62 | 1.311 | 0.865 |
| | a—d | 77.30 \pm 1.65 68.06 | 69.54 \pm 2.12 63.36 | 1.073 | 2.773* |
| | d—t | 88.44 \pm 1.85 85.93 | 106.69 \pm 4.52 285.94 | 0.300 | 3.599* |
| | angle atd | 38.00 \pm 0.74 13.69 | 39.77 \pm 1.49 31.24 | 0.437 | 1.022 |
| | distance c—t | 7.94 \pm 0.17 0.79 | 7.62 \pm 0.26 0.98 | 0.812 | 0.966 |

(*denotes significance)

Table XVIII. Interdigital ridge counts, angle atd and distance c-t
Female Palm (Christian)

| Side | Variable | Control group Mean \pm S.E. Variance | Exposed group Mean \pm S.E. Variance | F-ratio | t-test |
|--------------|--------------|--|--|---------|--------|
| <i>Right</i> | | | | | |
| | a-b | 35.67 \pm 0.96 23.42 | 36.42 \pm 0.00 23.04 | 0.983 | 0.550 |
| | b-c | 25.92 \pm 1.29 41.60 | 24.96 \pm 0.00 23.91 | 1.741 | 0.587 |
| | c-d | 36.08 \pm 0.00 25.00 | 37.27 \pm 1.12 30.03 | 0.832 | 0.800 |
| | a-d | 80.00 \pm 1.54 59.29 | 74.19 \pm 1.83 80.64 | 0.735 | 2.460* |
| | d-t | 92.38 \pm 2.00 100.00 | 93.71 \pm 3.67 322.56 | 0.310 | 0.343 |
| | angle atd | 39.29 \pm 1.18 34.81 | 43.42 \pm 1.56 57.45 | 0.606 | 2.160* |
| | distance c-t | 7.01 \pm 0.16 0.70 | 6.67 \pm 0.22 1.25 | 0.566 | 1.206 |
| <i>Left</i> | | | | | |
| | a-b | 36.25 \pm 1.25 39.31 | 35.31 \pm 0.86 18.00 | 2.179* | 0.617 |
| | b-c | 23.71 \pm 1.34 45.02 | 24.31 \pm 0.58 18.31 | 2.462* | 0.373 |
| | c-d | 34.42 \pm 0.81 16.56 | 38.04 \pm 0.96 22.18 | 0.747 | 1.305 |
| | a-d | 78.21 \pm 2.06 106.70 | 72.77 \pm 1.70 69.88 | 1.525 | 2.223* |
| | d-t | 85.21 \pm 2.76 190.99 | 96.31 \pm 3.64 317.55 | 0.601 | 2.471* |
| | angle atd | 39.83 \pm 1.30 42.77 | 42.77 \pm 1.61 62.72 | 0.682 | 1.434 |
| | distance c-t | 6.89 \pm 0.18 0.88 | 6.77 \pm 0.22 1.88 | 0.736 | 0.439 |

(*denotes significance)

Table XIX. Values of coefficient of correlation between different dermatoglyphic variables

Male Hindu Palm

| | Right hand | | | | | | | Left hand | | | | | | |
|------------|------------|-------|-------|-------|-------|-------|--------------|-----------|-------|------|-------|-------|-------|--------------|
| | a-b | b-c | c-d | a-d | d-t | ∠atd | distance c-t | a-b | b-c | c-d | a-d | d-t | ∠atd | distance c-t |
| Right hand | | | | | | | | | | | | | | |
| a-b | | .176 | .169 | .391 | .117 | .209 | .123 | .462 | .179 | .530 | .297 | .141 | .037 | .101 |
| b-c | .618 | | .288 | .438 | -.041 | .121 | -.135 | -.001 | .511 | .100 | .261 | -.021 | .123 | -.172 |
| c-d | -.109 | -.058 | | .451 | .191 | .158 | -.031 | .288 | .306 | .414 | .444 | .169 | .025 | .135 |
| a-d | .218 | .689 | .097 | | .186 | .278 | .119 | .465 | .508 | .451 | .228 | .116 | .293 | .006 |
| d-t | -.016 | .399 | .004 | .593 | | -.293 | .430 | .052 | .088 | .172 | -.021 | .399 | -.055 | .301 |
| ∠atd | .439 | .361 | .126 | .202 | -.260 | | -.734 | .127 | -.080 | .099 | -.012 | -.245 | .416 | -.445 |
| c-t | .093 | .114 | .444 | .053 | .210 | -.512 | | .161 | .176 | .105 | .148 | .324 | -.244 | .593 |
| Left hand | | | | | | | | | | | | | | |
| a-b | .681 | .714 | -.115 | .519 | .422 | .400 | .069 | | .297 | .423 | .481 | .105 | .324 | -.021 |
| b-c | .452 | .797 | -.039 | .593 | .475 | -.014 | .340 | .536 | | .125 | .415 | .190 | .135 | .059 |
| c-d | -.067 | .100 | .765 | .159 | .328 | .073 | .427 | .088 | .043 | | .291 | .112 | .161 | .164 |
| a-d | .302 | .463 | .271 | .673 | .360 | .077 | .274 | .337 | .597 | .377 | | .213 | .026 | .178 |
| d-t | .322 | .419 | .065 | .382 | .447 | -.247 | .513 | .469 | .516 | .077 | .213 | | -.426 | .578 |
| ∠atd | .345 | .257 | -.066 | -.032 | .086 | .617 | -.404 | .536 | .053 | .128 | .078 | -.012 | | -.744 |
| c-t | -.192 | -.114 | .427 | -.002 | .124 | -.627 | .776 | -.267 | .299 | .321 | .133 | .307 | -.670 | |

Control group

Table XX. Values of coefficient of correlation between different dermatoglyphic variables

Exposed group

Female Hindu Palm

| | Right hand | | | | | | | Left hand | | | | | | |
|------------|------------|-------|-------|-------|-------|-------|--------------|-----------|-------|-------|-------|-------|-------|--------------|
| | a-b | b-c | c-d | a-d | d-t | ∠atd | distance c-t | a-b | b-c | c-d | a-d | d-t | ∠atd | distance c-t |
| Right hand | | | | | | | | | | | | | | |
| a-b | | .373 | .094 | .481 | .093 | .154 | .030 | .253 | .184 | -.248 | .531 | -.049 | .104 | -.026 |
| b-c | .304 | | -.499 | .290 | .000 | .016 | -.112 | .233 | .385 | -.171 | .302 | -.014 | .096 | -.017 |
| c-d | .365 | .403 | | .176 | .101 | .168 | .217 | .031 | -.130 | .164 | .168 | .129 | -.150 | .288 |
| a-d | .280 | .498 | .464 | | .028 | .324 | -.052 | .107 | .175 | -.076 | .544 | -.072 | .164 | .018 |
| d-t | .078 | .432 | .249 | .221 | | -.563 | .650 | .113 | .328 | .128 | .137 | .124 | -.185 | .327 |
| ∠atd | .376 | .174 | -.035 | .173 | .541 | | -.702 | -.122 | -.054 | -.089 | .150 | -.209 | .412 | -.317 |
| c-t | -.014 | .353 | .345 | .343 | .601 | -.718 | | .195 | .162 | .143 | .153 | .378 | -.376 | .628 |
| Left hand | | | | | | | | | | | | | | |
| a-b | .509 | .345 | -.094 | .192 | -.242 | .100 | .033 | | .352 | .277 | .410 | .181 | .060 | .167 |
| b-c | .295 | .740 | .054 | .483 | .198 | .050 | .154 | .435 | | .066 | .340 | .244 | .130 | .031 |
| c-d | .202 | -.034 | .624 | .074 | .305 | -.031 | .259 | -.335 | -.194 | | .003 | .272 | -.165 | .310 |
| a-d | .342 | .465 | .541 | .704 | .259 | -.302 | .559 | .164 | .402 | .437 | | .239 | .128 | .176 |
| d-t | .340 | .433 | .278 | .339 | .604 | -.492 | .637 | .165 | .365 | .195 | .498 | | -.330 | .549 |
| ∠atd | .267 | -.101 | -.035 | -.257 | .408 | .778 | .630 | .095 | -.106 | -.394 | -.394 | -.597 | | -.763 |
| c-t | -.044 | .105 | .315 | .321 | .441 | -.682 | .739 | -.118 | -.008 | .316 | .471 | .717 | -.866 | |

Control group

Exposed group

Table XXI. Values of coefficient of correlation between different dermatoglyphic variables

Male Christian Palm

| | | Right hand | | | | | | Left hand | | | | | | | |
|------------|------|------------|-------|-------|------|-------|-------|--------------|-------|-------|-------|-------|-------|-------|---------------|
| | | a-b | b-c | c-d | a-d | d-t | ∠atd | distance c-t | a-b | b-c | c-d | a-d | d-t | ∠atd | distance c-t |
| Right hand | a-b | | .023 | .310 | .151 | -.264 | .377 | -.043 | .555 | .105 | .176 | .226 | -.280 | .398 | -.206 |
| | b-c | .454 | | -.024 | .155 | -.071 | .270 | -.331 | .259 | .466 | .233 | .341 | -.049 | .318 | -.220 |
| | c-d | .376 | .374 | | .364 | .058 | .025 | .293 | .362 | -.028 | .385 | .362 | .018 | .086 | .155 |
| | a-d | .566 | .432 | .437 | | .370 | .226 | -.108 | .044 | .312 | .199 | .658 | .319 | .175 | -.003 |
| | d-t | -.193 | -.307 | .117 | .093 | | -.680 | .587 | -.243 | -.367 | .031 | -.030 | .555 | -.597 | .531 |
| | ∠atd | .519 | .345 | .105 | .179 | -.825 | | -.729 | .346 | .564 | .092 | .483 | -.265 | .819 | -.556 |
| | c-t | -.299 | -.303 | .115 | .051 | .860 | -.878 | | -.080 | -.392 | .062 | -.221 | .517 | -.673 | .801 |
| Left hand | a-b | .460 | .454 | .138 | .298 | -.074 | .232 | -.186 | | .160 | .213 | .413 | -.218 | .541 | -.198 |
| | b-c | -.084 | .468 | .405 | .258 | .162 | -.165 | .267 | .194 | | .160 | .543 | .136 | .502 | -.201 |
| | c-d | .393 | .451 | .466 | .508 | -.011 | .106 | -.014 | .140 | .148 | | .390 | .038 | .032 | .190 |
| | a-d | .337 | .600 | .440 | .786 | -.003 | .185 | -.017 | .305 | .620 | .284 | | .192 | .413 | -.170 |
| | d-t | -.270 | -.117 | .222 | .077 | .620 | -.711 | .698 | .004 | .451 | -.214 | .115 | | -.423 | .713 |
| | ∠atd | .435 | .210 | .010 | .110 | -.787 | .903 | -.764 | .081 | -.201 | .162 | .074 | -.781 | | -.757 |
| | c-t | -.251 | .172 | .153 | .010 | .753 | -.810 | .842 | .047 | .254 | -.095 | .028 | .798 | -.890 | Control group |

Table XXII. Values of coefficient of correlation between different dermatoglyphic variables

Female Christian Palm

Exposed group

| | | Right hand | | | | | | Left hand | | | | | | | |
|------------|------|------------|-------|-------|-------|-------|-------|--------------|-------|------|-------|-------|-------|-------|---------------|
| | | a-b | b-c | c-d | a-d | d-t | ∠atd | distance c-t | a-b | b-c | c-d | a-d | d-t | ∠atd | distance c-t |
| Right hand | a-b | | .113 | .304 | .166 | .236 | .234 | .154 | .370 | .226 | .471 | .399 | .143 | .237 | .208 |
| | b-c | .651 | | .507 | .579 | .201 | .238 | -.369 | .162 | .659 | .207 | .411 | -.126 | .013 | -.065 |
| | c-d | .415 | .197 | | .826 | .530 | .401 | -.235 | .133 | .538 | .600 | .683 | -.095 | .188 | -.099 |
| | a-d | .434 | .518 | .606 | | .661 | .295 | -.167 | .092 | .740 | .519 | .696 | .055 | -.007 | .134 |
| | d-t | .396 | .347 | .385 | .710 | | .135 | .194 | .215 | .531 | .458 | .590 | .367 | -.191 | .226 |
| | ∠atd | -.104 | -.213 | -.167 | -.320 | -.622 | | -.386 | .138 | .262 | .389 | .263 | -.219 | .211 | -.017 |
| | c-t | .467 | .373 | .584 | .687 | .772 | -.837 | | -.101 | .086 | -.061 | .003 | .601 | -.550 | .637 |
| Left hand | a-b | .753 | .537 | .097 | .055 | -.068 | .070 | .113 | | .092 | .325 | .170 | .141 | .421 | -.149 |
| | b-c | .665 | .507 | .691 | .717 | .418 | .206 | .317 | .333 | | .348 | .684 | .401 | -.399 | .545 |
| | c-d | .465 | .190 | .562 | .560 | .050 | .260 | .184 | .263 | .663 | | .576 | .148 | .179 | .099 |
| | a-d | .430 | .423 | .139 | .419 | -.035 | .390 | .159 | .426 | .475 | .498 | | .227 | .037 | .266 |
| | d-t | .577 | .305 | .668 | .609 | .496 | -.133 | .548 | .403 | .746 | .364 | .459 | | .443 | .653 |
| | ∠atd | -.058 | .307 | -.239 | -.236 | -.625 | .892 | -.786 | .124 | .204 | .327 | .263 | -.239 | | -.660 |
| | c-t | .478 | .239 | .616 | .572 | .675 | .729 | .940 | .111 | .327 | .170 | -.046 | .569 | -.758 | Control group |

Exposed group

Table XXIII. Results summarized : Significant differences between the control and exposed groups.

(A) *Qualitative traits*

(i) *Finger*

Frequency of whorl,
loop and arches : Christian male

(ii) *Palm*

Hypothenar patterns : Christian female
IV interdigital patterns : Christian female

(B) *Quantitative traits*

(i) *Finger*

Ridge count V finger : Hindu male (right hand)
Ridge count IV finger : Christian female (left hand)

(ii) *Palm*

Ridge count d—t : Hindu male (right & left hand)
: Christian female (left hand)
: Christian male (left hand)
: Hindu female (left hand)
Angle atd : Hindu male (right & left hand)
: Christian female (right hand)
Distance c—t : Hindu male (right & left hand)
Ridge count a—b : Christian male (right hand)
Ridge count a—d : Christian male (right & left hand)
: Christian female (right & left hand)
Ridge count c—d : Hindu female (right hand)

right and left palms is significantly higher in exposed group than in the control group. This has also subsequently reduced significantly the angle atd in the exposed group as compared to the control group. Among Hindu females though both palms continue to maintain high d-t ridge-counts in the exposed group, it reaches statistical significance (at 5% level of probability) only in the left palm. Instead, right palm of female Hindu control group shows significantly high c-d ridge count. Similarly, among

Christian males the exposed group shows high d-t ridge-count in both the palms, the difference being statistically significant only in the left palm. In male and female Christians the ridge-count a-d in both the palms is significantly high in control group, whereas the a-b ridge count of the right palm of Christian males is significantly high in the exposed group, and d-t is significantly low in control group among Christian females. Among Christian females the value of angle atd is lower in the control group, showing statistically significant difference in right palm.

The values of coefficients of correlation in different quantitative palmar dermatoglyphic variables in control and exposed groups among Hindu and Christian males and females are presented in Tables XIX, XX, XXI and XXII. Generally, a relationship was observed between these variables, but the differences between the control and exposed groups were not significant statistically.

From the above observations it may be inferred that Christian males show significant differences in the frequency of whorls, loops and arches. The ridge-count of the V finger of Hindu males and IV finger of Christian females is significantly lower in the exposed group (Table XXIII).

In palmar dermatoglyphics, the differences between control and exposed groups among Christian females are observed for patterns in hypothenar and IV interdigital areas. The ridge-count d-t of the right palm of Hindu males and left palm of Hindu and Christian males, as well as that of Hindu females shows significant differences. Angle atd is significantly different among Hindu males (both the palms) and Christian females (right palm), as given in Table XXIII.

Ridge-count a-b of the right palm is significantly different between exposed and control groups among Christian males, whereas, ridge-count a-d is significantly different in male and female Christians (both palms). Christian females also show significant differences in ridge-count d-t of the left palm. Ridge-count c-d is significantly different only in the left palm of Hindu females. Statistically greater magnitude of difference between control and exposed groups is observed among Hindu males and Christian females, and least among Hindu females.

Discussion

Ahuja *et al*⁸ observed that all six quantitative characters i.e. TFRC, a-b ridge-count, mainline index, pattern intensity index, c-t distance and angle atd showed lower variance among the exposed population. Apart from the assumption that the exposed population might have originated from a small group of related individuals and absence of subsequent gene flow, a more relevant explanation offered is the attribution of this low

variance to the background radiation in that area. In the present study a more detailed analysis has been done. While considering sexes separately and taking into consideration the bimanual differences, we have observed that the F-value discrepancies in control and exposed groups are not pronounced. In the present study, it has been observed that for the angle atd and distance c-t, the exposed groups exhibited low variances and significant F-values, when both the palms were treated separately as is also reported by Ahuja *et al.*³ With regard to a-b ridge-count this trend is observed only on the left palm, though, the F-ratio test does not indicate significant differences. Also, the exposed Hindu (female) show significantly lower variance on left hand only for a-b ridge count. Similar trends have been observed among exposed Christian (female) group with respect to a-b and b-c ridge-counts. In general, the pattern of values of variance is largely not uniform; however, our results give sufficient support to the claim that the chronic low level radiation could be a causative factor in decreasing the variances of certain quantitative characters.

In Table XXIII, the characters that differ significantly between control and exposed groups are listed and it has been observed that the significant differences are found for variables associated with the axial triradius. The sensitivity of triradius 't' to the intrinsic biological disturbances is well evident from the literature on clinical genetics and dermatoglyphics.^{10 20} Distally displaced axial triradius is observed in individuals with trisomy-21⁵, Trisomy-15,²⁵ Turner's Syndrome¹⁷, D/G translocation,²² short arm deletion of chromosome 5,¹⁵ anomalies of face, skeleton and male genitalia,²³ Holt-Oram Syndrome,¹⁰ congenital heart disease² and rubella infection.¹ In the present study, disturbances in the position of axial triradius are striking. Here the displacement is proximal, indicated by the high d-t ridge count (right and left palms of Hindu males, left palms of Christian males and females, and left palms of Hindu females), longer distance c-t (in right palm of Hindu males) and narrower angle atd (in Hindu males) among the exposed group, all the differences being statistically significant.

It may be inferred from the above discussion that the proximal displacement of the axial triradius may have its origin due to the effect of natural background radiation, the biological significance of which is yet to be understood.

References

- 1 Achs R, Harper RG and Seigel M. Unusual dermatoglyphic findings associated with rubella embryopathy. *New Engl J Med* 1966, 274 : 148.

- 2 Alter M and Schulenberg R. Dermatoglyphics in congenital heart disease. *Circulation* 1970, 49 : 49.
- 3 Ahuja YR, Sharma A, Nampoothiri KUK, Ahuja MR and Dempster ER Evaluation of high natural background radiation in some genetic traits in the inhabitants of monazite belt in Kerala, India. *Hum Biol* 1973, 49 : 167.
- 4 Barcinski MA, Abreu MC, de Almeida JCC, Naya JM, Fonseca LG and Castro LE. Cytogenetic investigation in a Brazilian population living in an area of high natural radioactivity. *Amer J Hum Genet* 1975, 27 : 802.
- 5 Beckman L, Gustavson KH and Noring A. Dermal configurations in the diagnosis of the Down's syndrome : An attempt at a simplified scoring method. *Acta Genet (Basel)* 1965, 15 : 3.
- 6 Bharatwal DA and Vaze GH. Radiation dose measurements in the monazite areas of Kerala State in India. *Proc II Conf on Peaceful uses of Atomic Energy* 1958, 23 : 156.
- 7 Buzzati-Traverso AA and Scossiroli RE. X-ray induced mutations in polygenic systems: *Proc II Int Conf on Peaceful uses of Atomic energy* 1958, 22 : 293.
- 8 Clayton G and Robertson A. Mutation and quantitative variation. *Amer Nat* 1955, 89 : 151.
- 9 Cummins H and Midlo C. *Finger Prints, Palms and Soles. An Introduction to Dermatoglyphics*. New York : Dover Publications, 1961.
- 10 Gall JC, Stern AM, Cohen MM, Adams MS and Davidson RT. Holt-Oram Syndrome : A clinical and genetic study of a large family. *Amer J Hum Genet* 1966, 18 : 187.
- 11 Gopal Ayengar AR. Possible areas with sufficiently different background radiation levels to permit detection of differences in mutation rates of marker genes. *WHO Tech Report Series No. 166, Geneva. 1957; 115-124.*
- 12 Gopal Ayengar AR, Sundaram K, Mistry KB, Sunta CM, Nambi KSU and Kathuria SP. Evaluation of long term effects of high background radiation on selected population groups on Kerala coast. In : *Peacefulness of Atomic energy (Vol. 2)*. United Nations IAE views, 1972.
- 13 Grewal MS, Kochupillai N, Verma IC, Singh IP and Ramalingaswami V. Genetic effects of high natural radioactivity in South India. *Proc Int Conf Hum Genet (Mexico)*. 1976.
- 14 Grueneberg H, Bains GS, Berry RJ, Riles L, Smith CAB and Weiss RA. A search for genetic effects of high natural radioactivity in South India. *Med. Res Council Special Report Series No. 307 (H.M.S.O. London), 1966.*
- 15 Hijmans JC and Shearin DB. Partial deletion of short arms of Chromosome No. 5. *Amer J Dis Child* 1965, 109 : 85.
- 16 Holt SB. *The Genetics of Dermal Ridges*. Springfield : Charles C Thomas, 1968.
- 17 Holt SB and Lindsten J. Dermatoglyphic anomalies in Turner's Syndrome : *Ann Hum Genet* 1964, 28 : 87.
- 18 Kochupillai N, Tangavelu M and Ramalingaswami V. Nodular lesions of the thyroid in an area of high background radiation in coastal Kerala, India. *Ind J Med Res* 1976, 64 : 537.
- 19 Kochupillai N, Verma IC, Grewal MS and Ramalingaswami V. Down's syndrome and related abnormalities in an area of high background radiation in coastal Kerala. *Nature* 1976, 262 : 60.
- 20 Penrose LS. The distal triradius 't' on the hands of parents and sibs of Mongol imbeciles. *Ann Hum Genet* 1954, 19 : 10.

- 21 Penrose LS. Memorandum on dermatoglyphic nomenclature. Birth Defects Original Article Series 1960, *IV* : 3.
- 22 Penrose LS and Delhanty JPA. Familial Langdon-Down anomaly with chromosomal fusion. Amer J Hum Genet 1961, *25* : 243.
- 23 Pinsky L and diGeorge AM. A familial syndrome of facial and skeletal anomalies associated with genetical abnormality in male and normal genitals in female. J Pediat 1965, *66* : 1049.
- 24 Ponnunni Kartha KI. Background radiation in the coastal monazite areas of Kerala (S. India). Hlth Physics 1968, *15* : 368.
- 25 Uchida IA, Patau K and Smith DW. Dermal patterns in 18-and D_1 -trisomics. Amer J Hum Genet 1962, *14* : 345.
- 26 Verma IC and Singh IP. Down's Syndrome in India. Lancet 1975, *I* : 1200.
- 27 WHO : Effects of radiation on human heredity. Investigation of areas of high, natural background radiation. I. Report of Expert Committee on Radiation. WHO Tech. Report Series No. 166, 1959.

Dr M.K. Bhasin
Department of Anthropology
Delhi University
Delhi 110 007 India