

Digital formulae of hands and feet in Indian Populations

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The differentiation of digital formulae was investigated taking into account the tribe and caste differentiation. The aim of the studies was a better investigation of the population genetics of Indian sub-continent.

Human hands and feet can be classified into three categories, each depending on the relative length of first toe over second in feet and second finger over fourth in hands [BAKER 1888, WOOD JONES 1941, 1949; HUIZINGA 1944]. Occasionally toe III can be the largest [HAWKES 1914, WOOD JONES 1949]. Precisely, digital formula is a numerical statement expressing the relative forward expression of the tips of digits when hand or foot is laid flat on the surface and the scale maintained in the long axis of the limb [WOOD JONES 1949].

HAWKES [1914] suggested irregular dominance of type $1 > 2$ over $1 < 2$ in males, and dominance of type $1 < 2$ in females, showing the autosomal inheritance of the trait with sex influence. KAPLAN [1963, 1964] showed

a goodness of fit of the frequencies of observed and expected genotypes by calculating gene frequencies on the assumption of random mating and recessiveness of the longer first toe, thereby concluding that longer toe II is due to a simple autosomal dominant gene. However, MUKHERJEE and RAO [1976] questioned the conclusiveness of the mathematical analysis. They observed additive inheritance with sex influence for the quantitative grades of the trait. For relative length of fourth finger over second PHELPS [1952] postulated autosomal inheritance with sex influence. DAS and MUKHERJEE [1962] emphasised the necessity of having a straight axis and using quantitative measurements in the genetic analysis of the trait. MUKHERJEE and RAO [1975] could not find linkage between the digital formulae of hands and feet in the family series of Pattusali, instead suggested pleiotropic genes for

pairs of hands, feet, and hands and feet of opposite side.

Though the inheritance of the traits in question is highly probable, the exact mode of inheritance is not clear. The influence of age, sex and bilaterality has further complicated the issue [HAWKES 1914; HUIZINGA, VETTEN 1967]. The traits exhibit significant differences between different ethnic groups of the world studied up to now [S. R. DAS 1954]. Except for a few studies from Assam, there are hardly any studies from other parts of India. In view of the complexity of the genetics of the traits and at the same time their ability to show marked differences between populations, a systematic observation of the occurrence of the traits in the Indian populations is recommended with the care to mention age, sex, symmetrical and asymmetrical combinations, with a proper description of the population, its place of origin, at least with the mention of the district place.

For further genetic analyses of the traits, quantification with more objectivity and attempts at linkage analyses with marker genes might be of much help.

Variability in the Indian populations

Data are now available from 7 caste and 6 tribal groups for pes digital formula, and 15 caste and 6 tribal groups for manus digital formula in the Indian sub-continent. Table 1 and 2 show the percent frequency

of the traits in different Indian populations studied. The type $1 > 2$ of pes digital formula of males varies from 69.6% to 91.1% and 33.5% to 90.7%, in tribe and caste populations respectively. For females variability is from 77.4% to 82.5% in tribes and 43.1% to 88.9% in castes. The low frequencies are reported for Mallia of Orissa. The marked differences in the occurrence of the trait in Mallia when compared to other populations might be due to the small effective size of the population [SAHU 1976]. If we ignore the frequencies of Mallia, there are no marked differences between sexes and between tribes and castes in the extent of variability of the trait. All populations of both sexes mark higher frequencies of $1 > 2$ types in comparison to other two types. The right feet of the most populations show lower frequencies of the type $1 > 2$ than the left ones.

The $4 > 2$ type of the manus digital formula shows higher frequencies than the others in all caste populations except Bengalee population where the $4 < 2$ is more frequent. In tribal populations, except Kodaku, Pando and Nagesia, others report comparatively high frequencies of type $4 < 2$. The range of variability in all populations (taking both hands into consideration) is 12.5% to 73.8%. The occurrence of type $4 > 2$ is more common in left hands than right in most of the populations, whereas the $4 < 2$ type shows the reverse trend.

Despite the marked variability, the clusterings of populations found in the material are not meaningful when ethnicity of the populations is taken into consideration.

Table 1. Pes digital formula in Indian populations

| State | Population | Sex | Side | N | 1>2 | 1=2 | 1<2 | Ref. | |
|--------------------|------------|-----|------|-------|-------|-------|-------|------------------|--------------------|
| Caste populations | | | | | | | | | |
| Andhra | Pattusali | M | R | 141 | 59.57 | 29.08 | 11.35 | RAO [1974] | |
| | | | L | 141 | 65.25 | 26.95 | 7.80 | | |
| | | F | R | 131 | 52.67 | 39.69 | 7.63 | | |
| | | | L | 131 | 64.88 | 30.53 | 4.58 | | |
| Orissa | Mallia | M | R | 352 | 33.52 | 42.89 | 23.58 | SAHU [1977] | |
| | | | L | 352 | 32.38 | 44.32 | 23.29 | | |
| | | F | R | 290 | 43.10 | 43.10 | 13.79 | | |
| | | | L | 290 | 42.41 | 45.17 | 12.41 | | |
| Assam | Hira | M | R | 76 | 85.52 | 11.84 | 2.63 | DAS & DAS [1967] | |
| | | | L | 76 | 92.10 | 3.94 | 3.90 | | |
| | | F | R | 105 | 86.66 | 3.80 | 9.52 | | |
| | | | L | 105 | 88.57 | 5.70 | 5.70 | | |
| | Kalitha | M | R | 130 | 90.70 | 1.50 | 7.60 | P.B. DAS [1970] | |
| | | | L | 130 | 93.80 | 5.30 | 0.80 | | |
| | | F | R | 345 | 87.50 | 6.10 | 6.30 | | |
| | | | L | 345 | 90.70 | 4.60 | 4.60 | | |
| | Kaibarta | M | R | 87 | 81.60 | 5.70 | 12.60 | | |
| | | | L | 87 | 89.60 | 1.10 | 9.10 | | |
| | | F | R | 118 | 88.10 | 5.10 | 6.10 | | |
| | | | L | 118 | 88.90 | 6.70 | 4.20 | | |
| Vaishya | M | R | 108 | 84.20 | 4.60 | 11.10 | | | |
| | | L | 108 | 85.10 | 9.20 | 5.50 | | | |
| | F | R | 53 | 83.00 | 7.50 | 9.40 | | | |
| | | L | 53 | 86.80 | 3.70 | 9.40 | | | |
| Brahmin | M | R | 71 | 85.90 | 7.00 | 7.00 | | | |
| | | L | 71 | 81.60 | 8.40 | 9.80 | | | |
| | F | R | 154 | 88.90 | 3.90 | 7.70 | | | |
| | | L | 154 | 87.00 | 4.50 | 8.40 | | | |
| Tribal populations | | | | | | | | | |
| Assam | Khasi | M | R | 56 | 91.07 | 0.00 | 8.92 | DAS & DAS [1967] | |
| | | | L | 56 | 83.92 | 10.70 | 5.35 | | |
| | | F | R | 62 | 77.41 | 14.51 | 8.06 | | |
| | | | L | 62 | 75.80 | 16.12 | 8.06 | | |
| | Mikir | M | R+L | 120 | 80.40 | 10.80 | 8.70 | | |
| | | F | R+L | 100 | 82.50 | 3.90 | 13.30 | | |
| | Rabha | M | R+L | 300 | 69.60 | 13.80 | 16.50 | | DAS & VIZIR [1959] |
| | | F | R+L | 300 | 72.60 | 9.00 | 18.30 | | |
| Orissa | Juang | M | R+L | 43 | 91.86 | 4.65 | 3.49 | SARKAR [1958] | |
| Bihar | Oraon | M | R+L | 44 | 93.18 | 1.14 | 5.68 | | |
| | | M | R+L | 45 | 81.11 | 5.56 | 13.33 | | |
| | Mundari | F | R+L | 9 | 83.33 | 5.56 | 11.11 | | |
| | | M | R+L | 29 | 79.31 | 8.62 | 12.07 | | |

Table 2. Manual digital formula in Indian populations

| State | Population | Sex | Side | N | 4 > 2 | 4 = 2 | 4 < 2 | References | |
|--------------------|-------------|-----|-------|-------|-------|-------|-------|-------------------------|-----------------------|
| Caste populations | | | | | | | | | |
| Kerala | Izhavas | M | R | 50 | 44.00 | 38.00 | 18.00 | MALHOTRA & BHANU [1967] | |
| | | | L | 50 | 40.00 | 46.00 | 14.00 | | |
| | | F | R | 50 | 64.00 | 28.00 | 8.00 | | |
| | | | L | 50 | 60.00 | 28.00 | 12.00 | | |
| Andhra | Pattusali | M | R+L | 329 | 56.84 | 27.05 | 16.11 | MUKHERJEE & RAO [1975] | |
| | | F | R+L | 265 | 55.47 | 26.04 | 18.49 | | |
| Maharashtra | Jains Oswal | M | R | 200 | 53.00 | 34.00 | 13.00 | GANDHI [1977] | |
| | | | L | 200 | 63.50 | 27.50 | 9.00 | | |
| | Jains Oswal | M | R | 140 | 52.14 | 22.14 | 25.72 | | |
| | | | L | 140 | 61.43 | 21.43 | 17.14 | | |
| | Jains | M | R | 300 | 64.67 | 25.00 | 10.33 | | |
| | | | L | 300 | 61.57 | 28.33 | 10.00 | | |
| | Jains | M | R | 100 | 54.00 | 35.00 | 11.00 | | |
| | | | L | 100 | 56.00 | 35.00 | 9.00 | | |
| | Jains | M | R | 150 | 38.00 | 46.00 | 16.00 | | |
| | | | L | 150 | 42.67 | 41.33 | 16.00 | | |
| Uttar Pradesh | Brahmins | M | R | 240 | 60.80 | 17.10 | 22.10 | VERMA [1956] | |
| | | | L | 240 | 78.80 | 6.60 | 14.60 | | |
| | Rajpute | M | R | 123 | 50.40 | 22.80 | 26.80 | | |
| | | | L | 123 | 72.40 | 8.90 | 18.70 | | |
| | Ahirs | M | R | 129 | 66.80 | 14.60 | 18.60 | | |
| | | | L | 129 | 79.80 | 10.80 | 9.40 | | |
| | Pasis | M | R | 61 | 60.70 | 18.00 | 21.30 | | |
| | | | L | 61 | 86.90 | 3.30 | 9.80 | | |
| | Muslims | M | R | 106 | 64.20 | 18.90 | 16.90 | | |
| | | | L | 106 | 78.30 | 10.40 | 11.30 | | |
| | Ramgarhias | M | R+L | 150 | 76.66 | 18.66 | 4.66 | | SINGH & BANSAL [1975] |
| | | | F | R+L | 150 | 62.33 | 23.33 | | |
| Orissa | Mallia | M | R | 350 | 46.86 | 50.86 | 2.28 | SAHU [1977] | |
| | | | L | 350 | 47.14 | 51.14 | 1.71 | | |
| | | F | R | 290 | 34.48 | 60.00 | 5.52 | | |
| West Bengal | Bengalees | M | R | 95 | 28.42 | 20.00 | 51.58 | S.R. DAS [1954] | |
| | | | L | 95 | 27.37 | 16.84 | 55.79 | | |
| | | F | R | 144 | 11.11 | 15.28 | 73.62 | | |
| | | | L | 144 | 13.89 | 17.37 | 68.75 | | |
| Tribal populations | | | | | | | | | |
| Tamil Nadu | Paniyan | M | R | 165 | 30.31 | 19.99 | 49.70 | S.R. DAS [1954] | |
| | | | L | 165 | 35.15 | 20.60 | 44.25 | | |
| | | F | R | 51 | 37.25 | 19.60 | 43.13 | | |
| | | | L | 51 | 33.33 | 33.33 | 33.33 | | |
| | Kurumbans | M | R | 58 | 27.59 | 12.86 | 60.35 | | |
| | | | L | 58 | 32.76 | 18.97 | 48.27 | | |
| | | F | R | 25 | 24.00 | 32.00 | 44.00 | | |
| | | | L | 25 | 36.00 | 16.00 | 48.00 | | |
| Adians | M | R | 35 | 37.14 | 28.57 | 34.29 | | | |
| | | L | 35 | 45.47 | 22.86 | 31.43 | | | |
| Madhya Pradesh | Kodaku | M | R+L | 114 | 64.91 | 0.00 | 35.09 | BANERJEE & DHAR* | |
| | | | Pondo | R+L | 122 | 60.66 | 0.00 | | 39.34 |
| | Nagesia | M | R | 101 | 66.34 | 21.78 | 11.88 | | |
| | | | L | 101 | 64.36 | 23.76 | 11.88 | | |

* Personal communication

Summary and conclusions

Type 1 > 2 of pes digital formula shows highest frequencies in all populations studied, including both tribes and castes. With regard to manus digital formula 4 > 2, there is a demarcation between tribes and castes, the exception being the Madhya Pradesh tribes and the Bengalees. Sex and bilateral differences seem to exist for these traits. For a better understanding of the population genetics of digital formulae, more data are needed for the Indian populations. Objective quantitative measurements might be of much use in the analysis of these traits.

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S t r e s z c z e n i e

FORMUŁY PALCÓW RĄK I STÓP W POPULACJACH INDII. Poza kilkoma opracowaniami dotyczącymi Asamu niewiele jest prac na temat formuł palców u mieszkańców Indii. Udział czynnika dziedzicznego w zróżnicowaniu tych cech wydaje się znaczny, choć niejasny jest sposób dziedziczenia.

Na podstawie dostępnych materiałów stwierdzono, że formuła palców ręki $4 < 2$ na terenie Indii wykazuje zwiększoną częstotliwość w populacjach o charakterze plemiennym. Formuła palców stopy nie wykazuje zróżnicowania międzykastowego i międzyplemiennego. Dalsze systematyczne badania, z uwzględnieniem płci, wieku, lateralizacji oraz pochodzenia grup (co najmniej terytorialnego) pozwolą lepiej zrozumieć genetykę populacyjną omawianych cech u ludności subkontynentu indyjskiego.