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# Sex Difference and Inheritance Pattern of the Relative Difference of the 2nd and 4th Digits of Port Harcourt, Nigeria.

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## ABSTRACT

The physical appearance of the difference in the index and ring finger has been associated with hormonal levels and sex. This study, therefore, evaluates the sex difference and heritability of the relative difference in the 2nd and 4th digits among families living in Port Harcourt. This research was designed as an observational, cross-sectional study involving 336 subjects comprising of 101parents and 135 offspring, obtained from 101 families within Port Harcourt, Rivers State. The second (2D; index finger) and fourth (4D; ring finger) digits were observed for relative difference in length; 2D<4D was noted as "$S_{IF}$ (shorter index finger)", and 2D>4D noted as "$L_{IF}$ (longer index finger)". The difference was determined by direct measurement using the digital vernier calliper (with an accuracy of 0.01mm), with a mathematical calculation (length of 2D minus 4D). The patterns were tabulated as family data and the parental combinations were highlighted to reflect offspring inheritance. XLSTAT (version 2015.4.01) Chi-square analysis (test) was used for association between sex and the difference in 2D & 4D at 0.05 significance level. While Mendelian Chi-square distribution modeltested the conformance to dominant-recessive inheritance. Parental and offspring allele frequency distribution were compared using Hardy Weinberg (H-W) equation. The analysis showed that 92.3% of the population had shorter index finger ($S_{IF}$) compared to the 7.7% of the population with longer index finger $L_{IF}$. There was no sex associated difference in the distribution ($\chi^2_{[df=2]}$=1.659, $P$=0.436).The results from the parental and offspring pattern suggest that 2D:4D ratio is inherited.The Mendelian test of association suggest that the assumption of index finger inheritance in a dominant-recessive fashion. This was further strengthened by the result from the H-W calculations, which showed conformity of the offspring allele distribution (5:4:1) to that of the parents (5:4:1). The distribution of the difference in 2nd to 4th digit favoured the shorter index finger; without sexual preference. The conformity of the trait to the Mendelian simple dominant dominant-recessive inheritance was strengthened by the H-Wcalculation outcome which suggested a uniform pattern for the offspring and parent.

**Keywords:** 2D:4D, sexual variation, Mendelian inheritance, dominant, recessive, Nigerians.

## INTRODUCTION

There have been extensive studies on the index (2nd) and ring (4th) fingerin medical science and anthropology. The index finger which is also called the pointer finger, trigger finger o r*digitussecondus*(*digitus II*), is the first finger and the second digit of a human hand.[3] It is located between the thumb and the middle finger and usually the most dexterous and sensitive finger of the hand.[3] It has been shown that men have relatively shorter index finger than the ring finger(96-97% the length of the ring finger in males and 97-98% the length of the ring finger in females).[4] Menwith more masculine finger ratio tend to perform better in several physical activities and sports.[1-3,5]

Twin studies using genetic models found that the 2D:4D ratio is heritable (h2: 50–80%).[6-8] Warrington[9] in a small genome-wide association study (GWAS) of 2D:4D ratio reported that two loci influence the variation in the trait. The ratio of the index/ring finger was reported to be significantly correlated between pairs oftwins, and the correlation was stronger for monozygotic twins than for dizygotic twins.Heritability was estimated to be about 66%, which indicates that there is some genetic basisfor the variation in this ratio.[10]While the minor allele (A) at rs314277 in LIN28B is associated with increased 2D:4D ratio, the minor allele (T) at the second locus, rs4902759 in SMOC1, is associated with decreased 2D:4D ratio. The SNP lies near the SMOC1 gene, which is known to regulate bone growth and has been hypothesized to control finger length growth. Independent studies have suggested that the activity of the SMOC1 gene is controlled by testosterone and oestrogen levels.[9,11]

Most recent researches focused on the hormonal,[1,12] physical,[13] and behavioural[5] implications, and diseases predisposition[14]of the 2D:4D ratio in relation to sex. From the review, the study observed that previous researches on the relative difference in 2nd to 4thdigit have not given much attention to accessing its pattern of inheritance. This study, therefore, evaluated the sexvariation in the relative difference in 2ndand 4th digits and its hereditary conformance to Mendelian dominant-recessive inheritance of pattern.

## MATERIALS AND METHODS

**Study design:** The research was designed as a family-based observational cross-sectional study of the inheritance pattern of the relative difference in length between the index finger (2D) and ring finger (4D).

**Sample size and sampling:** The study randomly selected one hundred and one (101) volunteer families of Nigerian descent, who reside in Port Harcourt, comprising of 101 parents (father and mother) and 135 children (68 sons and 67 daughters).

**Exclusion criteria:** Families that were incomplete, that is; single parents or no child, complete families but signs of damaged digit or digits, digits with signs of surgical intervention, and families with a history of foreign descent were excluded from the study.

**Data collection: Morphogenetic details -** The morphometric difference in length of the second (2D; index finger) and fourth (4D; ring finger) digits were determined by direct measurement using the digital vernier calliper(with an accuracy of 0.01mm) and excel sheet was used to mathematically evaluate the difference (length of 2D minus the length of 4D). The offspring traits were tabulated alongside the parents and patterns of parental combinations highlighted to reflect offspring inheritance (that is; the offspring trait when both parents had $S_{IF}$, $L_{IF}$, and a combination of $S_{IF}$ and $L_{IF}$.

**Index finger length:** The relative difference in the index finger length was observed and the result classified (fig 1) into;

a. longer (positive difference; $L_{IF}$)
b. Shorter (negative difference; $S_{IF}$)

**Ethical Consideration**: The study was conducted in accordance with the Helsinki's declaration regarding the participation of humans in research. Ethical clearance was obtained from the College Research Ethics Committee of the University of Port Harcourt, while written informed consent were obtained from the participating families.

**Data analysis:** The pattern was presented as family distribution (a single group of traits). The possible parental combinations were documented, with the offspring grouped from this combination. XLSTAT version 2015.4.01 was used to analyse the data, with the confidence level set at 95%.

Chi-square analysis was used test for association between sex and the morphogenetic trait distribution, while Mendelian Chi-square gene distribution model was used to test conformance to dominant-recessive inheritance pattern. Hardy Weinberg (H-W) equation for allele frequency distribution was used to compare parental allele frequency to that of the offspring.

## RESULTS

The sex-associated difference in the distribution of the index and ring finger patterns were presented in Table 1. The morphogenetic traits distribution for the offspring for trait combinations in parents (when both parents are assumed dominant for the trait, recessive and a combination dominant and recessive) presented in Tables 2a. Table 2b presents the mendelian chi-square analysis for distribution in offspring.

The assumption for the chi-square is that the alleles are either dominant or recessive or a combination of both following Mendelian laws and crosses. The comparison of the genotypic allele distribution for the index finger (F) of the parents using the H-W equation was presented in Table 3 and the summary of the outcome in Table 4.

In Table 1, 163 (48.4%) males have shorter index finger length ($S_{IF}$) as against 14 males representing 4.2% who have longer index finger length ($L_{IF}$), while 148 females (43.9%) had shorter index finger length ($S_{IF}$) as against 12 (3.6%) who have longer index finger length ($L_{IF}$). Population distribution of shorter index finger length ($S_{IF}$) is 92.3% (311) while longer index finger length ($L_{IF}$) is 7.7% (26) (Table 4.6). There was no sex-associated difference in index finger pattern distribution $P$=0.436).The heterozygous dominant allele constituted 40% of the total allele for the parental gene and 41% of offspring gene for index finger length (Table 3). The determined allele proportion revealed the same ratio (5:4:1) for both the parents and offspring (Table 4).

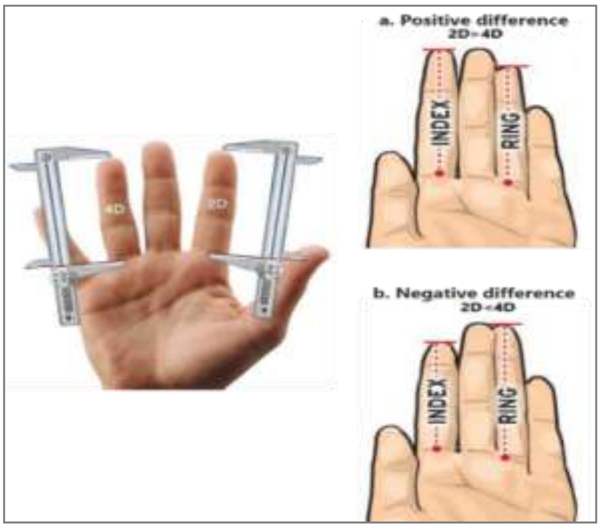


**Figure 1:** Measurement and pattern categorisation of the difference in 2nd (2D) and 4th (4D) digits.

**Table 1:** Distribution of index finger length among the study population and sex-associated difference

| Group | Index finger length | | Chi-square analysis (M vs F) | | |
|---|---|---|---|---|---|
| | LIF | SIF | df | χ2-cal | p-value |
| Father | 9 (8.9) | 92 (91.1) | | | |
| Son | 5 (7.4) | 63 (92.6) | | | |
| | | | | | |
| Males | 14 (8.3) | 155 (91.7) | 2 | 0.022 | 0.888 |
| Females | 12 (7.1) | 156 (92.9) | | | |
| | | | | | |
| Mother | 6 (5.9) | 95 (94.1) | | | |
| Daughter | 6 (9.0) | 61 (91.0) | | | |
| | | | | | |
| TOTAL | 26 (7.7) | 311 (92.3) | | | |

**Table 2a:** The Frequency, percentage, and distribution of index-finger length with respect to the parental combination

| Parents index-finger length Combinations | Total number of Offspring | | | Male Offspring | | | Female Offspring | | |
|---|---|---|---|---|---|---|---|---|---|
| | $L_{IF}$ | $S_{IF}$ | Total | $L_{IF}$ | $S_{IF}$ | Total | $L_{IF}$ | $S_{IF}$ | Total |
| Long index finger in both parents | 5 (83%) | 1 (17%) | 6 | 2 | 0 | 2 | 3 | 1 | 4 |
| Exp. outcome (if Long index finger is dominant) | 5 | 1 | (4%) | | | | | | |
| Exp. outcome (if Short index finger is dominant) | 0 | 6 | | | | | | | |
| Short index finger in both parents | 4 (3%) | 119 (97%) | 123 | 2 | 58 | 60 | 2 | 61 | 63 |
| Exp. outcome (if Long index finger is dominant) | 0 | 123 | (91%) | | | | | | |
| Exp. outcome (if Short index finger is dominant) | 30.75 | 92.25 | | | | | | | |
| Long in father and Short in mother | 2 (40%) | 3 (60%) | 5 | 1 | 2 | 3 | 1 | 1 | 2 |
| Exp. outcome (if Long index finger is dominant) | 2.5 | 2.5 | (4%) | | | | | | |
| Exp. outcome (if Short index finger is dominant) | 2.5 | 2.5 | | | | | | | |
| Short in father and long in mother | 0 (0%) | 1 (100%) | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| Exp. outcome (if Long index finger is dominant) | 0.5 | 0.5 | (1%) | | | | | | |
| Exp. outcome (if Short index finger is dominant) | 0.5 | 0.5 | | | | | | | |
| Total | 11 (8%) | 124 (92%) | 135 | 5 | 60 | 65 | 6 | 64 | 70 |

**Table 2b:** Mendelian chi-square test for the frequency of index-finger Length pattern (expected to the observed outcome)

| Parents index-finger Length Combinations | If $L_{IF}$ is dominant | | | If $S_{IF}$ is dominant | | |
|---|---|---|---|---|---|---|
| | Calculated | Critical | Inference | Calculated | Critical | Inference |
| Long index finger in both parents | 0.222 | 3.841 | Insignificant* | 0.167 | 3.841 | Insignificant |
| Short index finger in both parents | 0.130 | 3.841 | Insignificant* | 7.757 | 3.841 | Significant |
| Long in father and Short in mother | 3.267 | 3.841 | Insignificant* | 0.450 | 3.841 | Insignificant |
| Short in father and long in mother | 1.500 | 3.841 | Insignificant* | 0.250 | 3.841 | Insignificant |

** More insignificance with lower p-value observed for $L_{IF}$; therefore, it can be stated that the long index finger is dominant over the short index finger.*

**Table 3:** Parental and offspring allele frequency determination for the index length difference

| Gene | Allele distribution | Parent | | Offspring | |
|---|---|---|---|---|---|
| | | Proportion (%) | Total allele | Proportion (%) | Total allele |
| | Total population | 202 | 404 | 135 | 270 |
| | | | | | |
| SS | Homozygous Recessive (q2) | 0.07 (7) | | 0.08 (8) | |
| S | | 0.27 | | 0.29 | |
| | | | | | |
| L | | 0.73 | | 0.71 | |
| LL | Homozygous Dominant (p2) | 0.53 (53) | | 0.51 (51) | |
| | | | | | |
| LS | Heterozygous Dominant (2pq) | 0.40 (40*) | | 0.41 (41*) | |
| | | Ratio = LL : LS : SS 0.53: 0.40 : 0.07 | | Ratio = LL : LS : SS 0.51 : 0.41 : 0.08 | |
| | Total population | Long index finger ($L_{IF}$) | | | |
| | Actual number of homozygous $L_{IF}$ | | 107 | | 69 |
| | Actual number of heterozygous $L_{IF}$ | | 80* | | 55* |
| | Total $L_{IF}$ | | 187 | | 124 |

*LL=Homozygous long index finger, Bb=heterozygous long index finger, bb=homozygous short index finger*

**Table 4:** Summary of the genotypic ratio of the various traits

| Allele distribution | Index finger length |
|---|---|
| | LL: LS: SS |
| Parental genotype (ratio) | 5:4:1 |
| Offspring genotype (ratio) | 5:4:1^ |

^*conformance to parental distribution*

## DISCUSSION

The findings of this study is not in total agreement with the postulation that the index is always shorter than the ring finger;[15] although anthropometric sexual differences have been observed.[3,16,17]This study contradicts Phelps[18] finding; as he indicated three possible variations of the index finger length but agrees with findings of German[19] and Inderjit[20] as he declared the index finger shorter than or nearly equal to ring finger. The association of blood genotype with index finger ratio by Mollon[7] was not in agreement with the findings of this research as there was no enough evidence to state thus (P>0.05).

On an assumption that the allele combinations are recessive, the only expected outcome from a cross between two homozygous recessive parents is giving rise to all homozygous recessive offspring. Additionally, more of high significance is expected in homozygous recessive-homozygous dominant and heterozygous dominant-homozygous recessive combinations if a trait is to be referred to as being recessive. When short index finger was assumed to be dominant, the resultant offspring ratios from both parental combinations was highly insignificant, also when long index finger was assumed dominant, the observed to the expected outcome when both parents were presented with short index finger was significant. Therefore, it could be stated that the long index finger is dominant over the short index finger. Notwithstanding evidence from various research has stated the possibility of hormonal influence on the index finger length.[7,126] However, the research of Inderjit[20] and Ramesh and Murty[21] indicated heritability of this trait without any influence of sex-linked additive gene.

Based on the findings of this research, it will be noteworthy to argue that index finger length which was believed to be sex-linked is more of hormonal influence. The basis for this argument is on the premises that a sex-linked trait is always carried on the sex chromosome and are the constant marker for sexual dimorphism in human (for example, bone and reproductive structures). But this study observed that the distribution by percentage of females (92.5%) with shorter index finger, was similar to the proportion of males (92.1%) with shorter index finger. At this point, we could infer that sex chromosomes may not be the determinant for the transmitted trait from parents to their offspring. Rather, the developmental secretion of testosterone may be linked to the masked physical appearance, while retaining the genotypic characteristics.[8,17]

## CONCLUSION

The evidence of sex influence in the relative difference in 2nd and 4th digit length was too weak to suspect sexual dimorphism; however, the distribution favoured the shorter index finger. The conformity of the trait to the Mendelian simple dominant-recessive inheritance was strengthened by the H-W calculation outcome which suggested allele distribution similarity in parents and offspring.

## LIST OF ABBREVIATION

2D: index finger, 4D: ring finger, SNP: single nucleotide polymorphism, $L_{IF}$: long index finger length, $S_{IF}$: shorter index finger length, SMOC-1 gene: Secreted Modular Calcium Binding Protein-1 gene.

## COMPETING INTEREST

The authors declare that there are no competing interests as regards this research

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