

Finger Length Ratio (2D:4D) in Central India and an Attempt to Verify Fraternal Birth Order Effect: A Population Based Cross-Sectional Study

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ABSTRACT

Introduction: A normal physiology of a human being is not mere a series of functions occurring with specific intensities and timing. There are lot of factors that may change the normal physiological activity within normal limits. Finger length ratio is one of the markers of intrauterine androgen exposure and it is debated and contradicted by many authors. Digit ratio varies among the ethnicities. Many Indian studies show that there is considerable difference in finger length ratio in different population. Data regarding Central India was not found on extensive search.

Aim: To find out the finger length ratio and explore the birth order effect on finger length ratio among the first two successive born in the said population.

Materials and Methods: We conducted a survey on 1500 volunteer persons (800 male and 700 female) over two years of time. We measured the length of the index finger (2D) and ring finger (4D) of both the hands and asked about their birth order history to find out the digit ratio for Central India population and any existing correlation of the same with birth order. T Test and Analysis of Variance (ANOVA) were used for the measure of

significance and difference among the groups. The $p < 0.05$ was considered to be significant.

Results: Our study reports that, study population mean for right hand 2D:4D ratio was 0.976 (SD \pm 0.031) and for left hand it was found to be 0.969 (SD \pm 0.035). For males, mean finger length ratio for right hand was 0.967 (SD \pm 0.033) and 0.963 (SD \pm 0.037) for left hand. In females the mean Finger length ratio was 0.982 (SD \pm 0.027) for right hand and 0.974 (SD \pm 0.034) for the left hand respectively. Finger length ratio was found to be significantly less ($p=0.03$) in males for right hand. No significant ($p=0.24$) difference was observed for left hand. When assessed fraternal birth order effect among the eldest, second born with elder brother and second born with elder sister groups, no significant ($p>0.05$) variation for finger length ratio of right and left hands observed in both male and female population.

Conclusion: Our study reports that the finger length ratio (2D:4D) for Central India population did not show significant association between finger length ratio and fraternal birth order among the first two successive born.

Keywords: Digit ratio, H-Y antigen, Prenatal androgen exposure, Sex dimorphism

INTRODUCTION

Finger length ratio or digit ratio is a widely researched topic being studied in different parts of the world for its association with different psychological and physiological mechanisms [1]. Different population specific data is available for different ethnic population [2]. Finger length ratio is hypothesized as a marker for prenatal androgen exposure [3]. Finger length ratio is the relative lengths of the 2nd digit and 4th digit of hand. It is seen in different studies that this ratio is smaller in males than in females [4,5] and it is sexually dimorphic [5]. Finger length ratio is established early in life and remains static throughout the adult life [6].

Physiological basis for this dimorphic pattern goes deep into the genes and its behaviour. In human genome there are 39 HOX genes (HOX A, HOX B, HOX C, HOX D) and they regulate the developmental process [7]. HOX A and HOX D genes are associated with the development of the limbs [8]. It has been hypothesized that androgen exposure during the fetal life alters the expressions of the homeoproteins those are key regulators of the cellular differentiation [9,10]. In particular high prenatal androgen and low estrogen exposure produce a low (masculine) finger length ratio (2D:4D) [3].

Several studies have reported that how different physiological and psychological parameters are associated with finger length ratio. Fertility, autism, breast cancer, age of onset of myocardial infarction, sporting ability [10], sexual preference, cognitive abilities and many other aspects were studied and it has been shown that a remarkable correlation do exist with the finger length ratio [11].

Different studies show marked variability in results and contradictory conclusion [12-14]. One possible explanation to the contradictory findings may be the huge ethnic diversity among the study populations. Research shows that 2D:4D ratios vary substantially between ethnicity and nationalities [2].

Aim of our study was to find out the finger length ratio of Central India population and assess the effect of birth order on finger length ratio in Indian population. Current study will produce a data specific to Indian population and add up to the current research on finger length ratio.

MATERIALS AND METHODS

Participant selection: Study survey was conducted for two years from 2009 to 2011. To maintain a homogenous population only those participants were included in the analysis whose both parents originally belonged to central Indian population. This reduces the population size from 1500 to 964 including both female ($n = 464$) and male ($n = 500$) subjects [Table/Fig-1]. The mean age for males was 24 ± 6.44 and for females the mean age was 22.6 ± 7.23 . Volunteer subjects were recruited from students and staff of Chirayu Medical College Hospital, Bhopal, Peoples College of Medical Sciences and Research Centre, DB City Mall Bhopal, New Market, Bhopal. Subject's willingness to participate in continuing study was asked and contact details were recorded for future correspondence. Out of 964 subjects only 135 subject showed interest in the future study.

State/ Region	Total Subjects	Male	Female
Madhya Pradesh	450	225	225
Maharashtra	268	140	128
Chhattisgarh	246	135	111
Central India Region	964	500	464

[Table/Fig-1]: Statewise distribution of study population for Central Indian Region.

PROCEDURE

Participation in the study was purely on voluntary basis. Subjects were asked about their parent's ethnicity, age, birth order history (number of elder siblings and their sex and order). History regarding any miscarriage in the birth order was also asked. Finger lengths 2D (index finger) and 4D (ring finger) of both the hands (Palmer surface) were measured by direct measurement using a calibrated digital vernier caliper from the most proximal crease at the base of the digit to the tip of the finger [15].

The study was designed to assess the finger length ratio of the mentioned population and to find out fraternal birth order effect on the finger length ratio between the first born and second born child.

Exclusion Criteria: Subjects with any kind of arthropathy, history of cardiac disease, hyper/hypothyroidism, diabetes, hypertension, tuberculosis, any kind of restrictive or obstructive disease of lung, present history of liver disease, viral myositis, and other muscular diseases and if not 1st or 2nd child of the mother were excluded. Female subjects with hormonal disorders including polycystic ovarian disease and adrenal hyperplasia were excluded. If the subject was smoker or using tobacco in any form were excluded from the study.

Study population was categorized in several groups depending upon the sex and birth order.

Depending upon the birth order history three groups was made:

Group A: First born child,

Group B: With elder brother,

Group C: With elder sister

For both male and female subject groups.

STATISTICAL ANALYSIS

Data was expressed as mean ± Standard Deviation. The p<0.05 was considered as statistically significant. T-test was performed for comparison of the variables between the groups. Analysis of Variance

	Population (mean±SD)	Male (mean±SD)	Female (mean±SD)
Right Hand 2D length(mm)	68.07±4.49	70.60±3.81	66.30±4.10
Right Hand 4D length(mm)	69.76±4.97	73.04±3.91	67.48±4.35
Left Hand 2D length(mm)	68.05±4.84	70.73±3.82	66.18±4.63
Left hand 4D length(mm)	70.21±4.98	73.52±4.25	67.90±4.12
Right hand (2D:4D)	0.976± 0.031	0.967±0.033	0.982± 0.027
Left hand (2D : 4D)	0.969± 0.035	0.963 ± 0.037	0.974± 0.034

[Table/Fig-2]: Finger lengths (2D, 4D) and 2D:4D ratio data specific to the study population.

	Male	Female	p-value
Right hand (2D:4D)	0.967±0.033	0.982± 0.027	0.03 [§]
Left hand (2D : 4D)	0.963 ± 0.037	0.974± 0.034	0.24
Right Hand (2D-4D)	(-2.43± 2.50)	(-1.18± 1.87)	0.024*
Left Hand (2D-4D)	(-2.78 ± 2.79)	(-1.72 ± 2.36)	0.146

[Table/Fig-3]: Comparative data between the sexes for finger length ratio and difference of 2D and 4D.

[§]2D: 4D ratio for right hand is significantly less (p<0.05) in males. *The difference (2D-4D) is significantly more (p<0.05) in males for right hand.

(ANOVA) was applied to examine the fraternal birth order effect on finger length ratio.

RESULTS

Finger length ratio (2D:4D) for the males in the above mentioned population found to be 0.967 (SD ±0.033) for right hand and 0.963 (SD ± 0.037) for left hand. For females the digit ratio found to be 0.982 (SD ± 0.027) for right hand and 0.974 (SD ± 0.034) for the left hand [Table/Fig-2,3]. Total study population mean 2D:4D ratio for right hand appears 0.976 (SD ± 0.031) and 0.969 (SD± 0.035) for the left hand. The finger length ratio found to be smaller in male in comparison to females in both hands [Table/Fig-2]. The difference of finger length ratio was significant (p=0.03) for right hand [Table/Fig-3]. Birth order effect (Fraternal Birth order) did not show any significant variation in finger length ratio for both hands in case of males and females [Table/Fig-4,5].

Cluster	N	Mean± SD	Eldest	2 nd Born with Elder Brother	2 nd Born with Elder Sister	p-value
Population	964	0.976± 0.03	0.983±0.02 (n=338)	0.964±0.03 (n=301)	0.984±0.03 (n=325)	0.080
Male	500	0.967± 0.03	0.98±0.02 (n=208)	0.955±0.02 (n=157)	0.963±0.03 (n=135)	0.544
Female	464	0.982± 0.02	0.986±0.03 (n=130)	1.014±0.02 (n=144)	0.995±0.02 (n=190)	0.184

[Table/Fig-4]: Comparisons between the groups for right hand 2D:4D ratio showing non significant difference with birth order.

Cluster	N	Mean± SD	Eldest	2 nd Born with Elder Brother	2 nd Born with Elder Sister	p-value
Population	964	0.969± 0.03	0.967±0.02 (n=338)	0.962±0.04 (n=301)	0.971±0.03 (n=325)	0.793
Male	500	0.963± 0.03	0.959±0.02 (n= 208)	0.964±0.05 (n=157)	0.963±0.01 (n=135)	0.952
Female	464	0.974± 0.03	0.973±0.03 (n= 130)	0.960±0.03 (n= 144)	0.975±0.03 (n=190)	0.606

[Table/Fig-5]: Comparison between the groups for left hand 2D:4D ratio showing non-significant difference with birth order.

Study population (Male/Female)	Right 2D: 4D Male	Left 2D : 4D Male	Right 2D : 4D Female	Left 2D : 4D Female
Gujarat (127,190) J. Majumder et al., [16]	0.98±0.04	No Data	1.00± 0.04	No data
North India (200,0) Reena et al., [17]	0.943±0.002 – 0.95± 0.03	0.957± 0.022 – 0.97± 0.03	No data	No data
North india (200,0) Haryana RK Yadav et al., [18]	0.945±0.02 – 0.954±0.02	0.955± 0.02 – 0.964± 0.02	No data	No data
Maharashtra (100,95) Mohammed DT et al., [19]	0.96±0.027	0.957± 0.025	0.982± 0.022	0.980± 0.027
South India (80,80) Meera Jacob et al., [20]	1.01±0.06	0.97± 0.12	0.98± 0.11	0.97±0.03
Andhra Pradesh (96,104) M.Gayathri et al., [21]	0.981±0.42	0.973± 0.044	0.989± 0.044	1.083±0.554
Maharashtra , neonatal study (30,30) Manohar S et al., [22]	0.932±0.038	0.932± 0.030	0.950± 0.046	0.944±0.041
Eastern India (250,250) Jaydip Sen [23]	0.97±0.03	0.96± 0.03	0.97± 0.03	0.96±0.03
Central India (500,464) Present study	0.967±0.033	0.963 ± 0.037	0.982± 0.027	0.974± 0.034

[Table/Fig-6]: 2D: 4D ratio data from different Indian studies including the values of present study [16-23].

Difference of length of Index (2D) and ring finger (4D) was measured for both the hands in both the sexes. Difference of lengths for right hand ($R_{(2D-4D)}$) was significantly more in males (-2.43 ± 2.50 , $p = 0.024$) [Table/Fig-3].

DISCUSSION

The research related to finger length ratio in Indian context came in to limelight post 2001 era [1] and slowly increasing linearly with time. Scientists are trying to explore the relationship between finger length ratio and different physiological factors in Indian population [16-18]. The present study is the first to examine the 2D:4D ratio in a large sample from Central India regional population. We took up a particular view point to examine that whether the fraternal birth order has any relationship with finger length ratio.

Developmental biology research shows that the prenatal androgen exposure that is the intrauterine sex steroid levels are responsible for this sexually dimorphic structural change which takes place around thirteenth week of gestational age [3]. High level of sex steroid during intra uterine life is supposed to be the reason for the lower 2D:4D ratio which is termed as more masculine pattern [3]. Studies have found that there is a significant sex difference in 2D:4D ratio of right hand between males and females with men having lower 2D:4D ratio than female [4]. The 2D:4D ratio has prominent overlapping and varies appreciably by ethnicity [5]. But interestingly the sex difference in 2D:4D ratio exists across the various ethnic groups. We find from the earlier studies that, the finger length ratio (2D:4D) is around 0.99 to 1.00 for Polish, Spanish and English people, 0.93 to 0.95 among Zulus, Finns, Jamaicans and 0.96 to 0.97 among Indian, German and Hungarian people [2]. India is a vast country with people from various ethnic backgrounds. We find a wide range values regarding 2D:4D ratio among different geographical locations and population of India [Table/Fig-6] [16-23]. Central India region consists of three states of Madhya Pradesh, Chhattisgarh and Maharashtra [24]. Due to its immense geopolitical significance and since the region was considered as the passage way between indo-gangetic plains and deccan, amalgamation of different ethnic population is observed [25]. Prior available data regarding Central India population for the same was not found on extensive search.

Digit ratio research use four different ways: left 2D:4D, right 2D:4D, mean 2D:4D, difference between right and left 2D:4D (called Dr-l) and rarely used 4D/height [11]. In our present study we found that the difference of index to ring finger length is significantly more ($p = 0.024$) for right hand in males than females. The significance was not found for the left hand ($p=0.24$).

Breedlove informed about his findings that 2D:4D ratio is influenced and significantly varies with the number of older brothers [26].

Sexual orientation, finger length ratio and birth order are studied frequently. It was indicated that later birth order is related to homosexuality in males. That is chances of homosexuality increase with having older brother. This relation between high fraternal order and homosexuality is termed as the fraternal birth order effect [26-28].

Blanchard and Bogaert derived a hypothesis known as maternal immune hypothesis which can be summarized as H-Y antigen (Y linked minor histocompatibility antigens) which is present in the cell surfaces of male fetus may cross the placenta and produce an immune reaction to some mothers [27,28]. In response mother produce the antibody which cross the placenta and alter the fetal brain development. It has also been reported that H-Y specific CD8 T cells were functional in mothers with previous male pregnancies for after eight years of their last male pregnancy [29]. The response to the antigen increase with each male fetus and thus the probability of homosexuality increases with each elder male sibling. Four male specific proteins encoded by SMCY, PCDH11Y, NLGN4Y, TBL1Y genes were considered as a possible antigenic substance underlying the FBO which were found to support the maternal

immune hypothesis. Among these only the product of PCDH11Y isoform-a, was found to be exclusively expressed in the brain [28]. The other physiological aspects are also been correlated with this fraternal birth order. Birth weight and placental weight has negative and positive correlation with fraternal birth order. Animal studies where maternal immunization was done with paternal antigens have also shown that it affect fetal birth weight, placental weight or both. Zuckermann, Blanchard and several one indicate that prior male pregnancies decrease fetal weight for subsequent males [27].

These studies point towards the assertion that this fraternal birth order effect certainly causes alteration in growth of the male fetus. Williams found that men with more older brothers tend to have shorter index fingers relative to their ring fingers (i.e., low 2D:4D ratios). A replicated study done by Manning failed to confirm the finding of Williams study [26]. The study of Nicola S reported that males with more elder brother show more masculine 2D:4D ratios, and with more number of elder sisters the ratio appeared to be more feminine [30]. It was suggested that as the Y linked proteins those are targeted by maternal immune response are not exclusively limited to brain and may be found in other sites of the body [29]. The same effect in females was absent. In our present study the group consisting elder sister was made to make sure to avoid the effect of any maternal immune response. It was observed in our study that though mean value shows some differences similar to the previous studies but the difference between the groups is not significant. In our study we did not observe any birth order effect on finger length ratio. Our study observes that the fraternal birth order did not affect finger length ratio between the second born male or female and first born (elder) male. We observed that the applicability of the fraternal birth order theory is limited to males and this theory is not applicable to females because of lacking of Y linked proteins in them. Further researches show that different set of genes Wnt5a, Ihh, Bmp6, Fgfr2, Igfbp2/5, Sox9 and Runx2 play an important role in digit development and are regulated by the steroid [31].

Findings suggested that Androgen Receptor (AR) is a negative modulator of Wnt 5a expression in digits. 4D [31,32] has higher levels of AR and Estrogen Receptor (ER) than 2D. AR and ER activities influence the 2D:4D ratio by modulating levels of skeletogenic gene expression and cell proliferation in a digit-specific manner [31]. Another interesting fact was reported that the intrauterine timing of phalangeal growth regulation by AR and ER correlates with the timing of masculinization or feminization of brain by the steroids. It was also observed that several genes have role in the development of brain and different sexually dimorphic structures [33,34]. So, finger length ratio or 2D:4D ratio which was proposed as a reflection of prenatal androgen exposure is found to be caused by androgen and estrogen signaling [35].

Most of the research what we found regarding prenatal androgen exposure is related to sexual orientation and behavioural studies [1]. As earlier mentioned several studies show that there is considerable effect of prenatal androgen exposure (2D:4D ratio) on other physiological functions. More studies are required to establish the exact mechanism leading to adult diseases associated with finger length ratio.

LIMITATION

Fraternal birth order effect on finger length ratio was not established in the study. Authors realize that more detailed study in the field to reach the depth of the finger length ratio and its correlation with different physiological functions in Indian population is required.

CONCLUSION

Our study is in accordance with the previous studies and results show that there is considerable sexual dimorphism in central India population. Along with the other existing traditional calculation method used in the finger length study we used difference of 2D

and 4D (2D-4D). We find this difference is significantly more in male right hand than in female.

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