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FINGER DIGIT RATIO AS A PREDICTOR OF MOTOR SKILL IN CHILDREN

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Abstract- Second to fourth finger length ratio (2D:4D) has been hypothesized to be determined by prenatal sex steroids which has an influence on motor skill. Present study aimed at investigating extent to which 2D:4D ratio correlates with fine and gross motor skill in children. Results of the study showed a significant association between mean 2D:4D ratio and gross motor skill in both the sex. Both male and female 2D:4D ratio had a positive correlation in precision of fine motor skill and negative correlation on speed of fine motor activity. Thus this study shows that prenatal testosterone may have a causal role in the development of motor skills which can be predicted by 2D:4D ratio as a proxy marker.
Key words- 2D:4D ratio, Fine motor skill, Gross motor skill, Children, Testosterone.
Running Title- Digit Ratio and Motor Skill.

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Introduction

Ratio between the lengths of the second digit (index finger) and the fourth digit (ring finger) is called the 2D:4D ratio or digit ratio. Digit ratio is sexually dimorphic. Males tend to show lower values of 2D:4D than do females, i.e., males have on an average longer fourth digit relative to their second [1-2]. Manning, et al [2-3] showed that it is largely determined prenatally and is correlated with adult concentrations of sex steroids, negatively related to prenatal testosterone and positively associated with prenatal oestrogen. Forstmeier, et al [4] have shown that digit ratio can be an indicator function of oestrogen pathway. At molecular level studies have shown that development of gonads and fingers are brought about by the same Hox gene [5] and digit ratio is influenced by allelic variation in androgen receptor sensitivity [6]. Digit ratio thus acts as a marker of the levels of testosterone and oestrogen to which the developing foetus is exposed.

Studies have shown correlation between 2D:4D ratio and sperm count, sexuality, cerebral lateralisation and sporting ability. Manning, et al [2] found negative correlation between testicular activity and 2D:4D ratio, and hence fertility in men. However a recent report by Hurd, et al [7] has shown no correlation between androgen receptor sensitivity and the 2D:4D ratio. Studies on autistic children showed that children with this disorder tend to have unusually long ring fingers, compared to their index fingers [8]. This finding supports the "extreme male brain" theory of autism.

Prenatal hormones act on distinct population of neurons in the brain due to the presence of specific receptors which is the primary target for action. Lateralization of brain has been widely studied and linked to sex steroid exposure in utero. Various theories have been put forward to account for the same. 'GBG' hypothesis claimed that high levels of foetal testosterone may compromise development of the left cerebral hemisphere and enhance development of the right hemisphere [9-10]. However, the findings relating to spatial ability are highly variable and appear to be task and sex dependent. Kelley [11] hypothesized that testosterone inhibits ontogenetic cell death in the left hemisphere, though with prolonged exposure both hemispheres are affected, leading to anatomical asymmetry and handedness. High levels of testosterone and other androgen that are present early in development are shown to facilitate development of male-typical characteris-

tics, and to inhibit development of female-typical characteristics. Studies have shown that sporting success might be determined prenatally with research linking 2D:4D ratio and sports like football, skiing, fencing, endurance running [3,12-14]. Manning, et al [15] shown in a sample of Afro-Caribbean Jamaican children that low 2D:4D was associated with faster left-hand speed relative to right-hand speed in a peg moving test. Fink, et al. [16] found that hand performance scores correlated positively with high 2D:4D in Austrian children. However, there is dearth of such studies in Indian population. Thus this study was intended to find associations between 2D:4D ratio and both gross and fine motor skills in a sample of Indian children.

Method

Participants

Eighty children (male=40, female=40) in the age group 8-12 years (9.84 ± 1.32) with no physical abnormality were randomly selected as participants from a private school at Chennai, Tamilnadu in India. The study was approved by the institute Human Ethics committee and conducted according to the principles and guidelines of Declaration of Helsinki. On obtaining the written consent from parents after explaining the purpose of the study, a subject data sheet regarding date of birth, handedness, siblings, interest and participation in art and sports or any other aspect of the child that might account for differential skill between hands were obtained. Though participants were selected randomly from the specified age group they were all right handed. Participants of the study were tested individually by the same investigators at the school premises.

Measurement of 2D:4D Ratio

Lengths of index and ring fingers of both hands were measured from the ventral proximal crease of each digit to the finger tip from digital photographs of well extended hand using an online ruler. The ratio was subsequently calculated by dividing index finger length (in cm) by ring finger length (in cm). Mean of right and left hand ratio was taken as mean 2D:4D ratio for the individual participant.

Assessment of Motor Skill

Assessments of fine motor skill were done using the motor accuracy test which involves time trace of a butterfly and the Hand Dominance test (HDT) [17]. HDT comprised of dexterity task to be performed with speed and precision (maze trace, dotting circle) over 30 seconds. In addition "nine peg hole test" was also used to evaluate the fine motor skill [18]. The tests were performed by participants individually using the right hand first followed by their left hand.

Assessment of gross motor skill was done using a subtest of test of gross motor development, stationary bounce [19]. It consisted of two tests. The first test required the participant to do perfect bounces. A bounce was considered perfect if it was done using his fingers, not palm, at the height of his hip and the ball touches the floor in front or on the side of the hand being used. They were scored on the basis of number of correct bounces out of a total of 10 bounces. The second test necessitated the participants to do as many bounces as possible within a circle of diameter of 60 cm in 10 seconds. Best of three trials was taken as the score. Each test was administered individually after giving specific instructions to avoid bias, results of the tests were blinded and one investigator observed while another administered the test.

Statistical Analysis

Data were analyzed using SPSS version 14. All the data obtained were analyzed using student T test. Pearson's correlation was performed to find out the association between 2D:4D ratio and parameters assessed. Level of significance was set at $P<0.05$.

Results and Discussion

Mean 2D:4D ratio and 2D:4D of the dominant hand (right hand) showed a significant difference between the two sexes, however, there was only a slight inclination towards lower 2D:4D ratio in males when compared to females in the non-dominant hand (Table 1). Results of this study is well correlated with earlier studies [1,2].

Table 1- Influence of sex on 2D:4D Ratio

	2D:4D Ratio Right Hand	2D:4D Ratio Left Hand	Mean 2D:4D Ratio
Female n=40	0.979 ± 0.03	0.962 ± 0.05	0.970 ± 0.03
Male n=40	0.967 ± 0.05*	0.959 ± 0.05	0.963 ± 0.04*

*All the data given are Mean ± SD. All comparisons were made using Student T test between Male and Female and * denotes significance at p< 0.05.*

Males showed better performance when compared to females in tests which assessed the motor speed, gross (number of bounces) and fine (butterfly trace). However the precision of fine motor skill (maze trace) was better in females. No sex difference was seen in the accuracy of the gross motor skill gauged by the number of correct bounces in both the hands (Table 2).

Table 2- Influence of Sex on Fine and Gross Motor Skill

Parameter	Female (mean ± SD)	Male (mean ± SD)
Number of participants (n)	40	40
Right Hand		
2D:4D Ratio	0.979 ± 0.03	0.967 ± 0.05*
Circle dots (in 30 sec)	50.49 ±7.98	47.97 ±10.51
Maze trace (cm)	35.90 ±8.80	29.73 ±10.18*
Butterfly trace (sec)	90.04 ±28.25	104.77 ±39.70*
Peg hole (sec)	19.13 ±2.67	19.28 ±2.74
No. of bounce in 10 sec	23.46 ±4.90	25.44 ±5.95
Correct ball bounce /10	8.97 ±1.55	8.93 ±1.39
Left hand		
2D: 4D ratio	0.962 ± 0.05	0.959 ± 0.05
Circle dots (in 30 sec)	26.38 ±7.41	26.31 ±8.26
Maze trace (cm)	28.15 ±9.37	21.21 ±8.94*
Butterfly trace (sec)	106.30 ±35.26	120.25 ±44.34
Peg hole (sec)	21.95 ±3.27	21.76 ±3.26
No. of bounce in 10 sec	19.79 ±4.64	23.31 ±6.71*
Correct ball bounce /10	8.03 ±1.83	8.72 ±1.79

*All the data given are Mean ± SD. All comparisons were made using Student T test between Male and Female and * denotes significance at p< 0.05.*

Influence of 2d:4d Ratio on Motor Skills

This study considered relation between 2D:4D ratio and motor skill of individual hand specifically in relation to precision and speed.

Much of the available literature on 2D:4D ratio and motor skill has been with regard to sporting skills as a whole, like endurance running, fencing, etc. Manning, et al. showed in his studies that lower 2D:4D ratio was associated with greater endurance running and sporting ability in male [12-13]. In our present study we observed that there was significant negative correlation between Mean 2D:4D ratio and gross motor speed in both the sex ($p<0.05$). However with respect to precision of gross motor skill male showed a positive association in contrast to the negative association seen in females (statistically not significant). Mean 2D:4D ratio was positively associated with precision and negatively with speed of fine motor skill of the right hand in both the sexes (statistically not significant). This correlation is supported by GBG theory and its later modification that prenatal testosterone appears to compromise the development of the right-hemisphere leading to improved left-hand performance [9-10]. The negative relationship seen in females with respect to gross motor skill of left hand and both mean and right 2D:4D ratios could be due to lack of exposure to testosterone and hence brain development. This is well supported by an earlier report which showed that low 2D:4D is related to increased female sporting ability as shown by better world rankings in fencing [14].

Studies in Afro Caribbean right handed children showed a low 2D:4D ratio and faster left-hand performance as compared to right in fine motor skills [15]. This conclusion is also supported by findings among Austrian children that higher left-hand relative to right-hand speed in the performance of peg test was related to low 2D:4D values [16]. Our study however showed only a probable trend, i.e., a high mean 2D:4D ratio was associated with better fine motor skill as shown in dotting the circle and maze trace tests, in the right hand of both sexes. A negative trend was found in females on the peg board test, which is a measure of speed.

Variations in results obtained in the present study could be due to ethnicity, age of the children and tests tools applied. Previous studies were done on non Asians in the age group 6-8 whereas the present study was carried out in Indian population in the age group 8-12 years probably accounting for the obtained results. Age and practice on fine motor skill development could probably outweigh its associations with digit ratio.

Conclusion

This study provides support for the association between 2D:4D ratio and motor skill in children. A prospective study in a larger population will substantiate the possible role of prenatal testosterone on motor development and use of 2D:4D as a proxy marker in identifying motor disorders early.

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