**2D:4D Ratio in Adult Female and Their Comparison with Males: An Anthropometric Study from Northern India**

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**ABSTRACT**

**Background:** 2D:4D ratio is a sexually dimorphic marker that acts as potential marker of prenatal androgen exposure. Genital development in fetus depends on adequate and timely exposure to sex steroids. Assessment of fetal androgen levels and exposure are essential to predict normal development and future reproductive disorders. The 2D:4D ratio can be used to assess androgen action.

**Aim:** This study attempts to find out 2D:4D ratio of left and right hand in adult females and males and to find out whether any difference exists among these variables in males and females.

**Methods:** A total of 83 adults were included in the study. There were 51 females and 32 males. The distance of second finger and fourth finger was calculated from mid-point of proximal most digital crease to distal most end of the finger. The ratio was then obtained by dividing second finger length by fourth finger length.

**Result:** The mean 2D:4D ratio of left hand and right hand in adult female were 0.98 and 0.99 respectively. The mean 2D:4D ratio of left hand and right hand in adult male were 0.967 and 0.99 respectively. The males have lower 2D:4D ratio for left and right hand as compared to females. The mean 2D:4D ratio of left hand and right hand in left handed females were 0.99 and 1.01 respectively while mean 2D:4D ratio of left hand and right hand in right handed females were 0.987 and 0.99. The mean 2D:4D ratio of left hand and right hand in left handed males were 0.96 and 0.98 respectively while mean 2D:4D ratio of left hand and right hand in right handed males were 0.98 and 1.01.

**Conclusion:** Sexually dimorphic markers are variables that can be used as indirect marker of fetal androgen exposure. In this study the mean 2D:4D ratio in males for both left and right hand was lower than females in overall group and in case of both right and left handedness males and females. Male fetuses with higher testosterone levels will have a lower 2D:4D ratio. Digital ratio is an easy noninvasive parameter, abnormal 2D:4D ratio in females can predict excessive androgen action.

**Keywords:** 2D:4D Ratio, Sexual Dimorphism

**Introduction**

2D:4D ratio is a sexually dimorphic marker that acts as potential marker of prenatal androgen exposure. It is the ratio of length of second finger to that of fourth finger. The dimorphism trait was found in various species including mice, zebra and humans. Among humans marked variations have been reported among different geographic region and various ethnic groups. Genital development in fetus depends on adequate and timely exposure to sex steroids. Various congenital abnormalities and reproductive disorders in adults are associated with abnormal fetal androgen exposure. Assessment of fetal androgen levels and exposure are essential to predict normal development and future reproductive disorders. The sexually dimorphic markers variables like 2D:4D ratio can be used to assess androgen action. These markers are different in males and females. Various studies done have given variable 2D:4D ratio among males and females from different region and ethnicity. This study attempts to find out 2D:4D ratio of left and right hand in adult females and males and to find out whether any difference exists among these variables in males and females.

**Materials and Methods**

This cross sectional study was done in department of Anatomy, Government Medical College, Haldwani, Nanital, Uttarakhand. A total of 83 adults were included in the study. There were 51 females and 32 males. The distance of second finger (index) and fourth finger (ring) was calculated from mid-point of proximal most digital crease to distal most end of the finger with the help of Vernier caliper. The ratio was then obtained by dividing second finger length by fourth finger length. The ratio was calculated for both right and left hand. The mean 2D:4D ratio in both males and females were calculated for both hands. The digital ratio of left hand of males and females were compared to find out, if there is any difference between male and female digital ratio of each hand.
Result
The study included 83 adults with age range of 18 years to 20 years. There were 32 males and 51 females. The mean 2D:4D ratio of left hand and right hand in adult female were 0.98 and 0.99 respectively. The mean 2D:4D ratio of left hand and right hand in adult male were 0.967 and 0.99 respectively. The standard deviation of left hand and right hand in males were 0.027 and 0.032 while standard deviation of left and right hand in females were 0.03 for both the hands. The males have lower 2D:4D ratio for left and right hand as compared to females. (Table 1) (Graph 1)

The handedness was also observed in males and females. Out of 83 adults, 75 were right handed and 8 were left handed. Out of 8 left handed adults, 4 were males and rest were female. Out of 75 right handed adults, 47 were females and 28 were males.

The mean 2D:4D ratio of left hand and right hand in left handed females were 0.99 and 1.01 respectively while mean 2D:4D ratio of left hand and right hand in right handed females were 0.987 and 0.99. (Graph 2)

The mean 2D:4D ratio of left hand and right hand in left handed males were 0.96 and 0.98 respectively while mean 2D:4D ratio of left hand and right hand in right handed males were 0.98 and 1.01. (Graph 3)

Discussion
Early fetal reproductive development depends on adequate and timely androgen exposure. In initial weeks of development in sex determining region (SRY) on Y chromosome, males receive adequate androgen and females do not. The 2:4 ratio is lower in males and higher in females. The rise in ratio shows the rise in male androgen exposure. The result shows that the left 2D:4D ratio is higher as compared to right hand in both males and females. (Graph 1)

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The mean 2D:4D ratio of left hand and right hand in left handed females were 0.99 and 1.01 respectively while mean 2D:4D ratio of left hand and right hand in right handed females were 0.987 and 0.99. (Graph 2)

The mean 2D:4D ratio of left hand and right hand in left handed males were 0.96 and 0.98 respectively while mean 2D:4D ratio of left hand and right hand in right handed males were 0.98 and 1.01. (Graph 3)

Table 1: Shows mean and standard deviation of 2D:4D ratio of left and right hand in males and females.

<table>
<thead>
<tr>
<th></th>
<th>Left(Male)</th>
<th>Right(Male)</th>
<th>Left(Female)</th>
<th>Right(Female)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.967</td>
<td>0.97</td>
<td>0.987</td>
<td>0.99</td>
</tr>
<tr>
<td>Stand dev</td>
<td>0.027</td>
<td>0.032</td>
<td>0.03</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 2: Shows mean 2D:4D ratio of left and right hand in left and right handed males and females.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Left hand right handed</th>
<th>Left hand left handed</th>
<th>Right hand left handed</th>
<th>Right hand Right handed</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>0.967</td>
<td>0.96</td>
<td>0.98</td>
<td>0.969</td>
</tr>
<tr>
<td>F</td>
<td>0.987</td>
<td>0.982</td>
<td>1.01</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Graph 1: Shows mean 2D:4D ratio of left and right hand in males(Blue) and females(Orange). The males have lesser 2D:4D ratio than females.
Graph 2: Shows mean 2D:4D ratio in males (blue) and females (orange). The males have lesser 2D:4D ratio in left hand for both right and left handed males and females.

Graph 3: Shows mean 2D:4D ratio in males (blue) and females (orange). The males have lesser 2D:4D ratio in right hand for both right handed and left handed males and females.

chromosomes leads to differentiation of leydig cells, these cells start production of testosterone. In presence of testosterones the mullerian duct degenerates and male internal genitalia develops from wolffian duct. The male external genitalia develop from genital tubercle in presence of 5DHT, a derivative of testosterone. In absence of testosterone, female internal genitalia develop from mullerian duct and clitoris develops from genital tubercle. Therefore, timely and adequate exposure of androgens are needed for proper genital development. Inadequate and excessive exposure in fetus can leads to various congenital abnormalities and reproductive disorders in adults. Therefore, assessment of fetal androgens levels and action are necessary to rule out future reproductive disorders. Direct assessment of androgens levels is not possible in fetus and indirect measurement of fetal androgen action are necessary for the same. Sexually dimorphic markers are variables that can be used as indirect marker of fetal androgen exposure. 2D:4D ratio is ratio of length of second digit to the length of fourth digit.
In this study the mean 2D:4D ratio in males for both left and right hand was lower than females in overall group and in case of both right and left handedness males and females. This lesser 2D:4D ratio in males and greater 2D:4D ratio in females were expressed as masculine and feminine in males and females respectively.

The mean 2D:4D ratio in males for left and right hand was 0.967 ± 0.027 and 0.97± 0.03 while mean 2D:4D ratio in females for left and right hand was 0.98 ± 0.03 and 0.99± 0.03. Loehlin JC etal12 in their study found that 2D:4D ratios among males and females were less in males compared to females with values of 0.947±0.029 and 0.965±0.026, respectively.

Rebecca B13 in their study found that testosterone levels in fetus are negatively correlated with 2D:4D ratio while estrogen has positive correlation with estrogen. Therefore, male fetuses with higher testosterone levels will have a lower 2D:4D ratio, on the other hand females have lower levels of testosterone and have higher 2D:4D ratio. Jacob M etal14 in their study on South Indian population also found sexual dimorphism.

This difference in digit ratio were also correlated with various disorders that are associated with under and overexposure of androgen levels. The females with congenital adrenal hyperplasia(CAH) have a higher level of androgen exposure and therefore have a lower 2D:4D ratio.15 In a study by Coyne SM etal16 found that smoking in pregnancy is associated with higher testosterone levels and therefore the female fetuses have lower digital ratio. The ratio once established at birth remains same throughout the life and little influence by androgen levels in post-natal life. Various phenotypic traits were attributed to 2D:4D ratio including sperm count, personalities, handedness, spatial skills, academic performance, depression, autism etc.17

2D:4D ratio shows marked ethnic variations. Manning et al18 in his study among different ethnic study showed sexual dimorphism but the digital ratio showed marked variations among children of different ethnic communities. Xi H et al19 in their study on children found higher ratio among caucasians then blacks and Hans ethics of China. The relationship of 2D:4D ratio with metabolic syndrome and cardiovascular risk factors were also studied.18

Digital ratio is an important noninvasive sexually dimorphic marker. Abnormal values can be associated with congenital reproductive abnormality. This marker has great potential role to determine androgen exposure in fetal life and reproductive disorders in adult females. The use is limited by fact that it shows large geographical, ethical and regional variations. This study is a step forward in this regard and shows digital ratio from Northern India.

Conclusion
2D:4D ratio is a sexually dimorphic marker that can be used as indirect marker for androgen levels and action in fetal life, this study showed that males have lesser 2D:4D ratio in both hands as compared to females. In both right and left handed males and females, males were found to have lesser digital ratio. Digital ratio is an easy noninvasive parameter, abnormal 2D:4D ratio in females can predict excessive androgen action.

Reference

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