DIGITAL FINGER RATIO (2D:4D) AND SALIVARY TESTOSTERONE LEVEL IN ELITE SPORTSMEN AND NON-SPORTSMEN

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ABSTRACT

A longer relative fourth digit to second digit is indicative of increased intrauterine testosterone exposure prenatally and the converse is also true for oestrogen exposure. But there are very few studies which has evaluated the association between 2D:4D and the testosterone hormone in saliva of elite sportsmen. The aim of this study was to test the hypothesis that high levels of testosterone during prenatal life, testified by a low second-to-fourth digit ratio (2D:4D), as well as in adulthood affect the salivary testosterone in the elite players. Digital finger ratio 2d:4d and salivary testosterone hormone was measured in 91 elite sportsmen (Volleyball N-36, Basketball N- 30 & Football N- 25) of age 22.14 ±2.11 yrs. We found a significant difference in the digital finger ratio 2d:4d between the elite sportsmen and non sportsmen (Volleyball v/s NSM t value -3.89, P < 0.01, Basketball v/s NSM t value – 3.01, P < 0.01 & Football v/s NSM t value – 4.33, P < 0.01). Further significant difference (Volleyball v/s NSM t value -7.29, P < 0.01, Basketball v/s NSM t value – 4.10, P < 0.01 & Football v/s NSM t value – 8.57, P < 0.01) in the level of salivary testosterone hormone (pg/ml) between the elite sportsmen and non sportsmen was found. We suggest that low right-left 2D:4D is a predictive marker of testosterone receptiveness in men trained for sports and this association is programmed by the action of prenatal testosterone.

Key Words: Prenatal testosterone, androgen, digital finger ratio and sporting ability.

INTRODUCTION:

In humans, the ratio of the index finger to the ring finger (2D:4D) is sexually dimorphic. Women have a larger 2D:4D on average than men (George, 1930; Manning, Scott, Wilson, and Lewis-Jones, 1998). This sex difference in finger length patterns was first reported more than 135 years ago (Ecker, 1875). Although the genetic basis to the differentiation of the digit pattern is more recent. The HOX gene family is required for the growth and patterning of digits and the differentiation of the genital bud. Hoxd and Hoxa genes are strongly expressed in the gonads and are also required for the growth and differentiation of digits. This sharing of causal factors in digit and gonad differentiation allows patterns of digit formation to be a marker for prenatal sex hormone concentration (Manning, Scutt, Wilson, & Lewis-Jones, 1998). The length of the fourth digit (ring finger) is thought to be an index of prenatal testosterone exposure relative to the

length of the second digit (index finger), which is thought to represent an index of prenatal estrogen exposure. The 2D:4D ratio (second digit length divided by fourth digit length) therefore provides an index of prenatal testosterone exposure relative to prenatal oestrogen exposure. Digit ratio is thought to be fixed in utero and relative digit lengths remains constant throughout development from the age of 2 (Manning, 2002).

Low values of 2D: 4D are associated with high concentrations of testosterone. In the general population, men have a "digit ratio" of 0.98 on average - the index finger being slightly shorter than the ring finger. Women have a digit ratio of 1.0 on average, meaning the two fingers are the same length. However the 107 male and female academics surveyed at Bath University, UK, had very similar ratios - 0.987 for men and 0.984 for women. Digit ratio is an index of exposure to prenatal testosterone. Testosterone plays an important role in mammalian brain development. In neural regions with appropriate receptors testosterone, or its metabolites, influences patterns of cell death and survival, neural connectivity and neurochemical characterization. Prenatal gonadal hormones exert long-lasting organizational influences on brain and behaviour in humans (Collaer & Hines, 1995).

Prenatal testosterone slows the growth rate of the left side of the brain while enhancing growth of the right side (Geshwind and Galaburda, 1985). The right hemisphere is associated with better visual-spatial and mathematical abilities, as is the 2D: 4D ratio (Manning and Taylor, 2001). Thus, traditional sex differences in visual-spatial and mathematical abilities can be attributed to differences in exposure to prenatal testosterone, indexed by a sex dimorphic pattern in digit ratio. Additionally, it would appear that the 2D: 4D ratio is a marker for within-sex variance in visual-spatial ability (Koehler et al., 2004).

Fetal and adult testosterone as reflected by 2D:4D has many extra genital effects, including its relevance for the formation of an efficient cardiovascular system. Previous research has established a clear guide line about the association of low digit ratios with the sports performance. It has been reported that digit ratio (2D:4D) is negatively associated with prenatal

testosterone, and it is also negatively associated with ability in sports such as football, as average '2D:4D digit ratio' in football internationals of England (N=37) =0.94; black football professionals of England (N=13) = 0.93; Brazilian professionals (N=99) = 0.93; Brazilian first team professionals (N=20) = 0.92 (Manning 2002, Manning and Taylor (2001), skiing (Manning 2002), middle distance running, and endurance running (Manning 2009a), sprinting ability (Manning & Hill 2009b) , rugby performance (Bennett et al.,2010), swimming performance Sudhakar et al. (2013) and physical fitness component in adolescent girls Peeters MW et al.(2013), which are dependent upon an efficient cardiovascular system. Longman et al. (2011) has suggested that fetal testosterone exposure has long-term effects on traits associated with sports requiring high power (physical strength) and well-developed cardiovascular systems where as Voracek et al. (2006) reported similar effect in the female fencers. The comparative status of salivary testosterone and digit ratio (2d:4d) of team sports like Volleyball, Basketball and football has not been defined where aerobic endurance capacity, strength and visual-spatial skill are dominant prerequisites.

METHODS:

Data was collected from 91 sportsmen (Volleyball = 36, Basketball = 30 & Football = 25), who had won any medal at National/ All-India inter-university level (age = 22.14 ±2.11 yrs. & range 18 to 26 yrs.) and 150 non-sportsmen who had never participated in any competitive sports. Finger length of both was measured from the basal crease of each finger to the centre of top of each finger using Digital Vernier Calipers in millimeters to two decimal places (Manning, 1995, Scutt and Manning, 1996). Each measurement was undertaken twice. Digit ratio was calculated by dividing the length of the second digit (2D) by the length of the fourth digit (4D) for the left and right hand separately and then calculating the mean of these two ratios. Salivary testosterone sample was collected from 48 subjects (12 each from Volleyball, Basketball & Football & non-sportsmen) early in the morning into a sterilized clean glass tube, without force or inducement and before eating, drinking or brushing the teeth. All samples were sent to Centralised Processing Laboratory (CPL) of Thyrocare Technologies Limited (ISO 9001:2008 & Accredited to College of American Pathologist) at Navi Mumbai for further analyses in the frozen form.

RESULTS:

The mean 2D:4D of both hands in the sportsmen category were Volleyball - 0.969±0.026, Basketball- 0.972±0.027 and Football - 0.965±0.024, while in the non-sportsmen it was 0.989±0.034. The t-value between Volleyball and non-sportsmen was 3.89, which is significant at 0.01 levels. It indicates that there exists a significant difference in the mean 2D:4D of volleyball players and non-sportsmen. Further a significant difference was found in the mean 2D:4D of Basketball and non-sportsmen as t-value is 3.01,p =0.01. Similarly, a significant difference was found in the mean 2D:4D of Football players and non-sportsmen as t-value is 4.33 (p = 0.01).

Table No. – 1

Comparative status of mean digital finger ratio (2D:4D) between Sportsmen and Non-sportsmen

S. No.	Category	N_1	N_2	M_1	M_2	SD_1	SD_2	MD	S.E.D.	t-value
1.	Volleyball v/s Non-sportsmen	36	150	0.969	0.989	±0.026	±0.034	0.020	0.005	3.89**
2.	Basketball v/s Non-sportsmen	30	150	0.972	0.989	±0.027	±0.034	0.017	0.006	3.01**
3.	Football v/s Non-sportsmen	25	150	0.965	0.989	±0.024	±0.034	0.024	0.006	4.33**

N_1 & N_2 - No. of subjects of the 1st & 2nd group. M_1 & M_2 - Mean of 1st & 2nd group. SD_1 & SD_2 – Standard Deviation of 1st & 2nd group. MD – Mean Difference of the groups. S.E.D. – Standard error of difference. * & ** - Significant at 0.05 & 0.01 level

The mean salivary testosterones (pg/ml) in the different categories were Volleyball – 85.58 ±2.539, Basketball – 82.92 ±3.232, Football – 87.00 ±2.594 & non sportsmen - 78.08 ±2.503. The t-value between Volleyball players and non-sportsmen was 7.29 (p = 0.01), it indicates that there exists a significant

Table No. - 2

Comparative status of mean Salivary Testosterone Hormone (STH) between Sportsmen and Non-sportsmen

S. No.	Category	N_1	N_2	M_1 pg/ml	M_2 pg/ml	$S.D._1$	$S.D._2$	M. D.	S.E.D.	t-value
1.	Volleyball v/s Non-sportsmen	12	12	85.58	78.08	±2.539	±2.503	7.50	1.029	7.29**
2.	Basketball v/s Non-sportsmen	12	12	82.92	78.08	±3.232	±2.503	4.84	1.180	4.10**
3.	Football v/s Non-sportsmen	12	12	87.00	78.08	±2.594	±2.503	8.92	1.041	8.57**

N_1 & N_2 - No. of subjects of the 1st & 2nd group. M_1 & M_2 - Mean of 1st & 2nd group. SD_1 & SD_2 – Standard Deviation of 1st & 2nd group. MD – Mean Difference of the groups. S.E.D. – Standard error of difference. ** - Significant at 0.01 level

difference in the mean salivary testosterones (pg/ml) of Volleyball pllayers and non-sportsmen. Further as t-value is 4.10(p = 0.01), there exists a significant difference in the mean salivary testosterones between Basketball players and non-sportsmen. Similarly, a significant difference was found in the mean salivary testosterones between Football players and non-sportsmen as t-value is 8.57 (p = 0.01).

DISCUSSIONS:

We found a significant difference (p = 0.01) between in the finger ratios (both hands) of sportsmen (Volleyball, Basketball & Football) who had won medals in National/All India Inter University championships in their respective sports and non sportsmen (who had never ever participated in any competitive sports). The mean digit ratio 2D:4D in the sportsmen categories were much less then that of non sportsmen. Concentrations of testosterones in Salivary (pg/ml) were significantly higher in the sportsmen (Volleyball – 85.58 ±2.539, Basketball – 82.92 ±3.232 & Football – 87.00 ±2.594) then non sportsmen - 78.08 ±2.503). Further the concentration of salivary testosterones were very much in the normal range in the all categories but non sportsmen were found with significantly less (p = 0.01) then the sportsmen. These findings support previous results indicating that digit ratio (2D:4D) is negatively associated with prenatal

testosterone, and it is also negatively associated with ability in sports such as football Manning and Taylor (2001), skiing Manning (2002), middle distance running, and endurance running Manning (2009a), sprinting ability Manning & Hill (2009b), elite and non elite sports persons Porycuka et al. (2005), rugby performance Bennett et al. (2010), rowing Longman et al. (2011), fencing Voracek et al. (2006), competitiveness in sports Hönekopp et al. (2006), motor skills in children Mathangi K et al. (2012), swimming performance Sudhakar et al. (2013) and physical fitness component in adolescent girls Peeters MW et al.(2013).

The association we observed between salivary testosterone levels and digit ratio (2d:4d) encourages further study of sporting ability in the interpretation of digit ratios as markers. These results contribute to an increasingly consistent literature showing important associations of digit ratio (2D:4D), an indicator of Prenatal programming of sporting success and lateral differences in 2D:4D, with reproductive endocrine parameters both men and women. These results further encourage the use of digit ratio (2D:4D) as a marker for prenatal androgen exposure and help to further clarify the Prenatal programming of sporting success.

CONCLUSIONS:

Talent identification in youth sports is often more of an art than a science. Researchers and coaches continually debate what markers indicate natural talent for a particular sport. Factors such as genetics and anatomy are thought to determine potential ability. Digit ratio (2d:4d) may provide a useful retrospective marker for early androgen exposure, making it possible to correlate such exposure with sporting success in the sports requiring high power (physical strength), well-developed cardiovascular systems and high level of visual-spatial skills. Some known extragenital effects of prenatal testosterone that contribute to the development of efficient cardiovascular systems, good visuospatial abilities, physical endurance and speed, and to the propensity for rough-and-tumble play, apparently promote sporting success in adult life. These findings extend related evidence suggestive of prenatal programming of aptitude across a variety of sports and can be used as tool for sports talent identification.

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