SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

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 do men (George, 1930; Manning, Scott, Wilson, and Lewis-Jones, 1998). This sex difference in finger length patterns was first reported more than 100 years ago (Ecker, 1875). A recent replication of this sex difference in a cross-sectional sample of humans from a given population (Liverpool, England) reported stable means of 2D:4D for males and females from 2 years of age through adulthood (Manning et al., 1998, Manning, 2002). Since the masculinizing and defeminizing effects of androgens appear to be involved in most somatic sex differences reported thus far in the literature (Breedlove, Cooke, and Jordan, 1998), it appears that the 2D:4D sexual dimorphism may also be due to androgens. The 2D:4D sex difference may, however, arise from some other biological mechanism that differs between the sexes. For instance, an early report suggested that the longer index finger in women may be due to sex-influenced inheritance of a gene involved in skeletal structure that is dominant in women and recessive in men (Winchester, 1976). The consistency of the 2D:4D sex difference across age in humans suggests an organizational, developmentally early mode of action. However, Manning and colleagues’ in 2004 reported a significant negative correlation between adult circulating testosterone levels and 2D:4D in men, which suggest that adult levels of testosterone may affect finger length patterns in humans.

Variation in finger length ratio is thought to reflect the influence of prenatal testosterone during development (Manning, 2002a; Manning et al., 2003a). While this correlation is somewhat conjectural, two non-exclusive causes have been posited. The first is that common genes (Hoxa and Hoxd) underlie development of both fingers and gonads (Kondo et al., 1997; Peichel et al., 1997). The second is that allelic variation in androgen receptor sensitivity influences digit ratio. More masculine finger ratios are associated with androgen receptor alleles with fewer CAG base-pair microsatellite repeats in the terminal domain (Manning et al., 2003a). Increased number of such
repeats produces receptors with lower androgen sensitivity (Chamberlain et al., 1994; Kazemi-Esfarjani et al., 1995).

More evidence for a relationship between androgen concentration during development and finger ratio comes from children with congenital adrenal hyperplasia (CAH). CAH causes the individual to be exposed to increased levels of androgens from early in gestation to the early neonatal period (Berenbaum and Reinisch, 1997). Both males and females with CAH, and therefore high developmental androgens, exhibit more masculine finger length ratios than controls (Brown et al., 2002c; Okten et al., 2002), but not necessarily when measured on the left hand (Buck et al., 2003).

Manning and colleagues have found significant correlations between more masculine (small) digit ratios and achievement, ability, and speed in a variety of sports and in visual-spatial ability (Manning and Taylor, 2001; Manning, 2002a, 2002b).

Fetal and adult testosterone may be vital in the establishment and maintenance of sex-dependent abilities associated with male physical competitiveness. 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), 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. 2D:4D difference. The relationship between digit ratio and sports like archery and shooting has not been defined. Arms strength, calmness, concentration, accuracy and consistency are far more important virtues for an archer and shooter than aerobic endurance capacity, power and aggression. We investigated the difference and correlation of digit ratio and salivary testosterone in elite players of Handball, Volleyball, Basketball, Football,
Boxing, Wrestling, Judo, Shooting and Archery, which require different physiological, psychological and physical compositions.

**Statement of Problem**

“A STUDY OF DIGITAL FINGER RATIO AND SALIVARY TESTOSTERONE IN INDIAN ELITE SPORTS PERSONALS”

**Objectives of the Study**

1. To find out the digital finger ratio 2D:4D of the elite Indian sports persons participating in Boxing, Wrestling, Judo, Volleyball, Basketball, Football, Handball, Shooting and Archery.

2. To find out the digital finger ratio 2D:4D of non-sports personals both males and females.

3. To find out the concentration of salivary testosterone in the elite Indian sports persons of Boxing, Wrestling, Judo, Volleyball, Basketball, Football, Handball, Shooting and Archery.

4. To find out the concentration of salivary testosterone in non-sports personals both males and females.

5. To find out the difference in the digital finger ratio 2D:4D between elite sports persons participating in different sports discipline.

6. To find out the difference in the digital finger ratio 2D:4D between elite sports persons and non sports persons.

7. To find out the difference in the concentration of salivary testosterone between elite Indian sports persons of different sports discipline.

8. To find out the difference in the concentration of salivary testosterone between elite Indian sports persons and non-sports personals.

9. To find out the correlation between digital finger ratio 2D:2D and level of salivary testosterone present in elite sports and non-sports personals.

**Hypothesis of the Study**

1. There exists no significant difference in the digital finger ratio 2D:4D between elite sports persons participating in different sports discipline i.e. Boxing,
Wrestling, Judo, Volleyball, Basketball, Football, Handball, Shooting and Archery.

2. There exists no significant difference in the digital finger ratio 2D:4D between elite sports persons and non-sports persons.

3. There exists no significant difference in the concentration of salivary testosterone between elite Indian sports persons of different sports discipline.

4. There exists no significant difference in the concentration of salivary testosterone between elite Indian sports persons and non-sports personals.

5. There exists no significant correlation between digital finger ratio 2D:2D and level of salivary testosterone present in elite sports and non-sports personals.

Delimitations

1. The study was confined to a total sample of 850 both male and female.

2. The study was confined to 550 elite Indian sports persons both male (N=300) and female (N=250) participating in Boxing, Wrestling, Judo, Volleyball, Basketball, Football, Handball, Shooting and Archery.

3. The study was further delimited to three hundred (Male = 150 & Female=150) non sports personals who have never ever participated in any competitive sports and pursuing their masters degree from Kurukshetra university.

4. In the elite sports category only those sports personals who have won (First, Second & Third) position at National/All India Inter-University levels in the discipline of Boxing, Wrestling, Judo, Volleyball, Basketball, Football, Handball, Shooting and Archery were selected as subjects.

5. The study was further delimited to finger ratio 2D:4D of both right and left hands.

6. Concentration of testosterone hormone present in the saliva of subjects was analyzed with Solid Phase Radio Immuno Assay at Thyrocare Technologies limited, Mumbai.
Limitations

The lifestyle, habits, heredity, nutritional intakes, physical fitness level, psychological and physiological variables were beyond control of the research worker. These were considered as limiting factors of the study.

Selection of Sample

In the present study purposive sampling method has been used for the collection of data. The research worker selected a total of 850 subjects (450 males and 400 females) to measure the digital finger ratio 2D:4D out of the total of 850; 300 were non sportspersons who have never participated in any competitive sport/game and remaining 550 were elite sports persons both male and female who had participated and got first, second and third position at least at national/ inter-university levels in the discipline of Boxing, Wrestling, Judo, Volleyball, Basketball, Football, Handball, Shooting and Archery. The age of all the subjects selected for the present study above was 17 years. Similarly the 240 subjects (120 males and 120 females) were selected for the testing of Salivary Testosterone Hormone (STH) out of these 240; 216 were elite sportspersons 12 from each category of game (both males and females) remaining 24 subjects were selected from non sportspersons( 12 males & 12 females).

Variables Studied

In the present study following two variables were studied:

a) First variable was digital finger ratio (Ratio between the length of Index finger and Ring finger) i.e. 2D:4D.

b) Second variable was Salivary Testosterone Hormone (Level of testosterone hormone present in the subjects Saliva).

Tool Used for the Collection of Data

Following tools were used for the collection of data for different variables:

(i) **Digital Vernier Caliper**: Digital Finger Ratio (2d:4D) was measured with digital veriner Caliper.
(ii) **Salivary Testosterone Hormones:** All the samples collected from the subjects were sent to the Thyrocare Technologies Limited, D-37/1 TTC MIDC, Navi Mumbai-400703 for the analyses of level of testosterone present in saliva.

**Statistical Techniques Used**

In order to analysis the data in the present study the following statistical techniques were used manually as well as on computer:

a) **Mean:** Arithmetic mean was calculated by adding up all the Observations and dividing the sum by the number of individuals.

\[
\bar{X} = \frac{\sum X}{N}
\]

Where \( N \) = Total Number of subjects
\( \sum X \) = Sum of all individual values.

b) **Standard Deviation:** It measures the absolute dispersion of variability. It is calculated by following method.

\[
\text{S.D.} = \sqrt{\frac{\sum x^2 - (\sum x)^2}{n-1}}
\]

Where \( \sum x^2 \) = Sum of squares of the individual values.
\( (\sum x)^2 \) = The square of the sum of the individual values.
c) **Standard Error of Difference (S.E.D.):**

\[
S.E.D. = \sqrt{\frac{(SD_1)^2}{N_1} + \frac{(SD_2)^2}{N_2}}
\]

Where

- S.D1 = Standard Deviation of First Group.
- S.D2 = Standard Deviation of Second Group.
- N1 = Number of Sources in First Group.
- N2 = Number of Sources in Second Group.

d) **t-Test:** This test was applied to determine whether the observation difference between two sample means X1 and X2 were indicative of real difference or it is due to the sampling error. The t-ratio was calculated with the following formula of t-test:

\[
t = \frac{M_1 - M_2}{SD}
\]

Where

- M1 = Mean of First Group.
- M2 = Mean of Second Group.

e) **Karl Pearson’s Co-efficient of Correlation:**

\[
r = \frac{\sum XY}{\sqrt{\sum X^2 + \sum Y^2}}
\]

Where

- \( \sum X \) = Deviation of x-series from the mean of x.
- \( \sum y \) = Deviation of y-series from the mean of y.

f) **ANOVA:** The purpose of analysis of variance is to test differences in means (for groups or variables) for statistical significance. This is accomplished by analyzing the variance, that is, by partitioning the total variance into the component that is due to true random error (i.e., within-group SS) and the components that are due to differences between means.
Findings and Conclusions

1. A significant difference in the digital finger ratio (2d:4d) between elite sports personal (except shooting and archery) and non sports persons has been found.

2. Elite sports men and women (except shooting and archery) were having significantly shorter digital finger ratio (2d:4d) then non sports men and women.

3. Elite sports men and women of shooting and archery were having lesser mean ratio of digital finger(2d:4d) then non sports men and women but no significant difference was found between them.

4. Digital finger ratio was found to be sexually dimorphic in non sports categories as men were having significantly lesser 2d:4d then their female counterpart.

5. In the sports category men participating in archery, shooting and handball were having significantly smaller 2d:4d then their female counterpart.

6. The sportsmen participating in boxing, judo, wrestling, football and volleyball were having lesser mean value of 2d:4d then female but no significant difference was found between them.

7. Elite sports men of boxing, judo, wrestling, volleyball and football were having significantly shorter 2d:4d when compared with elite sports men of handball, archery and shooting.

8. Elite sportswomen of boxing, wrestling and football were having significantly shorter finger ratio 2d:4d when compared with elite sportswomen of judo, volleyball, handball, archery and shooting.

9. Elite sports men of boxing, wrestling, judo, football and volleyball were having significantly higher concentration of testosterone in their saliva in comparison to sportsmen of handball, archery and shooting.

10. Sports men of boxing, wrestling, judo, football and volleyball were having significantly higher concentration of testosterone in their saliva in comparison to non sportsmen.
11. Sports men of handball were having higher mean concentration of testosterone in their saliva in comparison to shooting, archery and non sportsmen but no significant difference was found between them.

12. Elite sports women of boxing, wrestling and football were having significantly higher concentration of testosterone in their saliva in comparison to sportswomen of judo, volleyball, handball, archery and shooting.

13. Sports women of judo, volleyball and handball were having higher mean concentration of testosterone in their saliva in comparison to shooting, archery and non sportsmen but no significant difference was found between them.

14. Concentration of testosterone in the saliva was negatively correlated with digital finger ratio 2d:4d in all categories.

Recommendations

On the basis of conclusions of the research work done and in the light of the findings of the present study, the following recommendations could be made:

1. A similar study can be done on the different category of the athletes both males and females.

2. The scope of the study can be widen to cover
   
   (i) Junior Level and School level.
   
   (ii) International/Commonwealth/Asian/Olympic level.

3. A similar study may be undertaken to study the Psychological Variables.

4. This type of study may not be limited to the field of sports only, the similar study can be undertaken to study the various variables (Physiological and Psychological) in the corporate sectors, civil society and other variables may be studied on the various part of the society other than the field of sports.

5. This type of study may be undertaken as a predictor to the hormones related issues relating to Testosterone Hormone.
6. Coaches and Physical Education Teachers may take help of this type of study to identify the sports talent at early stage and utilize the same to give the best performance at an ideal stage.

7. This type of study will help not only in classification of specific individual for a specific sports but the further researches may also be helpful in the classification of specific individual for specific profession.

Finally the similar type of study may be undertaken to specify the characteristics of an individual relating to testosterone hormone.