

Original Research Article

Role of 2nd Digit:4th Digit Ratio(2D:4D Ratio) in Establishing the Biological Profile of an Individual

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Abstract

Introduction: The process of identification focuses mainly on establishing the biological profile by estimating the sex, age and stature which significantly narrows down pool of suspects. The 2D:4D ratio is a sexually dimorphic trait which is influenced by prenatal estrogen and testosterone levels. Studies also suggest that there might be strong relationship of this ratio and stature and age well. This study is taken in combination of all the 3 primary parameters of biological profile and co-related with that of 2D:4D ratio. And there is no such study conducted in this part of Karnataka.

Aims and Objectives: To study the role of 2D:4D ratio in establishing the biological profile(Sex, Age and stature) of an individual by manual digital measurements and digital print measurements.

Material and Method: Hundred first year medical students (n=100) (males= 50 and females =50) of S. N. Medical college, Bagalkot were included in the study. Authentic proof of age was collected and height measured by stadiometer and 2d:4d by digital callipers for both hands. SPSS 17.0 used to analyse the data.

Results: In Males, the ratio varied from 0.89 to 1.04 with mean and standard deviation of 0.97 ± 0.03 on right side and on left side it varied from 0.85 to 1.03 with mean \pm SD of 0.98 ± 0.04 . While in females ratio varied from 0.91 to 1.11 with Mean \pm SD of 0.97 ± 0.04 on right side and on left side it varied from 0.83 to 1.12 and Mean \pm SD of 0.98 ± 0.04 on left side

Based on the mean 2D:4D ratio for both the sexes, 0.97 on right and 0.97 on left side, sectioning point was derived. When all the cases below and equal to 0.97 were considered as males and those above 0.97 were considered as females, one could accurately determine the sex up to 90% accuracy.

Conclusions: 2D:4D ratio can be effectively and accurately used to establish the biological profile of an individual which can help forensic experts and medicolegal experts to narrow down the pool of suspects in crime or identify the victims of crime, mass disasters, road traffic accidents etc. Moreover 2D:4D, ratio relatively less time consuming, and cost effective.

Keywords: 2d:4d ratio, Biological profile, identification, sex, stature, age

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Introduction

Human identification has always been a major concern for forensic investigation and other law enforcement agencies. The process of identification focuses mainly on establishing the biological profile by estimating the sex, age and stature¹. In this era of

increasing crimes, violence, Road traffic accidents, natural calamities identification from mutilated remains poses a great challenge to the forensic experts. Most of the times in violence and road traffic accidents its only dismembered parts which are available for the experts to establish the biological profile of victims. Dismembered parts may be limbs, hand, foot etc. In case if hands are recovered from the site then one can establish the biological profile of an individual. Examination of the recovered hand proceeds with the somatometry of the hand then osteological and radiological analysis of the hand which helps to provide primary identity indicators such as sex, age, and stature².

The human hand is the most frequently used and versatile part of the body, and is of great scientific importance to investigators in the field of anthropometry, forensic pathology, orthopedic surgery, and ergonomics³.

Among the hand measurements, 2d: 4d ratios (measures of the relative lengths of index and ring fingers) attract considerable research interest because they exhibits sexual dimorphism and left–right asymmetry and is associated with a surprising variety of morphological, physiological, sexual preference and behavioural traits as well as with ability in certain sports and with the risk of developing medical conditions such as autism, infertility and breast cancer⁴.

Sex and 2D:4D

As stature and other parameters are influenced by sex, thus the determination of sex is the foremost criterion in identity authentication of an individual among all the primary parameters of identification. The 2D:4D ratio is a sexually dimorphic trait which is influenced by prenatal estrogen and testosterone levels. High prenatal levels of androgens (high testosterone / estrogen) determine lower values of 2D:4D and vice versa. Hox A and Hox D genes are responsible for both gonadal and digital differentiation⁵. This sexual dimorphism in 2D : 4D ratios is apparent by 2 years of age and appears to be established early in life, possibly by the 14th week of gestation⁶⁻⁸. This confirms the fact that digit ratio (2D:4D) acts as a sexually dimorphic phenotypic trait². Digit ratio is a sexually dimorphic trait found in a variety of species ranging from humans and mice to zebra finches and is constant since birth⁹. It is generally agreed that 2D : 4D ratios tend to be greater in females (closer to 1.0) and that gender differences tend

to be larger for the right hand than for the left^{10,11}.

Age and 2D:4D

Among the various parameters of identification, individual's stature is an inherent characteristic, the estimate of which is considered to be important in those cases where only fragmentary or mutilated remains of an unknown person are recovered¹². Gillam et al study findings indicate that the 2D : 4D ratio does increase with age⁽⁴⁾. According to Williams et al, lower 2D : 4D ratios were found in both genders early in postnatal life but stabilize at a higher value in adults¹³.

2D:4D ratio and stature

Danborno B et al, reported that stature can be estimated using 2D:4D ratio in both males and females and from both right and left hands and the ability to accurately¹⁴. According to predict height from 2D and 4D is greater in the males than the females due to the lower values of standard error of estimates¹⁵.

Need for the study

Previous studies have co-related 2D:4D ratio with either stature or sex or age . This study is taken in combination of all the 3 primary parameters of biological profile that is sex, stature and age and co-related with that of 2D:4D ratio. And there is no such study conducted in this part of Karnataka. This has prompted authors to test the role of 2D:4D ratio in establishing the biological profile of an individual. This research study proves beneficial for identity authentication, for criminal investigation and a powerful forensic tool for medico-legal cases. Also the data so collected can be useful as forensic anthropology population data.

Aims and objectives

To study the role of 2D;4D ratio in establishing the biological profile(Sex, Age and stature) of an individual by manual digital measurements and digital print measurements.

Material and Method

Hundred first year medical students (n=100) (males= 50 and females =50) of S. N. Medical college, Bagalkot were included in the study after taking the informed consent. Ethical clearance obtained from Institutional ethical committee. Research study was conducted on single community to minimize regional

& environment bias. Each participant was required to fill in a form containing basic demographic profile (e.g. sex; age; ethnicity). Informed consent was obtained. Participants with any medical history of hand, disease, injury, deformity were excluded from the research study.

Morphometric measurements

Recording of the height:

All the readings were taken at the same time of the day to minimize the diurnal variation. The height of each subject was recorded by asking the subject to stand erect with barefoot on the base of the standard stadiometer in a Frankfurt plane. The subject was instructed to stand without support and the arms by the side of the body. The horizontal plate being attached to the vertical wooden scale of two meters height and the reading was taken from the base of the stadiometer to the vertex of the head in centimetres.

2D:4D ratio: Measured by using digital callipers to the nearest millimetres.

2DL (length of Index finger): It is measured as the distance between the mid-point of metacarpo – phalangeal crease at the base of index finger to the tip or most forwardly placed point of the index finger. (A to B).

4DL (length of the Ring finger): It is measured as the distance between the mid-point of metacarpo – phalangeal crease at the base of ring finger to the tip or most forwardly placed point of the ring finger. (X to Y).

2D:4D digit ratio

2D: 4D Digit Ratio : Length of the index finger/ Length of the ring finger

Sectioning point

Sectioning point or cut-off was calculated based on average 2D:4D digit ratio for both hands and in both sexes. Percentage accuracy of sex determination was performed on the basis of sectioning point for 2D:4D digit ratio in the entire population.

Statistical analysis

SPSS 17.0 was employed for the statistical analysis of the research data. Descriptive statistics i.e. mean, standard deviation, range, standard error for 2D & 4D digit length was calculated. Male – female differences

for the variables were observed using student’s t-test at $p < 0.05$ as level of significance.

Results

Table 1: Descriptive statistics of 2D:4D ratio

Parameters	Right hand		Left Hand	
	Male	Female	Male	Female
Sex				
Minimum	0.89	0.91	0.85	0.83
Maximum	1.04	1.11	1.03	1.12
Mean	0.97	0.97	0.96	0.98
Standard Deviation	0.03	0.04	0.033	0.04
Sectioning Point	0.97		0.97	

Descriptive statistics of 2D:4D ratio is shown in Table no.1. In Males, the ratio varied from 0.89 to 1.04 with mean and standard deviation of 0.97 ± 0.03 on right side and on left side it varied from 0.85 to 1.03 with mean \pm SD of 0.98 ± 0.04 . While in females ratio varied from 0.91 to 1.11 with Mean \pm SD of 0.97 ± 0.04 on right side and on left side it varied from 0.83 to 1.12 and Mean \pm SD of 0.98 ± 0.04 on left side

Based on the mean 2D:4D ratio for both the sexes, 0.97 on right and 0.97 on left side, sectioning point was derived. When all the cases below and equal to 0.97 were considered as males and those above 0.97 were considered as females, one could accurately determine the sex up to 90% accuracy.

Table 2: Linear regression formulae were calculated for estimation of stature from 2D:4D ratio

Male	Height = $168.9 + 1.94(\text{Right sided ratio}) - 0.08(\text{Left sided ratio})$
Female	Height = $114.98 + 16.7(\text{Right sided ratio}) + 28.5(\text{Left sided ratio})$

Table 2 shows the linear regression equations derived for both the sexes to estimate the stature of an individual

Table 3: Linear regression formulae were calculated for estimation of age from 2D:4D ratio

Male	Age = 8.4+7.8(Right sided ratio)+ 24.4(Left sided ratio)
Female	Age = 35.1+9.3(Right sided ratio)-22.0(Left sided ratio)

Table 3 shows the linear regression equations derived for both the sexes to estimate the age of an individual

Discussion

This study was conducted to know the role of 2D:4D ratio in establishing the biological profile of an individual. Digit ratio is a sexually dimorphic trait found in a variety of species ranging from humans and mice to zebra finches and is constant since birth. Traits ranging from musical abilities, numerical and spatial skills and sporting capabilities and medical conditions have been reported to be associated with the digit ratios in different populations¹⁶.

Sex and 2D:4D

Manning et al. demonstrate that 2D:4D is the only trait that measurably explains sexual dimorphism. It reflects prenatal androgen action (such that higher testosterone is associated with lower 2D:4D⁷). Females have relatively high ratio whereas males show lower 2D:4D digit ratio. These statistically significant differences may be due to the early onset of puberty in females than males as males have two more years of physical growth. According to sangeeta et al study, ratio below and equal to 0.99 is suggestive of male sex for both hands, while a ratio of more than 0.99 is suggestive female sex for both the hands². In our study, a sectioning point of 0.97 derived for both right and left hands in both the sexes. When all the cases below and equal to 0.97 were considered as males and those above 0.97 were considered as females, one could accurately determine the sex up to 90% accuracy.

With respect to handedness, few authors reported that ratio was found slightly higher for right hand than left hand². In present study there was no significant difference on right and left side.

Age and 2D:4D ratio

Previous studies on effect of age on 2D:4D ratio are discrete and inconclusive. According to study done by

Gillam et al, 2D : 4D ratio does increase with age². More recently, a 4-year longitudinal study on children between 7 and 17 years of age found that 2D : 4D ratios increased slightly with age, with the effect more marked in the left hand¹⁷. In present study we have calculated the linear regression formulae for both sexes which can estimate the age from 2D:4D ratio for population of this region.

Stature and 2D:4D ratio

According to Danborno et al¹⁴, 2D:4D ratio could be used to estimate the height and weight of an individual accurately. In present study we have calculated the linear regression formulae for both sexes which can estimate the age from 2D:4D ratio for population of this region.

Conclusion

In this era of increasing the violence, road traffic accidents, crimes, forensic experts faces a challenge to establish the identity of an individual. 2D:4D ratio can be effectively and accurately used to establish the biological profile of an individual which can help forensic experts and medicolegal experts to narrow down the pool of suspects in crime or identify the victims of crime, mass disasters, road traffic accidents etc. Moreover 2D:4D, ratio may prove to be a reliable sex indicator, easy to carry out, relatively less time consuming, and cost effective. It has great implication in case of when fragmented part is retrieved and DNA analysis is out of reach. This study has to be carried out in larger population at community level involving different ethnic groups to increase its predictive value.

Conflict of Interest: None

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