Is There an Association between 2D:4D Upper Limb Digit Ratio and Resting Heart Rate: A UK Medical School Cross-Sectional Study

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ABSTRACT

BACKGROUND: Current literature suggests that upper limb digit ratio is sexually dimorphic in humans and is thought to correlate with prenatal sex steroids, whereby low 2D:4D is linked to high prenatal testosterone and low prenatal oestrogen. AIMS: To investigate correlations between 2D:4D ratio and resting heart rate. SUBJECTS AND METHODS: Participants were first-year medical students at the University of Leeds. 120 females and 30 males (mean ages (years): 18.89 ± 1.41 and 20.20 ± 4.89 respectively. Measurements of the length of second and fourth digits were taken in both the right and left hand, from the tip of the finger to the crease proximal to the palm, measuring to the nearest 0.01cm (average measurement recorded). Measurement of resting heart rate was also taken. RESULTS: No significant relationship was found between 2D:4D ratio and resting heart rate. 2D:4D ratio was 0.98 ± 0.03 in females and 0.98 ± 0.03 in males. Resting heart rate was 69.24 ± 10.51 and 68.17 ± 11.25 for females and males respectively. CONCLUSION: Previous studies have shown contrasting findings as to the association between 2D:4D ratio and physical fitness. However, we were relying on the assumption that a low resting heart rate is a surrogate marker for cardiovascular fitness, which may not be applicable in all cases. This perhaps explains why no correlation was seen between the two variables in this study.
INTRODUCTION

Researchers commonly use the term 2D:4D ratio, which describes the ratio of the second to fourth digit length in the upper limb. It is widely reported in the literature that digit ratio is sexually dimorphic in humans, whereby males may have on average lower digit ratios (longer fourth digits relative to second digits) when compared to females, who on average have a higher digit ratio (Suchonova et al, 2019; Manning et al, 2004).

Speculation has arisen that there may be a relationship between 2D:4D ratio and various physiological parameters, such as maximal oxygen uptake, athletic performance and patterns of cardiovascular disease (Hill et al, 2012). This relationship may exist since some of these parameters may represent surrogate markers for physical traits, whereby several studies have shown that there is a negative correlation between 2D:4D ratio and male and female performance in various sports such as football and rugby. In contrast, one study observed no significant correlations between 2D:4D ratio and physical fitness tests in prepubescent girls (Tester and Campbell, 2007) These findings were not replicated in prepubescent boys, where a significant negative correlation was seen when 2D:4D was compared with handgrip strength, aerobic fitness and agility (Bennett et al, 2010).

Extensive studies have shown a high performance in sports and athletics is a strong predictor of efficient cardiovascular function as well as high physical fitness and competitiveness in training that may be promoted by high levels of testosterone (Ranson et al, 2015).

Whilst there is ample evidence in the literature of an association between 2D:4D ratio and physical fitness, much research still remains into the use of other physiological markers, such as resting heart rate. Some studies have shown that high performing athletes with a resting heart rate closer to 40 beats per minute, (where a normal resting heart rate ranges from 60-100 beats per minute), display higher levels of cardiovascular function and better cardiovascular fitness (Reimers et al, 2018).

Since it is known that resting heart rate can be associated with a high level of cardiovascular fitness with 2D:4D ratio also serving as a marker for cardiovascular fitness (Eler, 2012), this study aims to determine whether there is an association between 2D:4D ratio and resting heart rate, using a larger sample size of 150 participants. This would be of interest given that resting heart rate is a surrogate marker of athleticism and is not gender-specific.

MATERIALS AND METHOD

Participants included 150 anonymous first-year medical students, recruited from the student population at the University of Leeds, UK. The female sample, n=120 females (80%) and the male sample, n=30 (20%).

The eligibility criteria was that participants were first-year medical students at the University of Leeds. All study participants contributed voluntary and the data was anonymised, hence no ethical approval was required.

MEASUREMENTS OF FINGERS

Measurements of the length of second and fourth digits were taken from the tip of the finger to the crease proximal to the palm, measuring to the nearest 0.01cm. The measurements were taken in both the right and left hand, twice on each hand and an average value calculated for each digit (left and right). For example, average 2D Left hand = [Reading 1 2D left + Reading 2 2D left] / 2.

The 2D:4D ratio was calculated by dividing the average length of the second digit by the average length of the fourth digit. The values of the ratio were calculated for the left and right hand separately.

MEASUREMENT OF RESTING HEART RATE

Measurement of resting heart rate was taken by asking participants to take their pulse at their wrist. Participants were instructed to place two fingers between the bone and tendon area, located over the radial artery and counting with the pulsation of a beat. An investigator timed the process for 30 seconds. The number of beats obtained was then multiplied by 2, to give the number of beats per minute.

STATISTICAL ANALYSIS

Data from the study were analysed using the STATA software package (version 15).

Pearson correlation analysis was used for assessing the association between 2D:4D ratio and resting heart rate. The alpha level for statistical significance was set at p ≤ 0.05.
ETHICAL APPROVAL

No ethical approval was required, as the data was collected from the participants during an optional teaching exercise. No identifiable patient information was obtained for this study.

RESULTS

The various results of 2D:4D ratio taken on both left and right hands for males and females and the measurement of resting heart rate was analysed.

All results are represented as mean ± SD. The descriptive statistics (means ± s) of the sample were as follows: age was 18.89 ± 1.41 years for females and 20.20 ± 4.89 years for males. 2D:4D ratio was 0.98 ± 0.03 in females and 0.98 ± 0.03 in males. Resting heart rate was 69.24 ± 10.51 and 68.17 ± 11.25 for females and males.

There was no relationship between 2D:4D ratio and resting heart rate. As 2D:4D ratio increases, resting heart rate is not affected. This is represented in Fig 1. showing a scatterplot of resting heart rate versus 2D:4D ratio, with a line of best fit and Fig 2. showing separate analyses by gender.

![Scatterplot showing no correlation between resting heart rate and 2D:4D ratio](image)

Figure No. 1: Scatterplot showing no correlation between resting heart rate and 2D:4D ratio

In both males and females, there was no correlation between 2D:4D ratio and resting heart rate, with results of \( r=0.018, n=148, P=0.83, 95\% \text{ CI} =-0.144 \text{ to } 0.179 \).

The line across each result represents the line of best fit.

**Figure No. 2:** Separate scatterplot by gender, showing no correlation between resting heart rate and 2D:4D ratio, with values of \( r=0.135, n=30, P=0.477 \) and \( r=-0.021, n=118, P=0.825 \) for males and females respectively.

The line across each result represents the line of best fit.

**DISCUSSION**

In an attempt to establish a correlation between 2D:4D ratio and resting heart rate, the data in the current study suggests no correlation between 2D:4D ratio and resting heart rate in both males and females. This is in contrast to previous studies that have shown an association between 2D:4D ratio and cardiovascular fitness (Ranson et al, 2015). However, we were relying on the assumption that a low resting heart rate is a surrogate marker for athleticism. Therefore, whilst it is true that keen sportsmen and those with high levels of physical exertion may have a lower resting heart rate due to an increased stroke volume, prenatal testosterone may also influence behaviours which impact on athletic performance such as frequency of exercise (Manning et al, 2007).
Furthermore, previous studies with a large sample size, similar to the current study, have suggested cardiovascular fitness was negatively correlated with 2D:4D ratio. This association was observed in male participants but not in female participants (Eler et al, 2018). Therefore, there are inconsistent findings among the studies, as in the current study, where there was no association between 2D:4D ratio and resting heart rate in both males and females. This may have arisen due to gender distribution in the study population, which consisted of 120 females and 30 males. A larger sample size with more equal male to female ratio would increase the reliability of the results and allow a statistically significant gender-specific analysis. For example, the gender ratio in similar studies was more matched (Manning et al, 2007) and found support for a negative correlation between 2D:4D ratio and measures of cardiovascular fitness in males.

Another possible source of conflicting data may be due to the methodology for measuring resting heart rate in the current study. It is reported that a pre-defined rest period prior to measurement would ensure that a resting recording was measured accurately, rather than a post exertional recording (Romero et al, 2017).

Although, the current study shows no association between 2D:4D ratio and resting heart rate, future research to further elucidate on this current study would need a larger sample size with more equal gender distribution, pre-defined exclusion criteria and standardisation of protocols for resting heart rate measurements. This could have potential implications for subject selection for high physical endeavours such as extreme sports or military recruitment.

REFERENCES
