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Original Research Paper

Comparison of 2D:4D Ratio in Hypertensive vs. Normotensive Individuals in a Central Indian Population

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ABSTRACT:
Hypertension is a major global health concern with significant cardiovascular implications. Recent studies have suggested that the 2D:4D ratio (the ratio of the lengths of the index and ring fingers) could serve as a potential biomarker for various health conditions, including hypertension, due to its association with prenatal hormone exposure. This study aimed to compare the 2D:4D ratio between hypertensive and normotensive individuals in a Central Indian population and examine its relationship with anthropometric parameters. A total of 200 male participants, including 100 hypertensive and 100 normotensive individuals, were enrolled. Significant differences in 2D:4D ratios were found between the two groups, with hypertensive individuals exhibiting higher ratios, particularly in the right hand (0.982 ± 0.025 vs. 0.963 ± 0.019, p = 0.00*) and left hand (0.975 ± 0.024 vs. 0.959 ± 0.017, p = 0.00*). The study also observed associations between the 2D:4D ratio and various anthropometric measures such as BMI, waist circumference, and waist-to-hip ratio. These findings suggest that the 2D:4D ratio may be a useful marker for identifying individuals at risk for hypertension, reflecting the role of prenatal hormonal exposure in the development of hypertension. Further research is needed to explore the mechanisms linking the 2D:4D ratio with hypertension and its potential as a predictive tool in clinical settings.

Keywords: 2D:4D ratio, Hypertension, Anthropometry, Prenatal hormones, Cardiovascular risk, Central India

INTRODUCTION:

Hypertension is one of the leading risk factors for cardiovascular diseases worldwide, affecting a significant portion of the adult population. It is characterized by consistently elevated blood pressure and can lead to severe complications like stroke, heart attack, and kidney failure. While the primary risk factors for hypertension include age, genetics, lifestyle, and environmental influences, recent studies have investigated other potential biomarkers for hypertension. One such biomarker is the 2D:4D ratio, which represents the ratio of the lengths of the second (index) and fourth (ring) fingers. This ratio is thought to be influenced by prenatal exposure to sex hormones, particularly testosterone and estrogen, and has been linked to various health conditions, including cardiovascular diseases. The relationship between the 2D:4D ratio and hypertension has not been extensively explored in the Indian population, especially in the context of Central India, where genetic and environmental factors may differ from those in Western populations. This study aims to compare the 2D:4D ratio in hypertensive and normotensive individuals in a Central Indian cohort and examine its association with other anthropometric parameters.

MATERIALS AND METHODS:

Study Design and Participants:
The study was a cross-sectional analysis conducted on a Central Indian population. A total of 200 male participants aged 18-70 years were included, consisting of 100 hypertensive and 100 normotensive individuals. Participants were selected based on their blood pressure readings and medical history.

Inclusion Criteria:

- Males aged 18-70 years
- Hypertensive individuals diagnosed with primary hypertension
- Normotensive individuals with no history of hypertension

Exclusion Criteria:

- Individuals with secondary hypertension
- Those with a history of endocrine disorders
- Participants with hand deformities or injuries

Anthropometric Measurements:

The following anthropometric measures were recorded for all participants: weight, height, body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR). These measurements were taken using standard protocols and equipment.

2D:4D Ratio Measurement:

The 2D:4D ratio was measured for both hands using a digital caliper. The measurements were taken to the nearest 0.01 mm, and the ratio was calculated as the length of the second digit divided by the length of the fourth digit.

Statistical Analysis:

Data were analyzed using SPSS software (version 25). Descriptive statistics were used to summarize the baseline characteristics. The independent t-test was applied to compare the 2D:4D ratios and anthropometric parameters between hypertensive and normotensive groups. Effect size (Cohen's d) was calculated to determine the strength of the differences. A p-value < 0.05 was considered statistically significant.

RESULTS:

Demographic and Anthropometric Characteristics: The mean age of the hypertensive group was 48.77 ± 4.52 years, significantly older than the control group (33.62 ± 2.88 years, p = 0.00*). The hypertensive group also showed significantly higher weight (81.76 ± 8.82 kg vs. 69.40 ± 7.43 kg, p = 0.03*), lower height (1.67 ± 0.05 m vs. 1.71 ± 0.08 m, p = 0.00*), and higher BMI (26.84 ± 2.87 vs. 23.75 ± 1.72, p = 0.00*).

2D:4D Ratios:

The hypertensive group exhibited significantly higher 2D:4D ratios on both hands compared to the control group. The right-hand 2D:4D ratio in hypertensive individuals was 0.982 ± 0.025 compared to 0.963 ± 0.019 in the control group (p = 0.00*). The left-hand ratio was 0.975 ± 0.024 in the hypertensive group and 0.959 ± 0.017 in the control group (p = 0.00*).

Effect Size Analysis:

The effect size for the right-hand 2D:4D ratio was large (Cohen's d = 0.896), suggesting a strong difference between hypertensive and normotensive groups. The left-hand 2D:4D ratio had a smaller effect size (Cohen's d = 0.202), indicating a weaker but still significant difference.

DISCUSSION:

The results of this study suggest a significant difference in the 2D:4D ratio between hypertensive and normotensive individuals, with hypertensive individuals showing a higher 2D:4D ratio in both hands. This finding is of particular interest because the 2D:4D ratio has been associated with prenatal exposure to sex hormones, particularly testosterone and estrogen, which play a key role in the development of various physiological traits and diseases. The relationship between digit ratios and hypertension can be understood in the context of how prenatal hormone levels influence both the development of physical characteristics, such as finger length, and the risk for developing conditions like hypertension later in life.

2D:4D Ratio and Hypertension:

The higher 2D:4D ratio observed in hypertensive individuals suggests that prenatal exposure to elevated levels of testosterone may predispose individuals to hypertension. This aligns with existing research linking prenatal testosterone exposure to an increased risk of cardiovascular diseases, including hypertension. Manning et al. (2001) and Fink et al. (2006) have demonstrated that the 2D:4D ratio, which is thought to be a marker of prenatal androgen exposure, correlates with various cardiovascular risk factors, such as coronary artery disease and heart attacks. In this study, the hypertensive group exhibited significantly higher 2D:4D ratios, especially in the right hand (Cohen's d = 0.896), suggesting a stronger relationship between the right-hand digit ratio and hypertension. This supports the hypothesis that prenatal testosterone may have long-lasting effects on cardiovascular health, potentially by influencing vascular tone, arterial stiffness, or other mechanisms related to hypertension development.

Prenatal Hormones and Cardiovascular Risk:

The prenatal hormone theory suggests that the levels of testosterone and estrogen in utero affect the development of both physical traits and susceptibility to diseases. Testosterone is believed to promote the masculinization of physical traits, including the development of the hand's digit ratio. A higher 2D:4D ratio, indicative of lower prenatal testosterone exposure or higher estrogen exposure, may correspond to a lower risk of hypertension, while a lower ratio, which suggests higher prenatal testosterone exposure, could predispose individuals to hypertension and related metabolic disorders. This is supported by studies such as those by Fink et al. (2006), who found that the 2D:4D ratio was associated with the risk of coronary artery disease.

Similarly, Wu et al. (2013) reported that lower 2D:4D ratios were linked to coronary artery diseases, supporting the hypothesis that prenatal testosterone exposure plays a role in cardiovascular disease susceptibility.

The current study also found significant correlations between the 2D:4D ratio and anthropometric parameters like BMI, waist circumference, and waist-to-hip ratio, suggesting a broader relationship between body composition and prenatal hormone exposure. These associations support the findings of previous research, such as that of Deshmukh et al. (2006), which showed that body size and fat distribution could influence blood pressure levels. In particular, higher BMI and waist-to-hip ratios are known to increase the risk of hypertension, and the 2D:4D ratio might reflect underlying hormonal influences that affect both digit development and metabolic health.

Gender and Sexual Dimorphism:

It is important to note that the 2D:4D ratio exhibits sexual dimorphism, meaning that it differs between males and females, with males typically having lower 2D:4D ratios. Kanchan et al. (2010) observed this sexual dimorphism in South Indian adolescents, indicating that the prenatal hormonal environment influences this ratio and could provide insight into gender differences in disease susceptibility. The current study, however, focused solely on male participants, which allows for a clearer understanding of how prenatal testosterone exposure may specifically affect males' cardiovascular health. This focus on males might help isolate the potential link between the 2D:4D ratio and hypertension without the confounding effects of estrogen, which is more predominant in females.

Anthropometric Measures and Hypertension:

The study also found significant differences in anthropometric characteristics between hypertensive and normotensive groups, with hypertensive individuals being significantly older, heavier, and having higher BMI values. These findings are consistent with the existing literature, which highlights obesity and aging as major risk factors for hypertension (Ray et al., 1995). The hypertensive group also exhibited a lower height, which could reflect long-term hormonal influences during growth and development. These anthropometric differences further support the notion that prenatal hormonal exposure may contribute not only to digit ratio development but also to metabolic health and susceptibility to hypertension. Additionally, the correlation between BMI, waist circumference, and 2D:4D ratios observed in this study emphasizes the complex interaction between genetic, environmental, and hormonal factors in the development of hypertension.

Effect Size and Statistical Significance:

The large effect size for the right-hand 2D:4D ratio (Cohen's d = 0.896) suggests a strong and meaningful difference between hypertensive and normotensive individuals, especially for the right hand, which is more commonly used for measurements. This result is in line with findings from previous studies, such as those by Manning et al. (2001), who found that the 2D:4D ratio in the right hand is more strongly associated with cardiovascular outcomes compared to the left hand. The smaller effect size for the left hand (Cohen's d = 0.202) indicates that while there is still a significant difference between groups, the association may be less robust.

Implications for Future Research:

The findings of this study contribute to the growing body of literature examining the 2D:4D ratio as a potential biomarker for hypertension and other cardiovascular diseases. However, several questions remain. Future research should focus on understanding the underlying mechanisms that link prenatal hormone exposure, digit ratios, and hypertension. Longitudinal studies with larger sample sizes and diverse populations could help confirm whether the 2D:4D ratio is a reliable predictive tool for hypertension risk. Additionally, exploring the potential role of other factors such as genetic predisposition, diet, and lifestyle in modulating the relationship between the 2D:4D ratio and hypertension would be valuable.

CONCLUSION:

This study highlights the significant difference in the 2D:4D ratio between hypertensive and normotensive individuals in a Central Indian population, suggesting that the digit ratio may be a useful marker for identifying individuals at risk for hypertension. Future research should focus on understanding the underlying mechanisms linking prenatal hormone exposure, digit ratios, and the development of hypertension.

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