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Digit Ratio

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Synonyms

2D:4D; Finger ratio

Definition

Digit ratio is the ratio of the length of two fingers. Often it refers to the ratio of the length of the index finger to that of the fourth finger, or 2D:4D. It is a tentative biomarker of prenatal testosterone exposure.

Introduction

Digit ratio is primarily used as a biomarker of prenatal (before birth) exposure of testosterone, a powerful androgenic hormone that exerts wide-ranging effects on development, especially in aspects that show sex differences. Although circulating hormone exposure after birth also affects development, prior research has focused more on prenatal hormone exposure, as it is believed to have more lasting effects (Hines 2010). Some of the methods that have been used to measure prenatal testosterone levels include direct measurement using hormonal assay of amniotic fluid and indirect measurement using groups of individuals known to have been exposed to different levels of testosterone before birth. Various biomarkers that can be readily measured to retrospectively indicate earlier testosterone exposure have also been identified for this purpose.

Among these biomarkers, 2D:4D has been used in hundreds of human studies (Voracek and Loibl 2009) since its popularization by Manning et al. (1998) who suggested that 2D:4D negatively correlates with prenatal testosterone exposure, i.e., a smaller ratio indicates greater exposure, and a larger ratio indicates less exposure. The Hox genes, which underlie the development of both the reproductive system and digit ratio in mammals, are thought to be responsible for the hypothesized correlation between digit ratio and testosterone exposure (Kondo et al. 1997).

Measurement

For 2D:4D, each digit length is measured from the midpoint of the lower crease adjacent to the palm to the tip of the finger, and the ratio is the length of the second digit divided by the length of the fourth digit (Manning et al. 1998). The exact method of measurement varies across studies, but often involves taking photocopies or scans of the palm, and less frequently directly measuring the fingers. The measurement is typically made with

V. Zeigler-Hill, T.K. Shackelford (eds.), *Encyclopedia of Personality and Individual Differences*,
DOI 10.1007/978-3-319-28099-8_742-1

tools that allow high precision (e.g., digital calipers or computers).

Sex Difference and Timing

Because digit ratio is thought to correlate negatively with prenatal testosterone exposure, which is typically higher in males, an important prediction is that the ratio should be smaller in males. A meta-analysis has shown that this is generally what has been found in many studies of children, adolescents, and adults (Hönekopp and Watson 2010). Several studies have also reported the sex difference in digit ratio in infants as well as fetuses. Evidence of a similar sex difference in nonhuman animals is more mixed (McIntyre 2006).

Controversy

Despite the availability of some evidence suggesting that 2D:4D reflects prenatal testosterone exposure, counterevidence has limited the conclusion that 2D:4D is a reliable biomarker.

Indirect Evidence of a Relationship with Testosterone

2D:4D has been found to relate to many outcomes (McIntyre 2006), including autism, aggression, academic achievement, personality, spatial skills, and sexual orientation. In these studies, a larger (more female-typical) ratio was associated with more female-typical scores on the outcome measures. These findings are consistent with the assumption that 2D:4D is an indicator of prenatal testosterone exposure, often taken as supportive evidence that the outcomes are influenced by testosterone.

However, among the many reported behavioral correlates of 2D:4D, only a few, such as sexual orientation, have been confirmed in review studies. The majority of the behavioral correlates have been subjected to testing by only small numbers of studies, or have not been consistently found across studies, posting a challenge to replicability across samples, hands, and sex.

Direct Evidence of a Relationship with Testosterone

More critical to the assumption that 2D:4D reflects prenatal testosterone exposure is direct evidence of a correlation between the two (Cohen-Bendahan et al. 2005; Wong and Hines 2015). To this end, 2D:4D has been reported to correlate in humans with androgen receptor sensitivity, with testosterone or the ratio of testosterone to estradiol in amniotic fluid, and in mice with experimentally manipulated prenatal testosterone levels. Other supportive evidence comes from individuals with atypical hormone exposure. For example, the ratio has been found to be smaller (masculinized) in women with excessive testosterone exposure before birth than in control women. On the other hand, genetic males who are completely insensitive to androgens develop ratios that are larger (feminized) than control genetic males.

Nevertheless, other findings suggest that 2D:4D is at best a weak reflector of prenatal testosterone exposure. For example, a correlation with testosterone alone on both hands in both sexes has not been reported in any human studies. Moreover, the finding that 2D:4D correlates with androgen sensitivity was not replicated in an analysis aggregating multiple studies. Although 2D:4D differed as predicted between individuals with and without atypical prenatal testosterone exposure, the difference is notably smaller than what would be predicted if 2D:4D is perfectly correlated with this exposure.

Conclusion

2D:4D is hypothesized, and has been used, to reflect prenatal testosterone exposure. Boys and men typically have a smaller ratio than girls and women, and the ratio has been correlated with many outcomes, although only a few of these correlations have been replicated across studies.

Current evidence showing the hypothesized relationship between 2D:4D and prenatal testosterone exposure is limited. Some researchers believe that 2D:4D may correlate with prenatal testosterone exposure but only weakly (Berenbum et al. 2009; Cohen-Bendahan et al. 2005; Wallen 2009; Wong and Hines 2015).

Cross-References

- Biological Perspectives
- Hormone Assays
- Hormones and Personality
- Personality and Sexual Behavior
- Sexual Dimorphism
- Sex Differences in Personality Traits

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