Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Biological Psychology xxx (2004) xxx–xxx
BIOLOGICAL PSYCHOLOGY
www.elsevier.com/locate/biopsycho

# Finger length ratio (2D:4D) correlates with physical aggression in men but not in women

Allison A. Bailey[a], Peter L. Hurd[a,*]

[a]*Department of Psychology, University of Alberta, Edmonton, Alberta, Canada T6G 2E9*

Received 8 November 2003; accepted 20 May 2004

**Abstract**

Finger length ratio (2D:4D) is a sexually dimorphic trait. Men have relatively shorter second digits (index fingers) than fourth digits (ring fingers). Smaller, more masculine, digit ratios are thought to be associated with either higher prenatal testosterone levels or greater sensitivity to androgens, or both. Men with more masculine finger ratios are perceived as being more masculine and dominant by female observers, and tend to perform better in a number of physical sports. We hypothesized that digit ratio would correlate with propensity to engage in aggressive behavior. We examined the relationship between trait aggression, assayed using a questionnaire, and finger length ratio in both men and women. Men with lower, more masculine, finger length ratios had higher trait physical aggression scores ($r_{partial} = -0.21$, $N = 134$, $P = 0.028$). We found no correlation between finger length ratio and any form of aggression in females. These results are consistent with the hypothesis that testosterone has an organizational effect on adult physical aggression in men.


*Keywords:* Second to fourth digit ratio, Prenatal steroids, Aggression

## 1. Finger length ratio (2D:4D) correlates with physical aggression in men but not in women

Finger length ratio (2D:4D) is a sexually dimorphic trait. The ratio of second digit (index finger) to fourth digit (ring finger) is smaller for males than females in humans, mice, and baboons (Brown et al., 2002b; Manning, 2002a; Manning et al., 2000; McFadden and Bracht, 2003; McFadden and Shubel, 2002; Peters et al., 2002). In zebra finches, the

* Corresponding author. Tel.: +1 780 492 3578; fax: +1 780 492 1768.
*E-mail address:* allie@ualberta.ca (A.A. Bailey), phurd@ualberta.ca (P.L. Hurd).

0301-0511/$ – see front matter 
doi:10.1016/j.biopsycho.2004.05.001

sexual dimorphism in digit ratio is reversed, and males have relatively longer second digits (Burley and Foster, 2004). This reversed foot pattern matches the reversed toe 2D:4D sexual dimorphism seen in humans (McFadden and Shubel, 2002) but not that found in mice, were sexual dimorphism in hind digit ratio is in the same direction as in the human hand (Manning et al., 2003b). Sexual dimorphism in digit ratio is seen by the age of two and is thought to be stable thereafter, even through puberty (Manning et al., 1998; Brown et al., 2002b; Manning, 2002a). Index to ring finger, or 2D:4D is the most strongly dimorphic of all human digit ratio combinations (McFadden and Shubel, 2002).

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).

Digit ratio has consistently been shown to be more dimorphic on the right hand than on the left in humans (Manning et al., 1998; McFadden and Shubel, 2002; Williams et al., 2000), baboons (McFadden and Bracht, 2003) mice (Brown et al., 2002b), and finches (Burley and Foster, 2004). Several authors have suggested that androgenization affects the right hand more than the left (McFadden and Shubel, 2002; Williams et al., 2000; Brown et al., 2002b). When both right and left hand digit ratios have been used to investigate relationships between digit ratio and psychological factors, stronger effects are seen on the right hand, or found on the right hand only (Williams et al., 2000; Brown et al., 2002a; Csatho et al., 2003a, 2003b).

Digit ratio has been shown to correlate with several psychological traits. Women with smaller digit ratios report higher, more masculinized scores on the Bem Sex Role Inventory (Csatho et al., 2003a). Men with smaller 2D:4D ratios are perceived as being more masculine and dominant by female observers (Neave 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). More male-like digit ratios are also associated with deleterious traits such as increased rates of autism, immune deficiency and reduced verbal fluency (Manning, 2002a).

Austin et al. (2002) have suggested that any cognitive or personality trait which is influenced by prenatal testosterone and shows differences between the sexes will also correlate with digit ratio within each sex. Aggression is a sexually dimorphic trait. Men score higher than women on the physical, verbal and hostility (but not anger) subscales of an aggression questionnaire (Buss and Perry, 1992). We examined the relationship between 2D:4D and scores on the four subscales of the aggression questionnaire. We hypothesized that testosterone organizes human aggressive behavior and that digit ratio will correlate with the most sexually dimorphic forms of trait aggression.

### *1.1. Methods*

We tested 298 introductory psychology students (149 male and 149 female; median age 19) who participated for course credit. Participants completed a questionnaire and we made digital images of their hands. The study was approved by the University's human research ethics board and subjects participated only after giving their informed consent.

The questionnaire included Buss and Perry's (1992) aggression questionnaire and the Paulhus Deception Scale (PDS). The aggression questionnaire consists of four subscales: hostility (eight questions), anger (seven questions), verbal aggression (five questions) and physical aggression (nine questions). The PDS measures the tendency to give socially desirable responses and is divided into two sections: self-deception management (20 questions) and impression management (20 questions). Both tests used a one (extremely uncharacteristic of me) to five (extremely characteristic of me) Likert scale. Questions from the different tests were combined and randomized so that no two questions from a section were placed together. If any of the questions in a particular category were left unanswered the participant was assigned a missing value for that category and the score was dropped from all analyses. Because Buss and Perry (1992) found that only some subscales of aggression were sexually dimorphic, we were interested in the properties of each subscale and ignore ''total aggression'', the sum of the four scales.

We dropped six male and seven female participants who scored high on the self deception or impression management scales. We did not attempt to partial out the effect of impression management or self-deception, but simply discarded those with high deception scores. The test scoring standards define high scores as greater than 7 for self-deception and greater than 14 for impression management. These thresholds correspond roughly to two standard deviations above the general population mean. Not knowing how our population compared to the general population, we applied the recommended absolute thresholds of 7 and 14 rather than those in the top two standard deviations of our sample.

Scanning was conducted prior to examining or analyzing questionnaire scores. A Hewlett Packard Scan-jet 5400C was used to scan participants' hands. Before scanning, small marks were drawn on the basal creases of the index and ring fingers using a ballpoint pen by the first author. This was done to increase accuracy because it was difficult to see the creases clearly on the scans. Both of the participants' hands were scanned at the same time, palms down. Participants' index (2D) and ring (4D) fingers were measured from the hand scans using the GNU Image Manipulation Program (GIMP). The total length of each digit in units of pixels, from the middle of the basal crease to the tip of the finger, was determined using the GIMP ''measure'' tool. The first author took all of the measurements. Ratios were calculated by dividing the length, in pixels, of the second digit (index finger) by the length, in pixels, of the fourth digit (ring finger) for both hands. This technique provides good reliability ($r = 0.98$, d.f. = 8, $P < 0.01$ blind test-retest of 10 individuals each scanned twice, with one week between the two scans).

We found stronger sexual dimorphism in digit ratio on the right hand than the left (as have many other authors, see above) and therefore present results for the right hand only.

We followed Moser and Stevens (1992) and employed the robust Welch's corrected *t*-test as a matter of policy (the power cost is negligible and the potential benefit in rejecting false positives is high, even when data is not significantly heteroscedastic).

## 2. Results

Men had smaller finger length ratios than women (Table 1). Hostility, verbal, physical, and total aggression scores showed significant sexual dimorphism, while anger did not.

Anger significantly correlated with the other three sub-scales of aggression (hostility, verbal, and physical aggression) in men (Table 2). Of the other sub-scales, the two instrumental measures of aggression (verbal and physical) were correlated. All scores on the four sub-scales were correlated in women, except in the case of verbal aggression and hostility.

We determined the unique relationship between digit ratio and the four subscales of aggression using multiple regression. The regressions are presented in ANOVA table format, along with the corresponding partial regression coefficients (Table 3). Males with lower finger length ratios had significantly higher physical aggression scores (partial regression plotted in Fig. 1). Finger length ratio did not predict anger, hostility, or verbal aggression in men. Female finger length ratio did not correlate with physical aggression, anger, hostility or verbal aggression.

## 3. Discussion

We found significant sexual dimorphism in physical aggression, verbal aggression and hostility but no difference in anger. Physical aggression was the most sexually dimorphic of the aggression indices ($d$ = 1.05). These results agree with Buss and Perry (1992), who

Table 1
Digit ratios and aggression scores by sex

| | Male | | | Female | | | *d* | *t* | *P* |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | *N* | Mean | S.D. | *N* | | | |
| Digit ratio | 0.947 | 0.029 | 136 | 0.965 | 0.026 | 137 | 0.66 | −5.43 | <0.001 |
| Physical | 24.45 | 7.41 | 140 | 17.54 | 5.59 | 141 | 1.05 | 8.82 | <0.001 |
| Verbal | 15.56 | 3.41 | 140 | 14.39 | 3.47 | 141 | 0.34 | 2.85 | 0.005 |
| Hostility | 21.45 | 5.45 | 140 | 22.68 | 4.82 | 140 | 0.24 | −2.00 | 0.05 |
| Anger | 17.55 | 5.06 | 140 | 16.94 | 4.81 | 139 | 0.12 | 1.04 | 0.30 |

Means, standard deviations, sample size, effect size *d*, Welch's *t*, and *P*-values for sexual dimorphism in digit ratios and test scores.

Table 2
Correlations between aggression questionnaire subscales by sex

| | Physical aggression | Verbal aggression | Hostility |
|---|---|---|---|
| Males | | | |
| Physical | – | | |
| Verbal | 0.37 (<0.001) | – | |
| Hostility | 0.08 (0.33) | 0.17 (0.051) | – |
| Anger | 0.49 (<0.001) | 0.43 (<0.001) | 0.45 (<0.001) |
| Females | | | |
| Physical | – | | |
| Verbal | 0.37 (<0.001) | – | |
| Hostility | 0.24 (0.004) | 0.13 (0.13) | – |
| Anger | 0.47 (<0.001) | 0.58 (<0.001) | 0.40 (<0.001) |

Pearson's $r$ (and $P$-values) for correlations between subscales on the Buss and Perry Aggression Questionnaire.

found hostility, verbal, and physical aggression, but not anger to be sexually dimorphic, and trait physical aggression to be most dimorphic ($d = 0.89$).

We found digit ratio to correlate with physical aggression, but not with hostility, anger, or verbal aggression in males. There was no correlation between digit ratio and any measure of aggression in females. Our finding of a correlation between finger ratio and physical aggression is as predicted by Austin et al. (2002). That they found no such result themselves—nor any correlation between finger ratio and hostility or verbal aggression—may have been due to their use of an unusual sample, in which no reliable sex difference in digit ratio was found.

The results we have presented are consistent with the hypothesis that digit ratio reflects the organizational activity of androgens, and that variation in organizational effects of androgens causes some variation in adult physical aggression, but not anger, hostility or verbal aggression. If this explanation is correct, we would expect digit ratio to correlate with physical aggression in women, and we did not find such an effect. One possible explanation for this is that physical aggression scores on the Buss and Perry aggression questionnaire have been found to be affected by menstrual cycle in women (Ritter, 2003).

Table 3
Multiple regression of digit ratio against aggression subscales

| | Sum Sq | d.f. | $r_{partial}$ | $F$ | $P$ |
|---|---|---|---|---|---|
| Males | | | | | |
| Physical | 0.004144 | 1 | −0.21 | 4.91 | 0.028 |
| Hostility | 0.001410 | 1 | 0.13 | 1.67 | 0.198 |
| Verbal | 0.000752 | 1 | 0.09 | 0.89 | 0.347 |
| Anger | 0.000108 | 1 | 0.02 | 0.13 | 0.721 |
| Error | 0.108882 | 129 | | | |
| Females | | | | | |
| Hostility | 0.000644 | 1 | −0.10 | 1.05 | 0.308 |
| Physical | 0.000112 | 1 | −0.03 | 0.18 | 0.670 |
| Anger | 0.000049 | 1 | 0.02 | 0.08 | 0.778 |
| Verbal | 0.000013 | 1 | 0.07 | 0.02 | 0.887 |
| Error | 0.076096 | 124 | | | |

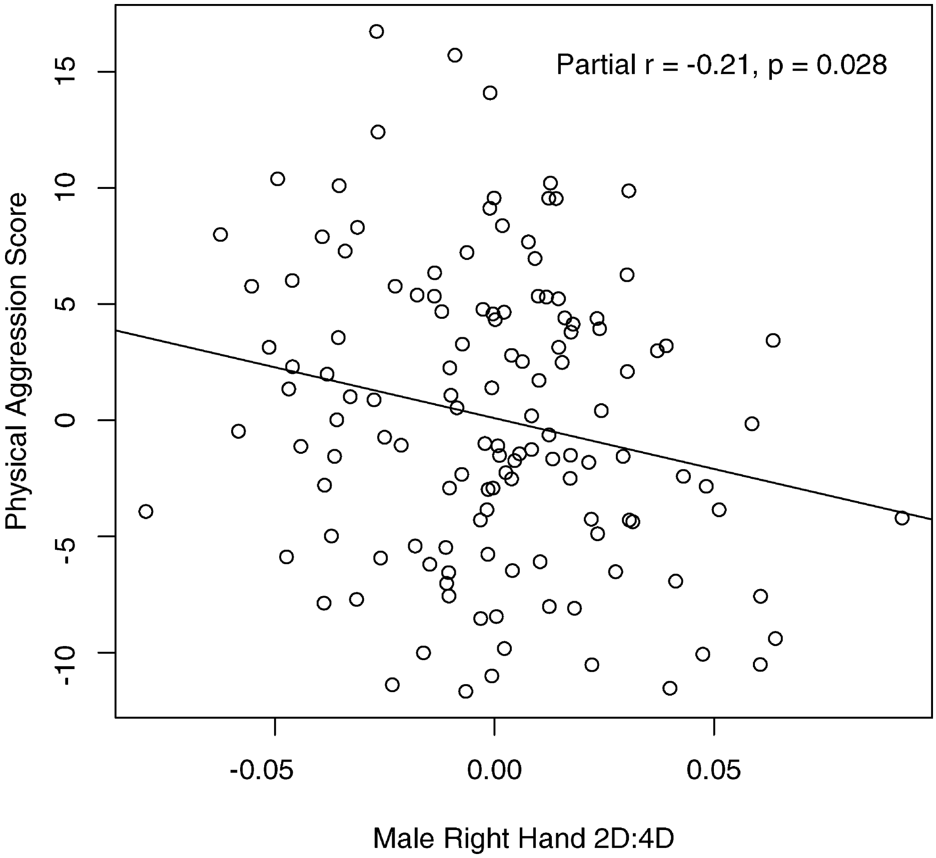


Fig. 1. Unique relationship between male right hand finger length ratios (2D:4D) and physical aggression scores.

Our lack of control for this effect, and the possible effects of birth control medications may explain the lack of a significant correlation in women, and deserves further investigation.

The size of the correlation between digit ratio and physical aggression seen in men in the present study (partial $r_{1.24} = -0.21$; uncorrected $r = -0.16$) is larger than the reported relationship between aggression and adult testosterone concentrations reported in meta-analyses ($r = 0.14$, Archer et al., 1998; Book et al., 2001). Archer et al. (1998) found no relationship between adult testosterone concentrations and any of the four components of aggression on the aggression questionnaire used in this study. It is possible that correlations between adult testosterone levels and behavior may be stronger once digit ratio effects are controlled for.

In summary, our results imply that prenatal testosterone, as assayed by digit ratio, has a stronger effect on trait physical aggression than do adult testosterone levels. This conclusion is based in part on the assumption that digit ratios reflect organizational effects of androgens, and that a questionnaire assay of aggressiveness is valid. This questionnaire has been validated by demonstrating a correlation between aggression scores and penalty minutes earned for aggressive offenses over the course of an ice hockey season (Bushman and Wells, 1998). We are currently collecting data on University hockey players' penalties and digit ratio to confirm these results using a behavioral assay. Further studies of digit ratio and aggressive behavior promise to yield insights into the source of individual variation in aggressiveness.

## Acknowledgments

Research was funded by an NSERC (Canada) Discovery grant to PLH. We wish to thank Ray Engeszer, Jamie Dyce, Alinda Friedman, Bob Trivers and Paul Vasey for valuable discussion and Walter Espinoza and Tricia Lowrey for assistance in collecting the data. We also thank Christopher Sturdy, and three anonymous reviewers for helpful comments on the manuscript.

## References

Archer, J., Birring, S.S., Wu, F.C.W., 1998. The association between testosterone and aggression among young men: empirical findings and a meta-analysis. Aggressive Behavior 24 (6), 411–420.

Austin, E.J., Manning, J.T., McInroy, K., Mathews, E., 2002. A preliminary investigation of the associations between personality, cognitive ability and digit ratio. Personality and Individual Differences 33, 1115–1124.

Berenbaum, S.A., Reinisch, J.M., 1997. Early androgen effects on aggression in children and adults with congenital adrenal hyperplasia. Psychoneuroendocrinology 22, 505–515.

Book, A.S., Starzyk, K.B., Quinsey, V.L., 2001. The relationship between testosterone and aggression: a meta-analysis. Aggression and Violent Behavior 6 (6), 579–599.

Brown, W.M., Finn, C.J., Bradley, M.C., Breedlove, S.M., 2002a. Differences in finger length ratios between self-identifies "butch" and "femme" lesbians. Archives of Sexual Behavior 31, 123–127.

Brown, W.M., Finn, C.J., Breedlove, S.M., 2002b. Sexual dimorphism in digit-length ratios of laboratory mice. The Anatomical Record 267, 231–234.

Brown, W.M., Hines, M., Fane, B.A., Breedlove, S.M., 2002c. Maculinized finger length patterns in human males and females with congenital adrenal hyperplasia. Hormones and Behavior 42, 380–386.

Buck, J.J., Williams, R.M., Hughes, I.A., Acerini, C.L., 2003. In-utero androgen exposure and 2nd to 4th digit length ratio—comparisons between healthy controls and females with classical congenital adrenal hyperplasia. Human Reproduction 18 (5), 976–979.

Burley, N.T., Foster, V.S., 2004. Digit ratio varies with sex, egg order, and strength of mate preference in zebra finches. Proceedings of the Royal Society of London Series B, Biological Sciences 271, 239–244.

Bushman, B.J., Wells, G.L., 1998. Trait aggressiveness and hockey penalties: predicting hot tempers on the ice. Journal of Applied Psychology 83 (6), 969–974.

Buss, A.H., Perry, M., 1992. The aggression questionnaire. Journal of Personality and Social Psychology 63, 452–459.

Chamberlain, N.L., Driver, E.D., Miesfeld, R.L., 1994. The length and location of cag trinucleotide repeats in the androgen receptor *n*-terminal domain affect transactional function. Nucleic Acids Research 15, 3181–3186.

Csatho, A., Osvath, A., Bicsak, E., Karadi, K., Manning, J., Kallai, J., 2003a. Sex role identity related to the ratio of second to fourth digit length in women. Biological Psychology 62, 147–156.

Csatho, A., Osvath, A., Karadi, K., Bicsak, E., Manning, J., Kallai, J., 2003b. Spatial navigation related to the ratio of second to fourth digit length in women. Learning and Individual Differences 13, 239–249.

Kazemi-Esfarjani, P., Trifiro, M.A., Pinski, L., 1995. Evidence for a repressive function of the long polyglutamine tract in the human androgen receptor: possible pathogenic relevance for the (cag)n-exppanded neuropathies. Human Molecular Genetics 4, 523–527.

Kondo, T., Zakany, J., Innis, W.J., Duboule, D., 1997. Of fingers, toes, and penises. Nature 390, 29.

Manning, J.T., 2002a. Digit Ratio: A Pointer to Fertility, Behaviour, and Health, Rutgers U Press, New Brunswick, NJ.

Manning, J.T., 2002b. The ratio of 2nd to 4th digit length and performance in skiing. Journal of Sports Medicine and Physical Fitness 42, 446–450.

Manning, J.T., Barley, L., Walton, J., Lewis-Jones, D., Trivers, R.L., Singh, D., et al., 2000. The 2nd:4th digit ratio, sexual dimorphism, population differences, and reproductive success: evidence for sexually antagonistic genes. Evolution and Human Behavior 21, 163–183.

Manning, J.T., Bundred, P.E., Newton, D.J., Flanigan, B.F., 2003a. The second to fourth digit ratio and variation in the androgen receptor gene. Evolution and Human Behavior 24, 399–405.

Manning, J.T., Callow, M., Bundred, P.E., 2003b. Finger and toe ratios in humans and mice: implications for the aetiology of diseases influenced by HOX genes. Medical Hypotheses 60 (3), 340–343.

Manning, J.T., Scott, D., Wilson, J., Lewis-Jones, D.I., 1998. The ratio of 2nd to 4th digit length: a predictor of sperm numbers and concentration of testosterone, leutenizing hormone and oestrogen. Human Reproduction 1311, 3000–3004.

Manning, J.T., Taylor, R.P., 2001. Second to fourth digit ratio and male ability in sport: implications for sexual selection in humans. Evolution and Human Behavior 22, 61–69.

McFadden, D., Bracht, M.S., 2003. The relative lengths and weights of metacarpals and metatarsals in baboons (papio hamadryas). Hormones and Behavior 43, 347–355.

McFadden, D., Shubel, E., 2002. Relative lengths of fingers and toes in human males and females. Hormones and Behavior 42, 492–500.

Moser, B.K., Stevens, G.R., 1992. Homogeneity of variance in the 2-sample means test. American Statistican 46, 19–21.

Neave, N., Laing, S., Fink, B., Manning, J.T., 2003. Second to fourth digit ratio, testosterone, and perceived male dominance. Proceedings of the Royal Society of London Series B, Biological Sciences 2167–2172.

Okten, A., Kalyoncu, M., Yaris, N., 2002. The ratio of second- and fourth-digit lengths and congenital adrenal hyperplasia due to 21-hydroxylase deficiency. Early Human Development 70, 47–54.

Peichel, C.L., Prabhakaran, B., Vogt, T.F., 1997. The mouse ulnaless mutation deregulates posterior hoxd gene expression and alters appendicular patterning. Development 124, 3481–3492.

Peters, M., Tan, U., Kang, Y., Teixeira, L., Mandal, M., 2002. Sex-specific finger-length patterns linked to behavioral variables: consistency across various human populations. Perceptual and Motor Skills 94, 171–181.

Ritter, D., 2003. Effects of menstrual cycle phase on reporting levels of aggression using the Buss and Perry Aggression Questionnaire. Aggressive Behavior 29 (6), 531–538.

Williams, T.J., Pepitone, M.E., Christensen, S.E., Cooke, B.M., Huberman, A.D., Breedlove, N.J., et al., 2000. Finger length ratios and sexual orientation. Nature 404, 455–456.