Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Personality and Individual Differences 39 (2005) 829–836
PERSONALITY AND INDIVIDUAL DIFFERENCES
www.elsevier.com/locate/paid

Depression in men is associated with more feminine finger length ratios

Allison A. Bailey, Peter L. Hurd *

Department of Psychology, University of Alberta, Edmonton, Alberta, Canada T6G 2E9

Received 3 August 2004; accepted 14 December 2004
Available online 23 May 2005

Abstract

Variation in the influence of prenatal androgens is thought to be reflected in an individual's finger length ratio (2D:4D). Many recent studies have examined the relationship between adult finger length ratio and traits thought to be affected by prenatal androgens. For example, Martin, Manning, and Dowrick (1999) have suggested that increased risk of clinical depression is a cost of high organizational testosterone in men. They presented data demonstrating a non-significant trend ($p = 0.24$) towards higher depression in men with more masculine finger length ratios. Given that women commonly show higher rates of depression than men, we suggest that depression should be associated with lower, rather than higher organizational testosterone. We tested a sample three times larger than that used by Martin et al. (1999) and found that men with more feminine finger ratios scored higher on a test for depression measured as a personality trait ($p = 0.04$). This result is consistent with the hypothesis that a portion of the variation in depression is due to the organizational effects of sex hormones in men.

Keywords: Second to fourth digit ratio; Prenatal steroids; Depression

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

0191-8869/$ - see front matter
doi:10.1016/j.paid.2004.12.017

1. Introduction

Finger length ratio (2D:4D, index to ring finger) is a sexually dimorphic trait found in a variety of species ranging from humans and mice to zebra finches (Brown, Finn, & Breedlove, 2002a; Burley & Foster, 2004; Manning, 2002a; Manning et al., 2000; Peters, Tan, Kang, Teixeira, & Mandal, 2002). On average, males have lower ratios (relatively shorter index (2D) fingers compared to ring (4D) fingers) than females. These digit ratios are thought to be fixed sometime during fetal development and to remain stable thereafter (Garn, Alphonse, Babler, & Stinson, 1975; Manning, 2002a; Manning, Scott, Wilson, & Lewis-Jones, 1998).

Finger length ratio is becoming a widely used measure of prenatal testosterone (Manning, 2002a; Manning, Bundred, Newton, & Flanigan, 2003). Evidence in support of this view comes from digit ratio studies of individuals with congenital adrenal hyperplasia (CAH). Individuals (both male and female) with elevated fetal androgens due to CAH exhibit lower, more masculine, finger length ratios than controls (Brown, Hines, Fane, & Breedlove, 2002b; Okten, Kalyoncu, & Yaris, 2002; but see Buck, Williams, Hughes, & Acerini, 2003). Two causal mechanisms have been conjectured to explain this phenomenon. The first is that common genes (*hoxa* and *hoxd*) underlie the development of both digits and gonads (Kondo, Zakany, Innis, & Duboule, 1997; Peichel, Prabhakaran, & Vogt, 1997) such that the timing of gene regulation leaves a finger length ratio that reflects the quantity of androgen produced. The second proposed mechanism is that finger ratio is a function of androgen sensitivity, rather than androgen concentration. Lower finger ratios are associated with androgen receptor alleles with fewer terminal domain CAG repeats in men (Manning et al., 2003), and fewer repeats produce receptors with higher androgen sensitivity (Chamberlain, Driver, & Miesfeld, 1994; Kazemi-Esfarjani, Trifiro, & Pinski, 1995).

Austin, Manning, McInroy, and Mathews (2002) have suggested that any sexually dimorphic personality trait influenced by prenatal testosterone will correlate with finger length ratio within each sex. Manning and colleagues found significant correlations in men between lower, more masculine digit ratios and achievement, ability, and speed in a variety of sports and in visual-spatial ability (Manning & Taylor, 2001; Manning, 2002a, 2002b). Women with digit ratios reported higher, more masculinized scores on the Bem Sex Role Inventory (Csathó et al., 2003a). A number of previous studies have shown that men with more masculine finger ratios tended to score higher on questionnaire-based tests of physical aggression (Bailey & Hurd, 2005), are perceived as being more masculine and dominant by female observers (Neave, Laing, Fink, & Manning, 2003), and are more likely to show increased rates of autism and reduced verbal fluency (Manning, 2002a).

Depression is a sexually dimorphic trait (Endler, Macrodimitris, & Kocovski, 2000, 2003). The risk and prevalence of major depression is about twice as high for females compared to males (Blazer, Kessler, McGonagle, & Swartz, 1994; Piccinelli & Wilkinson, 2000; Rohr, 2002). Not only do women report depression more often, but they also report more symptoms per depressive episode, and are more susceptible to stressors than men (Sowa & Lustman, 1984; Wilhelm, Parker, & Asghari, 1998). If this is the case, higher, more feminine digit ratios should correlate with higher scores for depression within each sex.

Martin, Manning, and Dowrick (1999) suggested however, that increased risk of depression is a cost of high organizational testosterone. They found a negative, non-significant ($p = 0.24$), trend between 2D:4D and the severity of clinical depression in men, which has lead some authors (e.g. Csathó et al., 2003b) to mistakenly conclude that "...lower 2D:4D ratios are associated with [...] depression (Martin et al., 1999)". Manning (2002a) suggested further investigations were required to explain the non-significant results of earlier studies attempting to link digit ratio and depression. If early developmental hormones affect depression, they should influence a stable part of the personality more than they effect fluctuating emotional states experienced in adulthood (such as depth of clinical depression). We measured depression using the NEO-PI depression sub-scale, which measures depression as a stable personality trait. We hypothesized that depression would correlate with 2D:4D on the right hand, such that individuals within sexes with more feminine finger ratios would score higher on the NEO-PI depression sub-scale. Our prediction is in the opposite direction to the trend reported by Martin et al. (1999).

2. Methods

We tested 298 introductory psychology students (149 male and 149 female; median age 19) who participated for course credit. After giving informed consent, participants had digital images of their hands made and completed a questionnaire, which included the NEO-PI trait depression sub scale. The depression sub-scale is an eight-item questionnaire that uses a one (extremely uncharacteristic of me) to five (extremely characteristic of me) Likert scale to measure depression as a personality trait.

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. These marks increased measurement accuracy, as it was difficult to see the creases clearly on the scans without them. 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) measure tool. The total length of each digit was measured, in pixels, from the middle of the basal crease to the tip of the finger. Ratios were calculated by dividing the length of the second digit (index finger) by the length of the fourth digit (ring finger) for both hands. This measurement technique provides good reliability (blind test–retest of ten individuals each scanned twice, with one week between the two scans $r = 0.98$, df = 8, $p < 0.01$).

We used Pearson's r to correlate depression scores with right hand 2D:4D and Welch's corrected t-test to test for sexual dimorphism in 2D:4D. (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.) All statistical tests were two-tailed.

Several authors have suggested that androgenization affects the right hand more than the left (Brown et al., 2002a; McFadden & Shubel, 2002; Williams et al., 2000). Digit ratio has consistently been shown to be more strongly differentiated on the right hand than on the left, in humans (Brown et al., 2002b; Lippa, 2003; Manning et al., 1998; McFadden & Shubel, 2002; Williams et al., 2000), regardless of handedness (Williams et al., 2000), and in mice (Brown et al., 2002a) and finches (Burley & Foster, 2004). Personality and behavioral traits have also been found to correlate more strongly with right hand digit ratio than left (Csathó et al., 2003a; Williams et al., 2000; Williams, Greenhalgh, & Manning, 2003). For this reason we present only right hand data.

3. Results

Men had smaller finger length ratios than women (male: 0.947, SD = 0.029, female: 0.965, SD = 0.0026, $t_{277.45} = -5.49$, $p < 0.001$, $d = 0.65$). We found no sex difference in depression scores (male: 21.90, SD = 5.46, female: 22.36, SD = 5.60, $t_{293.80} = -0.72$, $p = 0.475$). Males with lower finger length ratios had lower trait depression scores than men with more feminine ratios ($r_{139} = 0.17$, $p = 0.04$; Fig. 1). We found no such relationship in women ($r_{139} = 0.02$, $p = 0.83$).

4. Discussion

This is the first study to find a relationship between finger length ratio (2D:4D) and depression. We found higher levels of depression (measured as a personality trait) in males with higher, more feminine finger length ratios, suggesting that depression is associated with lower prenatal testosterone in men. Our results appear to contradict Martin et al. (1999) who reported a positive, but non-significant, relationship between prenatal testosterone and depression in men. Austin et al. (2002) also failed to find a significant relationship between severity of depression and finger length ratio. Three possible explanations for discrepancies between the studies were differences in (1) statistical power, (2) depression assays, and (3) sample populations. First, the sample size in the present study was three times that used by Martin et al. (1999), and approximately twice that used by Austin et al. (2002). This suggests that the present study had more statistical power.

Secondly, tests measuring the severity of depression, such as the Beck Depression Inventory and Zung Self-Rating Depression Scale used by Martin et al. (1999) and Austin et al. (2002), were designed to diagnose clinical depression. It has been suggested that these tests may not be able to

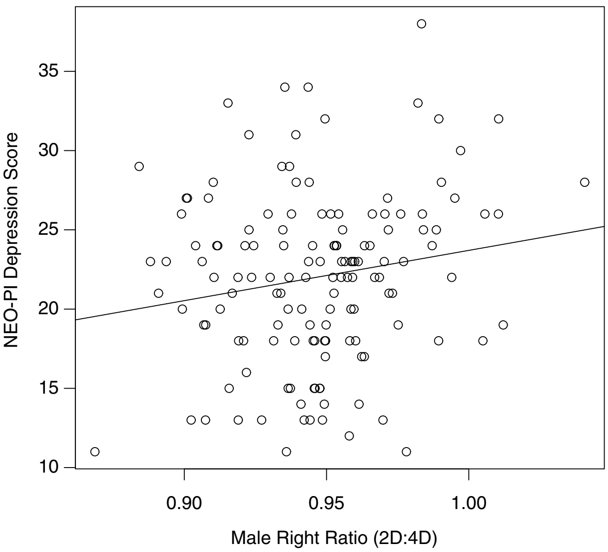

Fig. 1. A significant positive correlation between right hand finger length ratio and NEO-PI trait depression sub-scale scores in men ($r_{139} = 0.17$, $p = 0.04$).

detect small differences in non-clinical populations (Krohne, Schmukle, Spaderna, & Spielberger, 2002). Both state and trait depression are sexually dimorphic and correlate with one another (Endler, Macrodimitris, & Kocovski, 2003). Therefore, depression as an underlying, stable trait should influence adult state depression. If this is the case, then trait depression measures may be more sensitive to individual differences, and would more likely be influenced by prenatal testosterone.

Thirdly, Martin et al. (1999) used a mixed sample from both clinical and general populations to increase variability in depression severity scores. That we found no significant sexual dimorphism in depression scores may be due to an under-representation of depression in the university undergraduate population. A recent study using the same population found a very small, but statistically significant, sex difference in depression (effect size = 0.003, $n = 1800$; Lee & Brown, unpublished data). Such an effect would be difficult to detect in a sample as small as ours ($n \sim 300$). Williams et al. (2003) did not find emotionality in preschool children to be sexually dimorphic; the emotionality questions on their questionnaire were similar to items on our depression personality questionnaire. Austin et al. (2002) used university students and may have had a sample comparable to our own, however they were unable to detect a sex difference in 2D:4D. They may have been unable to detect a relationship between depression and 2D:4D due to a limited amount of variation in 2D:4D as well as using a state depression assay on a non-clinical population.

We found no correlation between finger length ratio and depression in women. This finding follows all previous studies' findings. Williams et al. (2003) found that emotionality was not related to digit ratio in females, but was significantly, positively correlated with digit ratio in males (i.e. more feminine digit ratios, higher emotionality). Neither of the previous studies examining finger length ratio and clinical depression found even a hint of an association between digit ratio and depression in women (Austin et al., 2002; Martin et al., 1999). If male digit ratio correlates with sexually dimorphic psychological traits due to these both varying with the strength of defeminization, then a lack of a correlation in women may be ascribed to the lack of a defeminizing gonadal androgen exposure. We do not believe this to be the case, since digit ratio does correlate with sexually dimorphic psychological traits, at least in some cases (e.g. Benderlioglu & Nelson, 2004; Csathó et al., 2003a, 2003b) perhaps reflecting the strength of adrenal source androgen exposure. Circulating hormone levels, including testosterone, which vary across menstrual phase have been demonstrated to influence depression scores, for example both high and low levels of testosterone are associated with increased depression (Christiansen, 2001; Hartmann et al., 1996; Payne, 2003; Rohr, 2002). The organizational effects of androgens on trait depression which we expect to see reflected in digit ratios may therefore be concealed by the uncontrolled effects of menstrual cycles and/or birth control medication. Future studies should control for this variability when examining the relationship between behavior and finger length ratio in women. Previous investigations of digit ratio have found no correlation between digit ratio and the second-order trait of neuroticism (Austin et al., 2002). There is some evidence that different genes are involved in linking neuroticism to major depression in men and women (Fanous, Gardner, Prescott, Cancro, & Kandler, 2002). Larger samples of women than were used in the present study will be required to investigate the link between organizational androgens, circulating hormones and the various components of neuroticism.

A variety of factors including, experience, coping skills, and gonadal or stress hormones, are speculated to be the cause of the gender differences seen in depression (Martin et al., 1999;

Nolan-Hoeksema, 1990; Piccinelli & Wilkinson, 2000; Rohr, 2002). Many feel that "biological explanations of sex differences in depression have not been well supported" (Nolan-Hoeksema, 1990). Our results suggest that hormones prior to birth may organize a small, but statistically significant, difference in depression as a personality trait in males. This conclusion is subject to the caveats; (1) that we found no correlation between digit ratio and depression in women and (2) that the effect-size was small. Further research investigating the relationship between both state and trait depression with respect to digit ratio and prenatal androgens is clearly warranted.

Acknowledgments

Funded by an NSERC (Canada) Discovery grant to PLH. We wish to thank Jamie Dyce, Norman Brown, and Peter Lee for discussion and comments on the manuscript, as well as Walter Espinoza and Tricia Lowrey for assistance in collecting the data. We also wish to thank Paul J. Watson, Martin Daily, Margo Wilson, Thomas Udhe, and 3 anonymous reviewers for valuable comments on earlier drafts of the manuscripts.

References

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.

Bailey, A. A., & Hurd, P. L. (2005). Finger length ratio (2D:4D) correlates with physical aggression in men but not in women. *Biological Psychology, 68*, 215–222. doi:10.1016/j.biopsycho.2004.05.001.

Benderlioglu, Z., & Nelson, R. J. (2004). Digit length ratios predict reactive aggression in women, but not in men. *Hormones and Behavior, 46*, 558–564.

Blazer, D. G., Kessler, R. C., McGonagle, K. A., & Swartz, M. S. (1994). The prevalence and distribution of major depression in a national community sample: The national comorbidity survey. *American Journal of Psychiatry, 151*, 979–986.

Brown, W. M., Finn, C. J., & Breedlove, S. M. (2002a). 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. (2002b). Masculinized 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, 271*, 239–244.

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.

Christiansen, K. (2001). Behavioural effects of androgen in men and women. *Journal of Endocrinology, 170*, 39–48.

Csathó, 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.

Csathó, A., Osváth, A., Karádi, K., Bicsák, E., Manning, J., & Kállai, J. (2003b). Spatial navigation related to the ratio of second to fourth digit length in women. *Learning and Individual Differences, 13*, 239–249.

Endler, N. S., Macrodimitris, S. D., & Kocovski, N. L. (2000). Depression: The complexity of self-report measures. *Journal of Applied Biobehavioral Research, 5*(1), 26–46.

Endler, N. S., Macrodimitris, S. D., & Kocovski, N. L. (2003). Anxiety and depression: Congruent, separate, or both? *Journal of Applied Biobehavioral Research, 8*(1), 42–60.

Fanous, A., Gardner, C. S., Prescott, C. A., Cancro, R., & Kandler, K. S. (2002). Neuroticism, major depression and gender: a population-6 used twin study. *Psychological Medicine, 32*, 719–728.

Garn, S. M., Alphonse, R. B., Babler, W., & Stinson, S. (1975). Prenatal attainment of adult metacarpal-phalangeal rankings and proportions. *American Journal of Physical Anthropology, 43*, 327–332.

Hartmann, B., Baischer, W., König, G., Albrecht, A., Kirchengast, S., Huber, J., & Langer, G. (1996). Disturbances in the hypothalamic-pituitary-gonadal axis of depressed fertile women compared with normal controls. In A. R. Genazzani, F. Petraglia, A. D. D'Ambrogio, A. D. Genazzani, & P. G. Atrini (Eds.), *Recent Developments in Gynecology and Obstetrics* (pp. 225–230). New York: Pantheon.

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*-expanded 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.

Krohne, H. W., Schmukle, S. C., Spaderna, H., & Spielberger, C. D. (2002). The state-trait depression scales: an international comparison. *Anxiety, Stress, and Coping, 15*(2), 105–122.

Lippa, R. A. (2003). Are 2D:4D finger-length ratios related to sexual orientation? Yes for men, no for women. *Journal of Personality and Social Psychology, 85*(1), 179–188.

Manning, J. T. (2002a). *Digit ratio: A pointer to fertility, behaviour, and health*. New Brunswick, NJ: Rutgers U. Press.

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. (2003). The second to fourth digit ratio and variation in the androgen receptor gene. *Evolution and Human Behavior, 24*, 399–405.

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.

Martin, S. M., Manning, J. T., & Dowrick, C. F. (1999). Fluctuating asymmetry, relative digit length, and depression in men. *Evolution and Human Behavior, 20*, 203–214.

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 two-sample means test. *American Statistician, 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.

Nolan-Hoeksema, S. (1990). *Sex differences in depression*. Stanford, CA: Stanford U. Press.

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.

Payne, J. L. (2003). The role of estrogen in mood disorders in women. *International Review of Psychiatry, 15*, 280–290.

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.

Piccinelli, M., & Wilkinson, G. (2000). Gender differences in depression. *British Journal of Psychiatry, 177*, 486–492.

Rohr, U. D. (2002). The impact of testosterone imbalance on depression and women's health. *Maturitas, 41*, S25–S46.

Sowa, C. J., & Lustman, P. J. (1984). Gender differences in rating stressful events, depression, and depressive cognition. *Journal of Clinical Psychology, 40*, 1334–1337.

Wilhelm, K., Parker, G., & Asghari, A. (1998). Sex differences in the experiences of depressed mood state over fifteen years. *Social Psychiatry and Psychiatric Epidemiology, 33*, 16–20.

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

Williams, J. H. G., Greenhalgh, K. D., & Manning, J. T. (2003). Second to fourth finger ratio and possible precursors of developmental psychopathology in preschool children. *Early Human Development, 72*, 57–65.