

Original Communication**THE RATIO OF SECOND FINGER TO FOURTH FINGER IN CHILDREN AND ADOLESCENTS WITH OBSESSIVE COMPULSIVE DISORDER****Hande Ayraller Taner¹, Rabet Gozil², Elvan Iseri³, Ece Buru⁴, Meltem Bahcelioglu⁵**¹*Department of Child and Adolescent Psychiatry, Baskent University Faculty of Medicine, Baskent University, Ankara, Turkey*²*Department of Anatomy, Yuksek Ihtisas University Faculty of Medicine, University of Yuksek Ihtisas, Ankara, Turkey*³*Department of Child and Adolescent Psychiatry, Gazi University Faculty of Medicine, Gazi University, Ankara, Turkey*⁴*Department of Anatomy, Yuzuncu Yil University Faculty of Medicine, Yuzuncu Yil University, Ankara, Turkey*⁵*Department of Anatomy, Gazi University Faculty of Medicine, Gazi University, Ankara, Turkey***RESUMEN**

Objetivos: La proporción entre los dedos índice y anular es diferente en las mujeres y en los hombres. Esta proporción ha sido estudiada en varias enfermedades como el trastorno de ansiedad, el trastorno de la concentración y la hiperactividad. El objetivo de este estudio era investigar la proporción entre los dedos de índice y anular en los niños y adolescentes que tienen trastorno obsesivo-compulsivo y determinar si existía alguna diferencia entre los participantes con trastorno obsesivo-compulsivo y los del grupo sano. Material y métodos: En el estudio fueron incluidos 30 niños y adolescentes que tenían entre 7 y 17 años de edad con trastorno obsesivo-compulsivo y 90 individuos sanos de igual edad y sexo como el grupo control. Después de las evaluaciones psiquiátricas, la longitud de los dedos fue medida con calibre digital. Resultados: Las niñas y adolescentes con trastorno obsesivo-compulsivo tenían una proporción mayor entre los dedos índice y anular en las manos derechas e izquierdas que el grupo control. Aunque no había una diferencia estadísticamente significativa, la proporción entre los dedos índice y anular en la mano derecha era más grande en el grupo de trastorno obsesivo-compulsivo que el grupo control. Conclusiones: Algunas diferencias fueron detectadas en la proporción entre los dedos índice y anular en los pacientes con trastorno obsesivo-compulsivo y los del grupo control, pero no había resultados estadísticamente significativos excepto las niñas y adolescentes con trastorno obsesivo-compulsivo. Se requieren más estudios para entender completamente la relación entre el trastorno obsesivo-compulsivo y la proporción entre los dedos índice y anular.

Palabras clave: relación 2D:4D, trastorno obsesivo-compulsivo; diferencias de género; hormonas gonadales

ABSTRACT

Objectives: The ratio of the index finger (2D) to the ring finger (4D) is different in males and females. This ratio (2D:4D) has been investigated in a variety of diseases, including autism, schizophrenia, attention deficit hyperactivity disorder, and anxiety disorders. The aim of this study was to investigate the 2D:4D ratio in children and adolescents with obsessive compulsive disorder and to detect any differences in that ratio between participants with obsessive compulsive disorder and a healthy control. Material and Methods: The study included 30 children and adolescents diagnosed with obsessive compulsive disorder between ages 7-17 and 90 age-sex matched controls. After the psychiatric evaluations; finger lengths were measured with a digital compass. Results: Girls with obsessive compulsive disorder had greater 2D:4D ratios in their right and left hands than the control group. Although there was no statistically significant difference, the 2D:4D ratio in the right hand was greater in the obsessive compulsive disorder group than in the control group. Conclusion: With relation to obsessive compulsive disorder, some differences were detected in 2D:4D ratios of patients with obsessive compulsive disorder and control groups but there were no statistically significant results except for that of girls with obsessive compulsive disorder. Further studies are needed to fully understand the relationship between obsessive compulsive disorder and the 2D:4D ratio.

Key Words: 2D:4D ratio; obsessive compulsive disorder; gender differences; gonadal hormones.

* Correspondence to: **Hande Ayraller Taner.** h_ayraller@hotmail.com

Received: 10 June, 2016. **Revised:** 30 June, 2016. **Accepted:** 14 July, 2016.

INTRODUCTION

Obsessive compulsive disorder (OCD) is a disorder composed of repetitive and intrusive thoughts, ideas, or images (obsessions) and repetitive behaviors or ideational actions (compulsions) aimed to relieve associated anxiety, both leading to marked limitation of daily activities (Kalra and Swedo, 2009). Its lifetime prevalence is 1.6% (Kessler et al, 2005). In childhood, its male/female ratio is 3:2, though some studies have reported contradictory results. Gender differences in OCD equalize by adolescence (Walitza et al, 2001). It has been reported that OCD has an earlier onset and a more insidious course in males whereas, in females, it mostly has an episodic course and an acute onset that is more related to life events (Bogetto et al, 1999). Also, alterations in sex hormones may affect the course of OCD (Flaisher-Grinberg et al, 2009).

The ratio of the index finger (2D) to the ring finger (4D), (2D:4D), differs between genders. The fourth finger tends to be longer than the second in males whereas the second finger tends to be longer than the fourth in females (Manning et al, 2000). The mean 2D:4D ratio has been reported as 0.98 in males and 1 in females. This difference is reportedly more prominent in the right hand (Hönekopp et al, 2010). It can be detected starting from the prenatal period (Malas et al, 2006) and is determined by in utero factors (Ronalds et al, 2002). A negative correlation has been reported between amniotic fluid fetal testosterone/fetal estradiol ratios and 2D:4D ratios by Lutchmaya et al (2004). In addition, it has been suggested that the difference in 2D:4D ratios between males and females may be secondary to perinatal androgens (McIntyre, 2006). Manning et al (1998) showed that an inverse relationship exists between 2D:4D ratio, sperm count, and blood testosterone concentration in males. The same study also demonstrated that luteinizing hormone, estrogen, and prolactin levels in males and females are proportional to 2D:4D ratio. Fink et al (2004) reported a negative correlation between waist-to-chest ratio and 2D:4D in females. Manning et al (2003) investigated the relationship between 2D:4D and offspring number, reporting a negative relationship between 2D:4D ratio and offspring number in males and a positive relationship between 2D:4D ratio and offspring number in females.

Studies have investigated the relationships between 2D:4D ratio and a number of conditions: congenital adrenal hyperplasia (Brown et al, 2002; Okten et al, 2002), breast cancer (Muller et al, 2012), prostate cancer (Muller et al, 2011), and atherosclerotic plaque progression

(Ozdogmus et al, 2010). In addition, various studies have investigated the relationship between 2D:4D and sexual orientation (Manning et al, 2003; Schneider et al, 2006) personality characteristics (Austin et al, 2001), sportive success (De la Cruz-Sanchez et al, 2015), fine motor skills and the speed of fine motor activity (Wang et al, 2016) and behavioral characteristics (Benderlioglu and Nelson, 2004; Millet and Dewitte, 2006). Furthermore, 2D:4D ratio has been examined in relation to some psychiatric disorders.

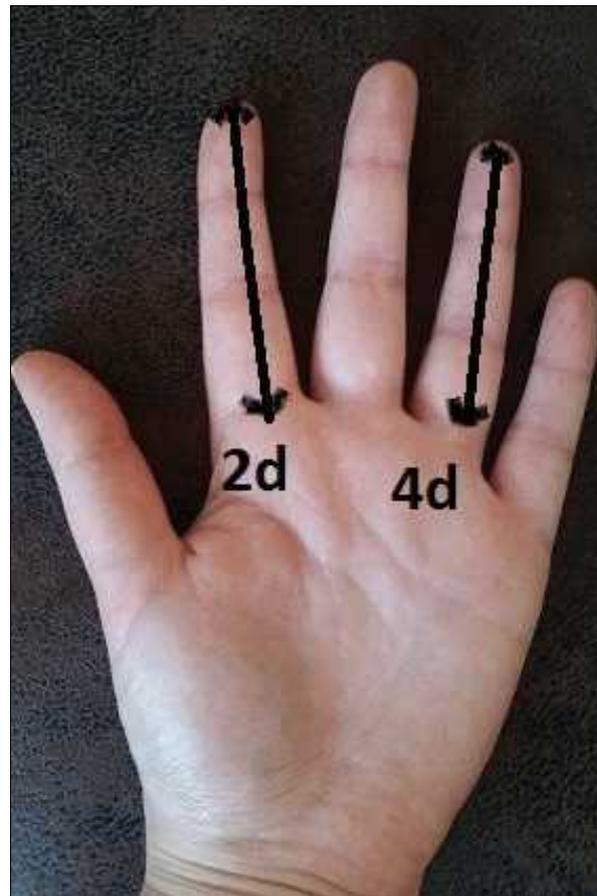


Figure 1- The length of index finger and ring finger, 2d: The length of index finger, 4d: The length of ring finger..

A correlation was shown between a low 2D:4D ratio and Schneider's first-rank symptoms in schizophrenia (Venkatasubramanian et al, 2006). Qian et al (2016) reported that the right and the mean 2d:4d ratio was higher in schizophrenics compared to controls both in males and female. Bailey and Hund (2005) reported higher depression scores in males with a feminine 2D:4D ratio. Martel et al (2008) reported that

boys with attention deficit hyperactivity disorder had a more masculine 2D:4D ratio than controls; they also reported that symptoms of attention deficit hyperactivity disorder were higher in children with a more masculine right hand 2D:4D ratio. Manning et al (2001) found a lower 2D:4D ratio in children with autism, their healthy siblings, and their parents than that in controls. That study also reported higher 2D:4D ratios in children with Asperger Syndrome (AS) than children with autism, although the level was lower than that of controls. Al-Zaid et al (2015) also reported lower 2D:4D ratio in boys with autism. Bruin et al (2006) reported a lower 2D:4D ratio in males with autism and AS than in males with anxiety disorders. In the same study, a lower 2D:4D ratio was reported in males with attention deficit hyperactivity disorder and oppositional defiant disorder than in males with anxiety disorders. A meta-analysis has showed that patients with autistic spectrum disorder tend to have more masculine 2D:4D ratios than those without (Teatero and Netley, 2013).

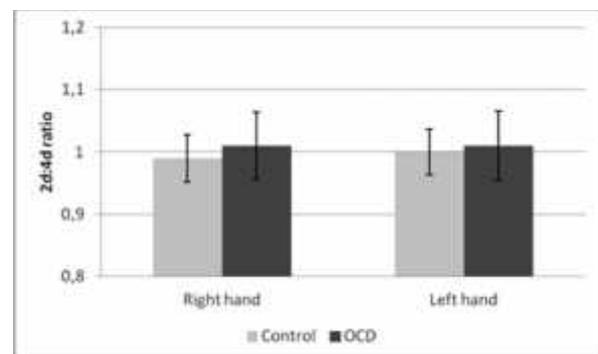
Although 2D:4D ratio has been investigated in relation to several psychiatric disorders, research investigating the relationship of prenatal androgens and testosterone with the development of OCD and 2D:4D ratio in OCD patients is scarce. The aim of this study was to investigate 2D:4D ratio in children and adolescents with OCD and to detect if any differences were present in the 2D:4D ratios of children and adolescents with OCD when compared to those of healthy controls.

MATERIAL AND METHODS

This study included 30 children and adolescent patients aged 7–17 years and diagnosed with OCD and 90 age- ($p=0.780$) and sex-matched ($p=1.000$) healthy controls. The mean ages of the patient and control groups were 12.9 ± 2.7 and 12.7 ± 2.7 years, respectively. This study was a case control study and there were 17 males and 13 females in the patient group and 51 males and 39 females in the control group. OCD diagnosis was based on Diagnostic and Statistical Manual of Mental Disorders IV Text Revision (DSM IV-TR) diagnostic criteria (American Psychiatric Association, 2000; Amerikan Psikiyatri Birli i, 2001) after obtaining patient history from each family, interviewing each patient and investigating their psychiatric status. Two expert child psychiatrists made the diagnosis. The patient group included child and adolescents who applied to Gazi University Faculty of Medicine Child and Adolescent Psychiatry Department and

who were diagnosed with OCD for the first time without co-morbidities between December 2011 and November 2012. The control group consisted in children and adolescents attending a primary school and a high school in Ankara, respectively, who had not been diagnosed with any physical and psychiatric disorders. Hand length, hand width, and finger length were measured with a digital compass after the evaluation. All measurements were performed twice by different researchers. The length of index finger and ring finger had shown in Figure 1.

Data analysis was performed by using SPSS for Windows, version 11.5 (SPSS Inc., Chicago, IL, United States). The Kolmogorov-Smirnov test was used to determine whether the continuous variables were normally distributed. Data were shown as the mean \pm SD or the number of cases, where applicable. Meanwhile, the mean differences between the case and control groups were compared using Student's t-test. Pearson's chi-squared test was used for nominal data. A p value of less than 0.05 was considered statistically significant. For all possible multiple comparisons, the Bonferroni correction was applied for controlling Type I errors.



Graphic 1- Comparison of 2D:4D ratios between the control and OCD groups

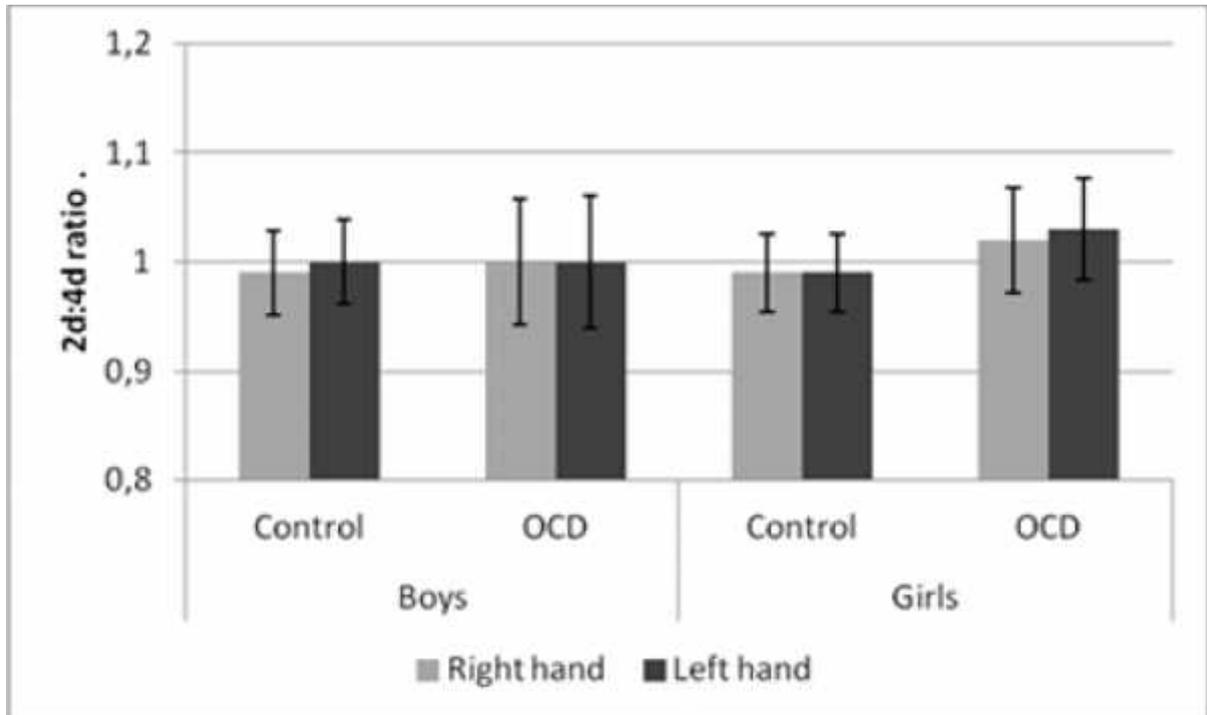
RESULTS

Although the 2D:4D ratio was higher in the OCD group, there was no statistically significant difference between the OCD and control groups with respect to right ($p=0.054$) and left hand 2D:4D ratio ($p=0.219$). Comparison of 2D:4D ratios between the control and OCD groups is shown in Graphic 1.

Analysis of 2D:4D ratio in boys and girls separately revealed that right hand ($p=0.724$) and left hand ($p=0.932$) 2D:4D ratios were not different between males in the patient and control

groups. But right ($p=0.008$) and left hand ($p=0.010$) 2D:4D ratios were significantly higher in females in the patient group than in females in the control group. Comparison of 2D:4D ratios

between the control and OCD groups in boys and girls is shown in Graphic 2. Table 1 shows the 2D:4D ratios and statistical evaluation results for all groups.



Graphic 2- Comparison of 2D:4D ratios between the control and OCD groups in boys and girls

Variables	Control	OCD	p¶
All cases			
Right hand	0.99±0.038	1.01±0.054	0.054†
Left hand	1.00±0.037	1.01±0.056	0.219†
Boys			
Right hand	0.99±0.039	1.00±0.058	0.724‡
Left hand	1.00±0.038	1.00±0.061	0.932‡
Girls			
Right hand	0.99±0.036	1.02±0.048	0.008‡
Left hand	0.99±0.036	1.03±0.047	0.010‡

Table 1- 2D:4D ratios in patient and control groups. ¶ Student's t test. † According to the Bonferroni correction $p < 0.025$ was considered as statistically significant. ‡ According to the Bonferroni correction $p < 0.0125$ was considered as statistically significant.

DISCUSSION

The 2D:4D ratio has been investigated in various disorders or characteristics in which gender differences are present. Psychiatric diseases, autism, schizophrenia and attention deficit hyperactivity disorder have been reportedly associated to a lower ratio (Venkatasubramanian et al, 2011; Martel et al, 2008; Manning et al, 2001; Teatero and Netley, 2013). In depression, on the other hand, this ratio is reversed (Bailey and Hurd, 2005). Bruin et al (2006) reported that anxiety disorder was associated more with a "feminine type" of finger ratio than other pediatric psychiatric disorders. Williams et al (2003) demonstrated that boys experiencing anxiety, fears, somatic complaints, and emotional problems had a higher 2D:4D ratio. Our findings showed that 2D:4D ratio in female children diagnosed with OCD was higher than that the control group and, although there was no statistically significant difference between the OCD and control groups, 2D:4D ratio in the OCD group tended to be higher. Although the small sample size and the lack of statistical significance in OCD and control groups, the results of our study seem more similar to the anxiety disorders. This results may be interpreted that OCD has a similar etiology with anxiety disorders in terms of 2D:4D ratio.

Abramson et al (2005) found significant links between a specific kind of repetitive behavior in probands with autism and the Y-BOCS (Yale-Brown Obsessive Compulsive Scale, an OCD index) scores of their parents. Bejerot (2007) proposed that OCD is related to autism spectrum disorders and is on a continuum from normal personality to severely autistic personality. Several studies have investigated 2D:4D ratios in autism (Manning et al, 2001; Bruin et al, 2006; Teatero and Netley, 2013) and they showed a lower 2D:4D ratio in patients with autism. Although there are some similarities between autism and OCD, we did not detect similar tendencies in the 2D:4D ratios of patients with OCD and healthy controls.

Our findings showed that the 2D:4D ratio in female children diagnosed with OCD was higher than that of female children in the control group. Male patients in both groups, on the other hand, had statistically similar 2D:4D ratios and finger length. Fink et al (2006) reported a directly proportional relationship between neurotic personality characteristics and 2D:4D ratio in females, whereas such a relationship did not exist in males. Lutchmaya et al (2004) reported an inverse relationship between fetal testosterone/fetal estrogen ratios and 2D:4D. The

results of our study may be interpreted that a lowered fetal testosterone/fetal estrogen ratio may be playing an important role in the etiology of OCD especially in female patients.

We did not detect a difference in 2D:4D ratio in male patients diagnosed with OCD. A study with adult healthy females and males had showed that 2D:4D ratio increased as trait anxiety level increased in males (Evardone and Alexander, 2009). This result suggests that there may be a relationship between 2D:4D ratio and anxiety level in males. Similarly, 2D:4D may be expected to rise in men with severe OCD symptoms. However, this could not be clarified in our study because the study did not employ any severity-related scales. Moreover, there was no difference between 2D:4D ratio in male children diagnosed with OCD and those in the control group, whereas a significant increase was observed in female children. This may suggest a different etiopathogenesis of male OCD than that of its female counterpart. It is well known that there are differences between the clinical characteristics of OCD in males and females: the disorder has an earlier onset and a more chronic course in males, and sexual and religious obsessions are more common in men (Torresan et al, 2009; Mathis et al, 2011). When such differences are taken into account, it may be hypothesized that OCD in male and female children may be childhood reflections of disorders with different pathways. Large-scale studies are needed to confirm this difference.

The most important limitation of our study was the small size of the patient group. In addition, our study lacked a structured interview scale and a disease severity assessment. Future large-scale studies using a structured interview scale will expand our knowledge of this condition. Allaway et al (2009) reported that the computer assisted analysis of 2d:4d ratio is more reliable than the other measurement techniques. We used digital compass for the measurements and we made two measurements by different researchers. These techniques could reduce the reliability and repeatability of our measurements.

As conclusion; in our study we found that females with OCD had a higher 2D:4D ratio than the females in the control group, but we could not detect the same difference between boys and OCD-healthy control groups. The results of our study showed that there may be a similar tendency between OCD and anxiety disorders in terms of 2D:4D ratio. Novel studies with larger samples and disease severity assessment scales are needed to fully understand the effect of prenatal androgens and the causes of the gender differences observed in OCD.

Conflict of Interest

None

Funding

None

Ethical approval

This study was approved by Gazi University Ethical Committee

Informed consent

Informed consent of the children and parents' were obtained.

Contributions

This paper has not been submitted/published elsewhere in the same form, in English or in any other language. This paper is the original work of the authors. The data collection was done by Dr. H.A.T. and Dr. M.B., the statistical analysis was done by Dr. H.A.T., Dr. E.I. and Dr.M.B and all of the authors contributed to the study planning, interpretation of the data and paper writing.

REFERENCES

- Abramson RK, Ravan SA, Wright HH, Wieduwilt K, Wolpert CM, Donnelly SA, Perican-Vance MA, Cuccaro ML.* 2005. The relationship between restrictive and repetitive behaviors in individuals with autism and obsessive compulsive symptoms in parents. *Child Psychiatry Hum Dev* 36: 155-65.
- Allaway HC, Bloski TG, Pierson RA, Lujan ME.* 2009. Digit Ratios (2D:4D) Determined by Computer-Assisted Analysis are More Reliable than Those Using Physical Measurements, Photocopies and Printed Scans. *Am J Hum Biol* 21: 365-70.
- Al-Zaid FS, Alhader AA, Al-Ayadhi LY.* 2015 The second to four digit ratio (2D:4D) in Saudi boys with autism: A potential screening tool. *91: 413-15.*
- American Psychiatric Association.* 2000. Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision. Washington, DC: American Psychiatric Association.
- Amerikan Psikiyatri Birli i.* 2001. Psikiyatri Hastalıklarının Tanımlanması ve Sınıflandırılması Elkitabı, Yeniden Gözden Geçirilmiş 4. Baskı (DSM-IV-TR), Amerikan Psikiyatri Birli i, Washington DC, E.Köro lu, trans. Ankara: Hekimler Yayın Birli i.
- Austin EJ, Manning JT, McInroy K, Mathews E.* 2001. An investigation of the associations between personality, cognitive ability and digit ratio. *Pers Individ Differ* 33: 1115-24.
- Bailey AA, Hurd PL.* 2005. Depression in men is associated with more feminine finger length ratios. *Pers Individ Dif* 39: 829-36.
- Bejerot S.* 2007. An autistic dimension A proposed subtype of obsessive-compulsive disorder. *Autism* 11: 101-10.
- Benderlioglu Z, Nelson RJ.* 2004. Digit length ratios predict reactive aggression in women, but not in men. *Horm Behav* 46: 558-64.
- Bogetto F, Venturello S, Albert U, Maina G, Ravizza L.* 1999. Gender-related clinical differences in obsessive-compulsive disorder. *Eur Psychiatry* 14: 434-41.
- Brown WM, Hines M, Fane BA, Breedlove SM.* 2002. Masculinized finger length patterns in human males and females with congenital adrenal hyperplasia. *Horm Behav* 42: 380-86.
- Bruin EI, Verheij F, Weigman T, Ferdinand RF.* 2006. Differences in finger length ratio between males with autism pervasive developmental disorder-not otherwise specified, ADHD and anxiety disorders. *Dev Med Child Neurol* 48: 962-65.
- De la Cruz-Sánchez E, García-Pallarés J, Torres-Bonete MD, López-Gullón JM.* 2015. Can Our Fingers Alone Raise Us Up to the Sky? Analysis of the Digit Ratio Association with Success in Olympic Wrestling. *Coll Antropol* 39: 515-19.
- Evardone M, Alexander GM.* 2009. Anxiety, Sex Linked Behaviour and Digit ratios. *Arch Sex Behav* 38: 442-55
- Fink B, Manning JT, Neave N.* 2004. Second to fourth digit ratio and the 'big five' personality factors. *Pers Individ Differ* 37: 495-503.
- Fink B, Neave N, Manning JT.* 2006. Second to fourth digit ratio, body mass index, waist-to-hip ratio, and waist-to-chest ratio: their relationships in heterosexual men and women. *Ann Hum Biol* 30: 728-38.
- Flaisher-Grinberg S, Albelda N, Gitter L, Weltman K, Arad M, Joel D.* 2009. Ovarian hormones modulate 'compulsive' lever-pressing in female rats *Horm Behav* 55: 356-65.
- Hönekopp J, Watson S.* 2010. Meta-analysis of digit ratio 2D:4D shows greater sex difference in the right hand. *Am J Hum Biol* 22: 619-30.
- Kalra SK, Swedo SE.* 2009. Children with obsessive-compulsive disorder: are they just "little adults"? *J Clin Invest* 119: 737-46.
- Kessler RC, Berglund P, Demler O, Rin J, Merinkangas KR, Walters EE.* 2005. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry* 62: 593-602.

- Lutchmaya S, Baron-Cohen S, Raggatt P, Knickmeyer R, Mannig JT. 2004. 2nd to 4th digit ratios, fetal testosterone and estradiol. *Early Hum Dev* 77: 23-28.
- Malas MA, Dogan S, Evcil EH, Desdicioglu K. 2006. Fetal development of the hand, digits and digit ratio (2D:4D). *Early Hum Dev* 82: 469-75.
- Manning JT, Scutt D, Wilson J, Lewis-Jones DI. 1998. The ratio of 2nd to 4th digit length: a predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and oestrogen. *Hum Reprod* 13: 3000-04
- Manning JT, Bundred PE. 2000. The ratio of 2nd to 4th digit length: A new predictor of disease predisposition? *Med Hypothesis* 54: 855-57.
- Manning JT, Baron-Cohen S, Wheelwright S, Sanders G. 2001. The 2nd to 4th digit ratio and autism. *Dev Med Child Neurol* 43: 160-64.
- Manning JT, Henzi P, Venkatramana P, Martin S, Singh D. 2003. Second to fourth digit ratio: ethnic differences and family size in English, Indian and South African populations. *Ann Hum Biol* 30: 579-88.
- Manning JT, Robinson SJ. 2003. 2nd to 4th digit ratio and a universal mean for prenatal testosterone in homosexual men. *Med Hypotheses* 61: 303-06.
- Martel MM, Gobrogge KM, Breedlove SM, Nigg JT. 2008. Masculinized Finger-Length Ratios of Boys, but Not Girls, Are Associated With Attention-Deficit/Hyperactivity Disorder. *Behav Neurosci* 122: 273.
- Mathis MA, Alvarenga Pd, Funaro G, Torresan RC, Moraes I, Torres AR, Zilberman ML, Hounie AG. 2011. Gender differences in obsessive-compulsive disorder: a literature review. *Rev Bras Psiquiatr* 33: 390-99.
- McIntyre MH. 2006. The use of digit ratios as markers for perinatal androgen action. *Reprod Biol Endocrinol* 4: 10.
- Millet K, Dewitte S. 2006. Second to fourth digit ratio and cooperative behavior. *Biol Psychol* 71: 111-15.
- Muller DC, Giles GG, Manning JT, Hopper JL, English DR, Severi G. 2011. Second to fourth digit ratio (2D:4D) and prostate cancer risk in the Melbourne Collaborative Cohort Study. *Br J Cancer* 105: 438-40.
- Muller DC, Baglietto L, Manning JT, McLean C, Hopper JL, English DR, Giles GG, Severi G. 2012. Second to fourth digit ratio (2D:4D), breast cancer risk factors, and breast cancer risk: a prospective cohort study. *Br J Cancer* 107: 1631-36.
- Okten A, Kalyoncu M, Yari N. 2002. The ratio of second- and fourth-digit lengths and congenital adrenal hyperplasia due to 21-hydroxylase deficiency. *Early Hum Dev* 70: 47-54.
- Ozdogmus O, Cakmak YO, Coskun M, Verimli U, Cavdar S, Uzun I. 2010. The high 2D:4D finger length ratio effects on atherosclerotic plaque development. *Atherosclerosis* 209: 195-96.
- Qian W, Huo Z, Lu H, Sheng Y, Geng Z, Ma Z. 2016. Digit ratio (2d:4d) in Chinese population with schizophrenia. *Early Hum Dev* 98: 45-48
- Ronalds G, Phillips DIW, Godfrey KM, Manning JT. 2002. The ratio of second to fourth digit lengths: a marker of impaired fetal growth? *Early Hum Dev* 68: 21-26.
- Schneider HJ, Pickel J, Stalla GK. 2006. Typical female 2nd-4th finger length (2D:4D) ratios in male-to-female transsexuals-possible implications for prenatal androgen exposure. *Psychoneuroendocrinology* 31: 265-69.
- Teatero ML, Netley C. 2013. A critical review of the research on the extreme male brain theory and digit ratio (2D: 4D). *J Autism Dev Disord* 43: 2664-76.
- Torresan RC, Ramos-Cerqueira AT, de Mathis MA, Diniz JB, Ferrão YA, Miguel EC, Torres AR. 2009. Sex differences in the phenotypic expression of obsessive-compulsive disorder: an exploratory study from Brazil. *Comp Psychiatry* 50: 63-69.
- Venkatasubramanian G, Arasappa R, Rao NP, Gangadhar BN. 2011. Digit ratio (2D:4D) asymmetry and Schneiderian first rank symptoms: implications for cerebral lateralisation theories of schizophrenia. *Laterality* 16: 499-512.
- Walitza S, Melfsen S, Jans T, Zellmann H, Wewetzer C, Warnke A. 2001. Obsessive-compulsive disorder in children and adolescents *Dtsch Arztebl Int* 108: 173-79.
- Wang Y, Wang HL, Li YH, Zhu FL, Li SJ, Ni H. 2016. Using 2D: 4D digit ratios to determine motor skills in children. *Eur Rev Med Pharmacol Sci* 20: 806-09.
- Williams JHG, Greenhalgh KD, Manning JT. 2003. Second to fourth finger ratio and possible precursors of developmental psychopathology in preschool children. *Early Hum Dev* 72: 57-65.