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Sexually dimorphic human body fat distribution and second-to-fourth digit ratio

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Abstract

Since second-to-fourth digit ratio (2D:4D) measures might afford a window into the prenatal environment in terms of testosterone exposure, many researchers are focused to find out the relations between sexually dimorphic characteristics and 2D:4D. Aim of this study is to find out whether there is a relation between sexually dimorphic subcutaneous fat distribution and 2D:4D. Height, weight and skinfold thickness (SFT) were measured in 120 male and 120 female university students. Trunk SFT (sum of subscapular and supraspinale) and limb SFT (sum of triceps, biceps and calf) was used as the absolute amount of the trunk and limb fat, respectively. Limb / trunk fat ratio were used as the indices for the relative distribution of fat mass in the trunk and limbs. The length of index and ring fingers of the participants was measured to the nearest 0.01 mm using Vernier caliper, directly on fingers. As a result correspondingly to the feminine 2D:4D in both hands of men and in the right hand for women; body fat distribution gets feminine. There was no relationship between total fatness and 2D:4D for either sex. These findings could mean that sexually dimorphic body fat distribution is closely related not only to postnatal but also to prenatal steroid levels.

Keywords: *Digit ratio, 2D:4 ratio, body fat distribution, sexual dimorphism*

Introduction

It has been known for over 100 years that males, on average, have relatively long ring fingers (fourth digit) than females (Ecker, 1875; Baker, 1888; see for review Peters et al., 2002). The ratio of the lengths of the index (2D) and ring (4D) fingers, expressed as the ratio 2D:4D, has been proposed as a negative marker of prenatal androgen action and a positive marker of prenatal estrogen. A lower 2D:4D is indicative of relatively higher prenatal testosterone than estrogen levels, which means that men may have, on average, lower digit ratios than women (Manning, 2002). The sex difference in 2D:4D is observable at the end of the first trimester of fetal development (Malas et al., 2006). Right hand 2D:4D measured at 2 years of age was found to be negatively

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correlated with the ratio of testosterone to estradiol measured by amniocentesis in the second trimester (Lutchmaya et al., 2004).

Since 2D:4D measures might afford a window into the prenatal environment in terms of testosterone exposure, many researchers are focused to find out the relation between some sexual characteristics and 2D:4D. In these studies, relations between 2D:4D and many other characters like physical and psychological anomalies, some diseases, sexuality, fertility, attractiveness, sexual selection, perceptive and cognitive abilities and sportive performance were examined (see Voracek and Loibl, 2009).

Homo sapiens display marked size and shape sexual dimorphism, suggestive of strong sexual selection. In all human societies the most fundamentally distinguished sexually dimorphic characteristics between females and males are that men have greater height, larger size, and shorter legs relative to height than women. The greater and taller the body structure of men, the greater advantage they have during the intra-male competition for partners. Also the athletic body required for hunting made the man builds better developed musculoskeletal system. In women, significant amount of subcutaneous fat is a metabolic adaptations to periodic starvation, particularly in periods of pregnancy and lactating (Dixon, 2009).

As well as the difference of amount of subcutaneous fat, subcutaneous fat distribution is also sexual dimorphic. While the body fat is distributed mainly around hip and extremities in women, it is distributed around abdomen and trunk in men (Rodriguez et al., 2005). This distribution of body fat is thought to signal the ratio of pubertal/adult estrogen to testosterone, since the predominance of estrogen at puberty produces a typical female body shape, while the predominance of testosterone produces a typical male body shape (Bjorntrop 1997).

Several studies have assessed associations between 2D:4D and body fatness (Fink et al. 2003; 2006; Muller et al., in press). But In these studies, subcutaneous fat distribution, which is differential between sexes, could not be measured directly. Aim of this study is to find out whether there is a relation between sexually dimorphic subcutaneous fat distribution and 2D:4D.

Material and methods

Study sample

This study was performed on 240 university students (males: N = 120, mean age = 21.40, SD = 1.88; females: N = 120, mean age = 21.73, SD = 1.68,) at Cumhuriyet University in Sivas, Turkey. The ages of the individuals were recorded as day/month/year and later calculated by the decimal system (Tanner et al., 1969). There was no difference between sexes in terms of the mean average age (F = 2.05, P > 0.05). The individuals, in general, belong to the middle socioeconomic status.

Measures of digits and subcutaneous fatness

The length of index and ring fingers of the participants was measured to the nearest 0.01 mm using Vernier caliper, directly on fingers. Manning et al. (2010) concluded that direct measurement of finger length is as reliable as indirect measurements (i.e., photocopy). Length of the second and fourth digits of right and left hand were measured from the crease proximal to the palm to the tip of the finger. The measurements were made twice with the second measurement made blind to the test and these measures displayed a high repeatability (all intraclass correlations = 0.91 to 0.98, all P < 0.0001). Average measures were used in analysis. Those participants who reported injuries to the second or fourth digits were discarded form the analyses (N = 3). 2D:4D was calculated by dividing 2nd by 4th digit length (Manning et al., 1998). In addition to this, the left digit ratio was subtracted from the right digit ratio to give a measure of directional asymmetry of 2D:4D. Associations between body fatness and 2D:4D were assessed separately for right and left 2D:4D, as McFadden and Shubel (2002) have suggested that hormone effects on hand growth may differ. Edinburgh Handedness Inventory was also applied to determine the handedness of the individuals (Oldfield, 1971).

Height, weight and fat measurements were taken in accordance with the techniques proposed by the International Society for the Advancement of Kinanthropometry (ISAK) protocol (Marfell-Jones et al., 2006). In addition, body mass index (BMI) values were calculated by dividing the body weight (kg) by body height in meters squared. The body weight of minimally clothed individuals was measured with a digital scale, sensitive to 0.1 kg (Tanita TBF-305, Tanita Corp. Tokyo, Japan). Their clothing weight was noted on measurement registry forms so that the actual body weight could later be obtained by subtracting the clothing weight. Body height was measured with a Martin portable anthropometer with 0.1 cm sensitivity.

Skinfold thickness (SFT) was measured using Holtain skinfold caliper to the nearest 0.1 mm. Measurements sides included five skinfolds: triceps (the most posterior surface of the arm over the triceps muscle), biceps (the most anterior surface of the arm in the mid-line at the level of the mid-acromiale-radiale landmark), calf (the most medial aspects of the calf at the level where maximal circumference), subscapular (2 cm along a line running laterally and obliquely downward from the subscapular landmark at a 45^0 angle), supraspinale (the line form the marked iliospinale to the anterior axillary border which intersects with the horizontal line at the superior border of the ilium). Trunk SFT (sum of subscapular and supraspinale) and limb SFT (sum of triceps, biceps and calf) was used as the absolute amount of the trunk and limb fat, respectively. Limb / trunk fat ratio were used as the indices for the relative distribution of fat mass in the trunk and limbs.

Statistical analysis

All analyses were performed using to computer program SPSS for Windows (Statistical Package for the Social Sciences, version 17.0, SSPS Inc, Chicago, IL, USA). Weight and height values were compared by using ANOVA. Since BMI and SFTs and all ratios were not normally distributed for these variables, sexes were compared by Kruskal-Wallis non-parametric ANOVA. Partial correlation coefficients were used for assessing the relationship between 2D:4D and body measures. Some studies put forward a significant relation between 2D:4D ratio and handedness (see Stoyanov et. al., 2009). Therefore, age and handedness were evaluated as control variables in partial correlation analysis.

Results

Descriptive statistics of weight, height and BMI were as follows; mean weight of males were 64.69 kg (SD = 11.43), females were 61.66 kg (SD = 12.11), $F = 3.98$ ($P<0.05$), mean height of males were 168.42 cm (SD = 8.05), females were 163.97 cm (SD = 8.04), $F = 18.38$ ($P<0.001$), BMI of males were 22.73 kg/m^2 (SD = 3.22), females were 22.90 kg/m^2 (SD = 3.87), $F = 0.13$ ($P>0.05$). As observed, males were significantly taller and heavier; but the difference in BMI between the sexes was insignificant. No association was found between 2D:4D and weight, height and BMI in both sexes (all $P>0.05$).

Table 1: Means (M) and standard deviations (SD) for 2D:4D, five skinfold thickness, limb fat, trunk fat, total fat and fat ratio

	Males		Females		
	Mean	SD	Mean	SD	Chi-Square
Right 2D:4D	0.95	0.033	0.97	0.027	11.13***
Left 2D:4D	0.96	0.031	0.98	0.032	7.72**
Triceps	7.43	3.25	10.73	8.17	12.03***
Biceps	3.95	1.27	5.22	2.96	14.16***
Calf	9.49	3.66	11.95	7.59	4.98*
Subscapular	9.29	2.44	10.38	3.81	0.010
Supraspinale	7.98	2.35	8.90	3.36	3.67
Limb fat[1]	20.87	7.30	27.91	11.46	9.40***
Trunk fat[2]	17.86	4.23	19.28	6.82	0.50
Total fat[3]	38.74	10.75	47.27	23.23	3.90*
Fat ratio[4]	0.97	0.26	1.14	0.43	9.87***

* *P*<0.05
** *P*<0.01
*** *P*<0.001,
1 = biceps + triceps + calf
2 = subscapular + supraspinale
3 = Sum of all skinfolds
4 = (biceps + triceps + calf) / (subscapular + supraspinale)

Table 2: Partial correlations between, limb fat, trunk fat, total fat and fat ratio and 2D:4D and directional asymmetry of 2D:4D (control variables = age and handedness)

	Trunk fat[2]	Total fat	Fat ratio[3]	Right 2D:4D	Left 2D:4D	D *r-l*
Males						
Limb fat[1]	0.720***	0.962***	0.442***	0.202*	0.138	-0.001
Trunk fat[2]	--	0.882***	-0.093	-0.032	0.022	-0.055
Total fat[3]	--	--	0.264**	0.098	0.086	-0.022
Fat ratio[4]	--	--	--	0.401***	0.283**	0.196*
Right 2D:4D	--	--	--	--	0.550***	0.635***
Left 2D:4D						-0.297***
Females						
Limb fat[1]	0.783***	983**	0.561***	0.194*	0.126	-0.077
Trunk fat[2]	--	883**	0.240**	0.016	0.115	-0.043
Total fat[3]	--	--	0.494***	0.075	0.107	-0.071
Fat ratio[4]	--	--	--	0.375***	0.175	0.146
Right 2D:4D	--	--	--	--	0.613***	0.364***
Left 2D:4D						-0.513***

**P*<0.05
** *P*<0.01
*** *P*<0.001
1 = biceps + triceps + calf
2 = subscapular + supraspinale
3 = Sum of all skinfolds
4 = (biceps + triceps + calf) / (subscapular + supraspinale)

Averages of digit ratio, SFTs, limb fat, trunk fat, total fat and fat ratio are in Table 1. 2D:4D, as expected, was lower in males than females for both hands. Right hand 2D:4D ratio was also lower for both sexes. While triceps, biceps and calf SFTs were higher in girls, subscapular and supraspinale SFTs representing trunk fatness were not different. Similarly, the limb fat level which consists of three SFTs representing peripheral fatness was significantly higher in females. When males and females are matched, the trunk fat data, which is calculated summing up subscapular and supraspinale SFT values, does not make sense. The total fat value that I find summing up five SFTs was significantly higher in females. As expected, fat ratio value was higher in females (*P*<0.001).

According to partial correlation analysis, there was a positive correlation between limb fat, fat ratio and 2D:4D in both sexes. However, fat ratio was related with both right and left hands 2D:4D, and limb fat was related with only right hand 2D:4D. In females, on the other hand, limb fat were related with both hands 2D:4D and fat ratio was related with only right hand 2D:4D. The correlation between trunk fat, total fat and 2D:4D was not significant for both sexes. There was no relationship between total, trunk and limb fat and D_{r-l} for either sex.

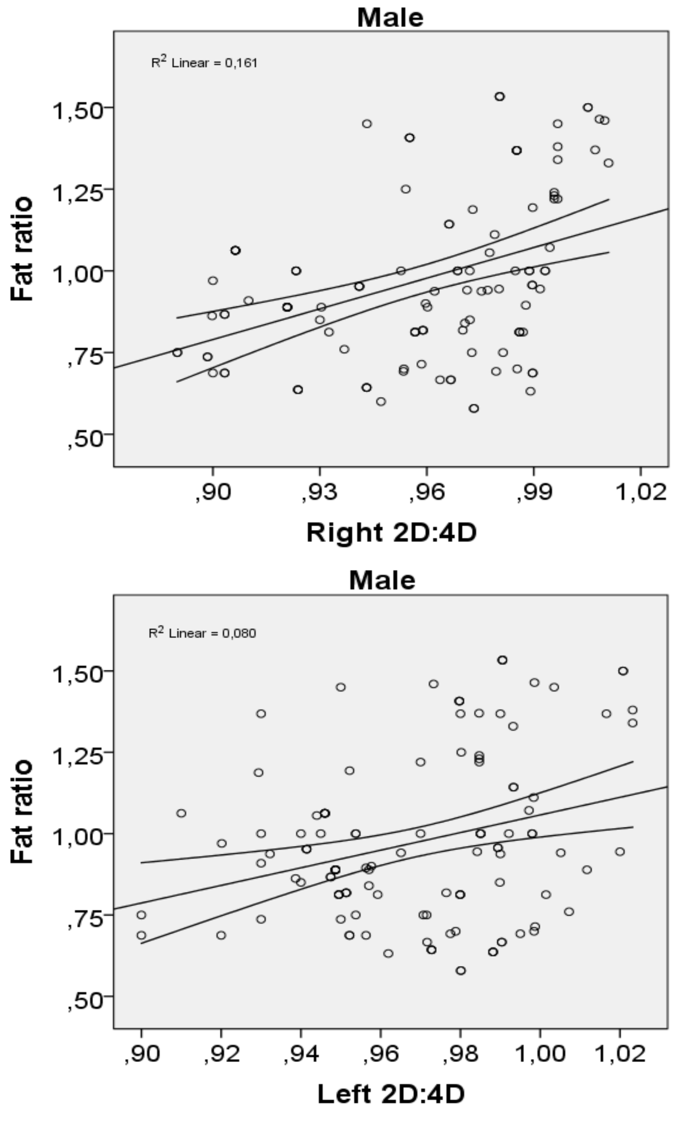

Fig 1: Associations between fat ratio and 2D:4D ratio in males.

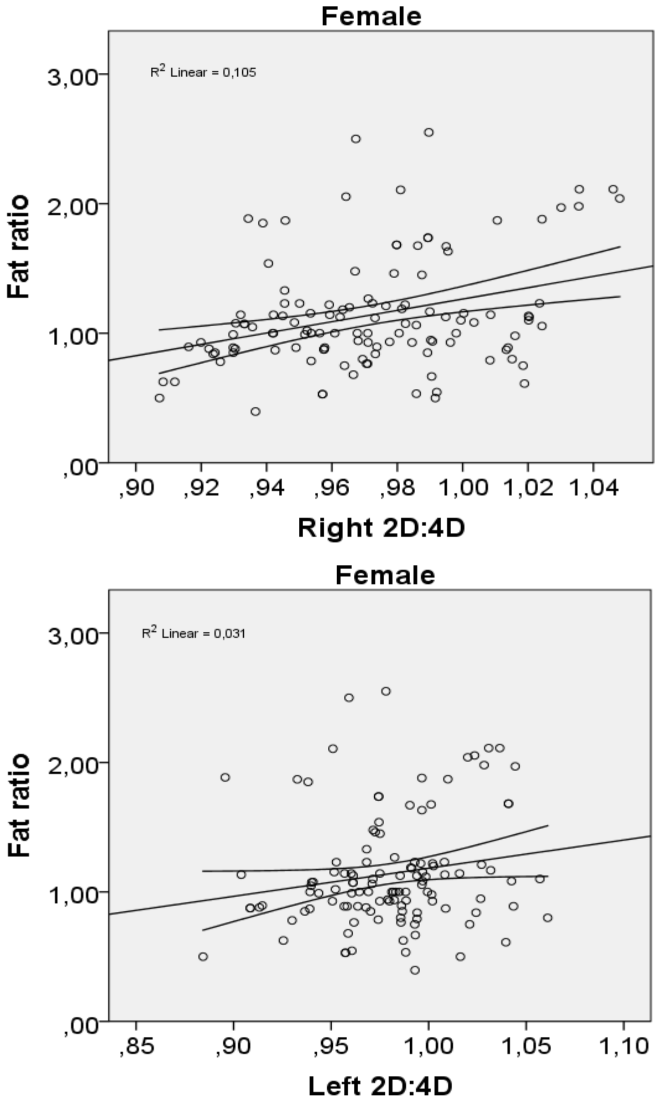

Fig 2: Associations between fat ratio and 2D:4D ratio in females.

Discussion

According to the results of this study, there was a significant correlation between subcutaneous fat distribution and 2D:4D for both sexes. Correspondingly to the feminine 2D:4D in both hands of men and only in the right hand for women; body fat distribution gets feminine. This correlation particularly appears depending to the increase of amount of fat in extremities.

The sole study based on measuring amount of body fat was conducted by Muller et al. (2012). In this study, researchers examined (8840 women and 6076 men) subjects' fat and lean body mass and waist and hip circumference as well as their weight and height. In this study which has an impressive sample size, they observed no strong association between 2D:4D and height, weight, BMI, waist circumference, hip circumference, waist-to-hip ratio, fat mass, fat-free mass or percentage fat mass (Muller et al., 2012). The body mass index and the waist-to-hip ratio are two variables relations of which between 2D:4D are researched in some studies since the former is an indirect indicator of amount of body fat and the latter is so of fat distribution. Fink et al. (2003) found moderately strong inverse associations between waist circumference, hip circumference and waist-to-chest ratio and both right and left

2D:4D for women. This study also found that BMI was strongly positively correlated with left 2D:4D for men. McIntyre et al. (2003) found a weak inverse association between right 2D:4D and waist circumference in a sample of 42 men. Fink and his colleagues (2006) found in another study that right 2D:4D was inversely associated with hip circumference and positively correlated with waist-to-hip ratio for men, but found no associations between 2D:4D and any anthropometric measure for women (Fink et al., 2006).

In my study, it was remarkable that, corresponding to the limb fatness which was regarded as a feminine characteristic, digit ratios become feminine for both sexes. Since 2D:4D is supposedly related to prenatal hormonal levels (Manning et al., 1998, Manning, 2002) my study suggests an early organizational effect of sex hormones through the association between body fat distribution and finger length patterns. However, at this point the challenging question is; why is not there a correlation between total body fatness, trunk fatness and BMI and 2D:4D. The answer to the question could be the sex hormones that have more active role on distribution of fat in body.

It is known for a long time that subcutaneous fat distribution is a sexually dimorphic. The ratio of triceps +biceps/subscapular + suprailiac is around 3% greater in females compared to males (Rodriguez et al., 2005; for review see Wells, 2007). Many studies consistently demonstrate that SKFs ratios diverge markedly between the sexes at puberty (Rolland-Cachera et al., 1990; Malina and Bouchard, 1991; Wells, 2007) with these differences maintained into the fifth decade of life. These differences can be attributed to a tendency for increased peripheral fat accumulation in females but not males, with this pattern reported in all the major ethnic groups (Wells, 2007). Nindl et al. (2003) examined regional body composition data obtained in 120 adults using dual energy x-ray absorptiometry. They found that both sex have a similar amount of fat in the trunk, but females have around 10% more in the arms and 30% more in the legs. In my study, as is seen in Table 1, sexes had no significant difference in trunk fatness. However, limb fatness was 33% higher in girls. These findings put forward that sexual dimorphism was more significant in limb fatness. The significant relation between limb fatness and 2D:4D makes me consider that the sex hormones are more effective on limb fatness not on the trunk fatness.

Evidence for exogenous sex hormone administration on body fat distribution can be observed in transsexual men and women. Elbers et al. (1997) found that long term testosterone administration in young, non-obese, female subjects increases the amount of visceral fat. In addition, an increase in weight in this hyperandrogenic state leads to a preferential storage of fat in the visceral depot. After all, in another study conducted by Elbers et al. (1999), 12 men, who reassigned their sex, have been given estrogen for a long time and at the end of the process it is found out that subjects' subcutaneous fat amount has increased particularly in arms and legs.

As a result, according to this study in which correlation between subcutaneous fat patterns and 2D:4D is examined in 240 young adults; it was found out that there was not an important relation between total amount of body fat and 2D:4D. On the contrary, there was significant relation between 2D:4D and body fat distribution. These findings could mean that sex specific body fat distribution is closely related not only to postnatal but also to prenatal steroid levels.

Bibliography

Baker F. (1888) Anthropological notes on the human hand. Am Anthropol 1:51-75.

Bjorntrop P. (1997) Body fat distribution, insulin resistance, and metabolic diseases. Nutrition 13:795–803.

Dixon A. (2009) Sexual selection and the origins of human mating systems. Oxford: Oxford University Press.

Ecker A. (1875) Einige Bemerkungen über einen schwankenden Charakter in der Hand des Menschen. Arch Anthropol 8:67-75.

Elbers JMH, Asscheman H, Seidell JC, Megens JAJ, Gooren LJG. (1997) Long-term testosterone administration increases visceral fat in female to male transsexuals. J Clin Endocrinol Metab 82:2044–2047.

Elbers JM, Asscheman H, Seidell JC, Gooren LJ. (1999) Effects of sex steroid hormones on regional fat depots as assessed by magnetic resonance imaging in transsexuals. Am J Physiol 276:317–325.

Fink B, Neave N, Manning JT. (2003) 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 30:728-738.

Fink B, Manning JT, Neave N. (2006) The 2nd-4th digit ratio (2d:4d) and neck circumference: implications for risk factors in coronary heart disease. Int J Obes (Lond) 30:711–714.

Frayer DW, Wolpoff MH. (1985) Sexual Dimorphism. Ann Rev Anthropol 14: 429-473.

Lutchmaya S, Baron-Cohen S, Raggatt P, Knickmeyer R, Manning 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 82:469-475.

Malina RM, Bouchard C. (1991) Growth, maturation, and physical activity. Champaign, IL: Human Kinetics.

Manning JT, Baron-Cohen S, Wheelwright S, Fink B. (2010). Is digit ratio (2D:4D) related to systemizing and empathizing? Evidence from direct finger measurements reported in the BBC Internet Survey. Person Indiv Diff 48:767-771.

Manning JT, Scutt Wilson J, Lewis-Jhones DI. (1998) The ratio of the 2nd to 4th digit length: a predictor of sperm numbers and concentrations of testosterone, luteinzing hormone and oestrogen. Hum Reprod 13:3000-3004.

Manning JT. (2002) Digit ratio: a pointer to fertility, behavior, and health. New Brunswick, N.J: Rutgers University Press.

Marfell-Jones M, Olds T, Stewart A, Carter L. (2006) International standards for anthropometric assessment. ISAK: Potchefstroom, South Africa.

McIntyre MH, Lipson SF, Ellison PT. (2003) Effects of developmental and adult androgens on male abdominal adiposity. Am J Hum Biol 15:662–666.

Muller DC, Manning JT, Hopper JL, English DR, Giles GG, Severi G. (in press) No strong association between second to fourth digit ratio (2D:4D) and adult anthropometric measures with emphasis on adiposity. Ann Hum Biol (doi:10.3109/03014460.2012.751127).

Nindl BC, Scoville CR, Sheehan KM, Leone CD, Mello RP. (2002) Gender differences in regional body composition and somatotrophic influences of IGF-I and leptin. J Appl Physiol 92:1611–1618.

Oldfield RC. (1971) The assessment and analysis of handedness: the Edinburgh inventory. Neuropsychologia 9:97-113.

Peters M, Mackenzie K, Bryden P. (2002) Finger length and distal finger extent patterns in humans. Am J Phys Anthropol 117:209-217.

Rodríguez G, Samper MP, Olivares JL, Ventura P, Moreno LA, Pérez-González JM. (2005). Skinfold measurements at birth: sex and anthropometric influence. Arch Dis Child 90: 273-275.

Rolland-Cachera MF, Bellisle F, Deheeger M, Pequignot F, Sempe M, (1990) Influence of body fat distribution during childhood on body fat distribution in adulthood: a two decade follow-up study. Int J Obes 14: 473–481.

Stoyanov Z, Marinov M, Pashalieva I. (2009) Finger length ratio (2D:4D) in left-handed and right handed males. Int J Neurosci 119:1006-1013.

Tanner JM, Hiernaux J, Jarman S. (1969) Growth and physique studies. In: Weiner JS, Lourie JA. editors. Human biology: a guide to field methods. IBP Handbook No. 9, Oxford: Blackwell Publications, 315-340.

Vorace M, Loibl LM. (2009) Scientometric analysis and bibliography of digit ratio (2D:4D)

research, 1998-2008. Psychol Rep 104:922-956.
Wells JC. (2007) Sexual dimorphism of body composition. Best Pract Res Clin Endocrinol Metab 21:415–430.