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ORIGINAL ARTICLE / PRACA ORYGINALNA

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THE 2D:4D RATIO VERSUS FEATURES OF BODY COMPOSITION AND BODY CONSTITUTION IN YOUNG WOMEN AND MEN

WSKAŹNIK 2D:4D A CECHY SKŁADU I TYPU BUDOWY CIAŁA U MŁODYCH KOBIET I MĘŻCZYZN

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Summary

Towards the end of the 19th century, a hypothesis was proposed of the dimorphic nature of the 2D:4D ratio. Differences in this ratio already develop in intrauterine life and result from different proportions and concentrations of sex hormones. High prenatal androgens and low prenatal estrogens cause a low, masculinizing, 2D:4D ratio. Numerous data from literature confirm that this ratio is connected with a number of traits associated with sex hormones.

The research was carried out into a group of men (166) and women (217) including students of physiotherapy (139) of Collegium Medicum of the Nicolaus Copernicus University in Toruń, tourism and recreation (63) and physical education (121) of the Kazimierz Wielki University of Bydgoszcz, and competitive sportspeople (59) from the sports club Zawisza Bydgoszcz. The lengths of right fingers were measured by a sliding caliper (GPM, Swiss Made). The body structure was assessed by Rohrer's index. The body composition was investigated with segmental bioelectrical impedance analysis (SBIA) using the Biospace Co. Ltd. In Body 3.0 apparatus.

The study was made on the relationship between the digit ratio (2D:4D) and a number of selected features and indices of body composition and body constitution. A significant correlation was found between the 2D:4D ratio and the protein mass, bone mass, soft lean mass (SLM), lean body mass (LBM) and segmental lean body mass (except lower limbs) in the group of female subjects. In the group of male subjects, no significant correlation between the 2D:4D ratio and the examined traits and indices was found.

Streszczenie

Jeszcze pod koniec XIX wieku wysunięta została hipoteza o dymorficznym charakterze wskaźnika 2D:4D. Różnice tego wskaźnika kształtują się już w życiu płodowym i wynikają z różnych proporcji i stężeń hormonów płciowych. Wysokie stężenie prenatalnych androgenów i niskie prenatalnych estrogenów powodują niski, maskulinizujący, wskaźnik 2D:4D. Liczne dane z literatury potwierdzają powiązanie tego wskaźnika z wieloma cechami połączonymi z hormonami płciowymi.

Badania prowadzono na grupie mężczyzn (166) i kobiet (217) składającej się ze studentów fizjoterapii (139) Collegium Medicum Uniwersytetu Mikołaja Kopernika w Toruniu, turystyki i rekreacji (63) i wychowania fizycznego (121) Uniwersytetu Kazimierza Wielkiego w Bydgoszczy oraz sportowców wyczynowych (59) z klubu sportowego

Zawisza Bydgoszcz. Długość palców prawej dłoni zmierzono cyrklem liniowym (GPM, Swiss Made). Typ budowy ciała oceniono na podstawie wskaźnika Rohrera. Skład ciała zbadano metodą segmentalnej bioelektrycznei impedancji (SBIA), przy użyciu aparatu „In Body 3.0" firmy Biospace Co.Ltd.

Badania dotyczyły zależności między wskaźnikiem palcowym (2D:4D) a szeregiem wybranych cech i wskaźników składu ciała oraz typu budowy ciała. Znaleziona została istotna korelacja pomiędzy wskaźnikiem 2D:4D a masą proteinową ciała, mineralną masą kości, miękką, szczupłą masą ciała, szczupłą masą ciała (LBM) i segmentalną szczupłą masa ciała (oprócz kończyn dolnych) w grupie badanych kobiet. W grupie zbadanych mężczyzn nie znaleziono jakichkolwiek istotnych korelacji pomiędzy wskaźnikiem 2D:4D a badanymi cechami i wskaźnikami.

Key words: 2D:4D, body composition, body constitution
Słowa kluczowe: 2D:4D, skład ciała, typy budowy ciała

INTRODUCTION

The recent years have brought an increased scientific interest in the ratio of the lengths of index and ring fingers (2D:4D) and its association with a number of morphological, functional, psychological, personality and other traits in people of both sexes. Only in 1998 to 2011, more than 450 scientific papers were published on this subject [1].

During the previous scientific studies it was established that in the whole human population the ratio of the lengths of index finger (2D) to ring finger (4D) is slightly different between women and men [2]. The average 2D:4D ratio, also called the digit ratio [3], is 0.98 in men and 1.00 in women. These differences already develop during intrauterine life (in the 13th to 14th week of pregnancy). They result from different proportions and concentrations of sex hormones [4, 5]. A higher level of testosterone facilitates the development of digit 4, whereas a higher level of estrogens – the development of digit 2. To sum up, high prenatal androgens, low prenatal estrogens, or both combined, cause a low (masculinizing) ratio 2D:4D [5, 6]. The 2D:4D ratio is connected with a number of traits associated with sex hormones, such as fertility, sexual attraction, sexual orientation, spatial imagination, aggression and sport [7, 8, 9, 10, 11]. According to Manning and Bundred [12], the ratio of the finger lengths tells a lot about many features and tendencies which we could acquire during intrauterine life with the participation of sex hormones. It was proved that people who are left-handed, autistic, who have dyslexia or musical abilities, have a lower ratio than the average in the population [12, 13]. The 2D:4D ratio can be helpful in the assessment of breast cancer risk in women and predisposition to coronary heart disease in men [12, 14]. It also appears helpful in the assessment of predispositions for specified sports disciplines [15, 16].

The aim of the study was to examine the correlation between the digit ratio and the body constitution and body composition in young men and women.

MATERIAL AND METHODS

The study included a group of 166 men and 217 women aged 19 to 36 years.

The study was performed in the Department of Anthropology Nicolaus Copernicus University Collegium Medicum in Bydgoszcz in 2011.

The subjects were students of physiotherapy (139) of Collegium Medicum of the Nicolaus Copernicus University in Toruń, physical education (121) and tourism and recreation (63) of the Kazimierz Wielki University of Bydgoszcz and sportspeople (59) – footballers, pole-vaulters and volleyball players - from the sports club Zawisza Bydgoszcz. The subjects had their body height, shoulders width and lengths of index and ring fingers measured. The anthropometric measurements were done with Martin's technique [17]. The lengths of the right hand fingers were measured by a sliding caliper (GPM, Swiss Made). The type of the body constitution (slender, medium, stout) was assessed on the basis of Rohrer's index. The body composition was examined by segmental bioelectrical impedance analysis (SBIA) using the Biospace Co. Ltd. *In Body 3.0* apparatus. The principle of the SBIA method is measurement of electrical resistance in the body, which mainly depends on tissue hydration and electrolyte concentration [18, 19]. The following features of body composition were examined: protein mass, bone mass, soft lean body mass, lean body mass, segmental lean body mass, waist to hip ratio (WHR), as well as muscular and total circumference of arm.

The estimation of total lean body mass (LBM) and segmental lean body mass of limbs and trunk (sLBM) was based on the general and segmental content of organic water in the body [20, 21, 22]:

$$LBM\ (\%) = \%\ of\ water / 0.732$$

and

$$sLBM\ (\%) = segmental\ \%\ of\ water/0.732$$

The basic statistical characteristics (arithmetic mean and standard deviation) have been calculated. The differences between the groups of subjects were evaluated using a t-Student test and a correlation analysis.

RESULTS

The results of the research are shown in Tables I-V.

Table I. *Statistical characteristics of anthropometric features of the male and female subjects*
Tabela I. *Charakterystyki statystyczne cech antropometrycznych badanych mężczyzn i kobiet*

Feature/cecha	Sex/płeć	
	♂ (n_1=166)	♀ (n_2=217)
	M ± SD	M ± SD
Age/wiek	22.3 ± 3.5	21.0 ± 2.5
Height/wysokość ciała [cm]	182.0 ± 7.2	168.6 ± 7.0
Body mass/masa ciała [kg]	78.9 ± 9.8	61.3 ± 9.7
Shoulders width/szerokość barkowa [cm]	43.1 ± 2.2	37.5 ± 1.9
Body Mass Index/wskaźnik BMI [kg/m^2]	23.81 ± 2.53	21.52 ± 2.91
Rohrer's index/wskaźnik Rohrera [g/cm^3]	1.31 ± 0.16	1.28 ± 0.18

M – mean
SD – standard deviation

Table II. *Statistical characteristics of body composition of the male and female subjects*
Tabela II. *Charakterystyki statystyczne składu ciała badanych mężczyzn i kobiet*

Feature/cecha		Sex/płeć	
		♂ (n_1=166)	♀ (n_2=217)
		M ± SD	M ± SD
Protein mass/ masa proteinowa [kg]		17.36 ± 2.01	11.77 ± 1.64
Bone mass/ mineralna masa kości [kg]		3.57 ± 0.34	2.61 ± 0.29
Soft lean body mass/ miękka szczupła m.ciała[kg]		65.02 ± 7.53	44.09 ± 6.15
Lean body mass/ szczupła masa ciała[kg]		68.58 ± 7.87	47.70 ± 6.44
Segmental lean body mass/:	$sLBM_{pkg}$	4.02 ± 0.58	2.28 ± 0.45
Sgmentalna szczupłam. ciała	$sLBM_{lkg}$	3.95 ± 0.57	2.23 ± 0.45
	$sLBM_t$	30.10± 3.37	20.10± 2.72
	$sLBM_{pkd}$	10.58 ± 1.29	7.34 ± 1.15
	$sLBM_{lkd}$	10.55 ± 1.28	7.34 ± 1.15
Total circumference of arm/ obwód całkowity ramienia [cm]		29.0 ± 3.1	26.8 ± 2.6
Muscular circumference of arm/ obwód mięśniowy ramienia [cm]		26.4 ± 2.1	21.1± 1.6
Waist hip ratio/ wskaźnik WHR		0.81± 0.04	0.79 ± 0.05

LBM_{pkg} - right upper limb/ prawa kończyna górna
LBM_{lkg} – left upper limb/ lewa kończyna górna
LBM_t – trunk/ tułów
LBM_{pkd} – right lower limb/ prawa kończyna dolna
LBM_{lkd} – left lower limb/ lewa kończyna dolna
M – mean
SD – standard deviation

Table III. *Measurements of right hand fingers of the subjects*
Tabela III. *Pomiary palców prawej ręki badanych osób*

Feature/cecha	Sex/płeć		T-Student test/ test t Studenta
	♂ (n_1=166)	♀ (n_2=217)	
	M ± SD	M ± SD	
Length of digit 2/długość palca II [cm]	7.35 ± 0.43	6.77 ± 0.43	$p \le 0.001$
Length of digit 4/długość palca IV [cm]	7.55 ± 0.46	6.85 ± 0.45	$p \le 0.001$
Digit ratio (2D:4D)/ wskaźnik palcowy	0.975 ± 0.033	0.990 ± 0.030	$p \le 0.001$

Table IV. *2D:4D ratio broken down into 3 types of body structure according to Rohrer's index*
Tabela IV. *Wskaźnik 2D:4D z podziałem na 3 typy budowy ciała wg wskaźnika Rohrera*

Sex/ płeć	Group/grupa	N	M ± SD	T-Student test/ Test t Studenta		
				I/II	I/III	II/III
♂	Slender build/budowa smukła (I)	15	0.971 ± 0.035			
	Medium build/budowa średnia (II)	128	0.975 ± 0.032	n.s.	n.s.	n.s.
	Stout build/budowa tęga (III)	235	0.978 ± 0.039			
♀	Slender build/budowa smukła (I)	27	0.984 ± 0.034			
	Medium build/budowa średnia (II)	166	0.991 ± 0.030	n.s.	n.s.	n.s.
	Stout build/budowa tęga (III)	24	0.985 ± 0.027			

Table V. *Correlation between the 2D: 4D ratio and the examined features*
Tabela V. *Korelacja między wskaźnikiem 2D:4D a badanymi cechami*

Feature/cecha		Sex/płeć	
		♂ (n_1=166)	♀ (n_2=217)
Heigh,wysokość ciałat [cm]		-0.056	-0.111
Body mass/masa ciała [kg]		-0.018	-0.079
Protein massmasa proteinowa [kg]		-0.063	-0.141*
Bone mass/mineralna masa kości [kg]		-0.065	-0.140*
Soft lean body mass/miękka szczupła m. ciała [kg]		-0.065	-0.141*
Lean body mass/szczupła masa ciała [kg]		-0.065	-0.141*
Segmental lean body mass/:	$sLBM_{pkg}$	-0.101	-0.155*
Segmentalna szczupła m. ciała	$sLBM_{lkg}$	-0.112	-0.150*
	$sLBM_t$	-0.077	-0.144*
	$sLBM_{pkd}$	-0.048	-0.130
	$sLBM_{lkd}$	-0.059	-0.128
Body Mass Index/wskaźnik BMI [kg/m^2]		0.021	-0.017
Rohrer's index/wskaźnik Rohrera [g/cm^3]		0.042	-0.015
Waist hip ratio (WHR)/obwód pasa do bioder		0.043	-0.055
Muscular circumference of arm/obw. mięśniowy ramienia [cm]		-0.082	-0.100
Total circumference of arm/obw. całkowity ramienia [cm]		-0.027	-0.014
Shoulders width/szerokość barkowa [cm]		-0.077	-0.070
Length of digit 2/długość palca II [cm]		0.180*	0.164*
Length of digit 4/długość palca IV [cm]		-0.333**	-0.298**

*$p \le 0.05$
** $p \le 0.01$

The basic measurements, anthropometric indices and body composition of the subjects are presented in Tables I and II. The differences in the lengths of digit 2 and 4 between both sexes and the digit ratio (2D:4D) in both sexes are shown in Table III. In both sexes, digit 4 was longer than digit 2. The proportion of digit 2 to digit 4 is 0.975 in men and 0.990 in women. This difference is statistically significant, which indicates that the male subjects' digit 4 is longer than digit 2.

Based on Rohrer's index, 3 types of body constitution were distinguished (slender, medium, stout) and the index ratio examined (Table IV). No significant differences between body constitution and the 2D:4D ratio were found.

The correlations between the digit ratio and the selected feature of body constitution were examined (Table V). In men the digit ratio significantly correlated with the lengths of digits 2 and 4 only. In women the negative correlation applied to protein mass, bone mass, soft lean body mass and its segmental parts including upper limbs and the trunk.

DISCUSSION

The results of our study confirm that women have lower length of fingers and higher 2D:4D ratio than men. This is documented by a number of other publications [4, 23, 24, 25]. In our research, the measurements of finger lengths were carried out on the right hand. As regards the legitimacy of using the right or left hand, there is no unanimity between the researchers. Some of them claim that the right-hand 2D:4D is a better ratio of prenatal androgenization than the left-hand 2D:4D [4, 10, 16, 24, 25, 26] and the other way round [6, 23, 27].

In our analysis we found a correlation between the 2D:4D ratio and the few examined features in the group of females. This concerns protein mass, bone mass, soft lean body mass, lean body mass (LBM) and segmental lean body mass (except lower limbs). Such interdependence was not found in relation to the other examined traits (BMI, body constitution type – according to Rohrer's index, WHR, muscular and total circumference of arm, shoulders width). In the group of male subjects, no statistical interdependence was found between the examined features and the digit ratio (2D:4D).

When examining the correlations between BMI and 2D:4D, Danborno et al. [25] did not find any significant interdependence between these indices, which is confirmed in our research. This also concerns the WHR index [28, 29, 30, 31]. There are some authors, however, who has found significant correlation between these indices [23].

The correlative interdependence between the typically masculinizing features of body composition and 2D:4D, found in our female subjects, and their absence in the males, suggests that the sex dependent 2D:4D ratio has a limited prediction in men. Similar conclusions were drawn by Neave [29] and Putz [5], when they examined other sex dependent features.

The hypothesis that the type of body constitution may correspond to the 2D:4D ratio, appeared to be erroneous.

The thesis of the significant correlation of the 2D:4D ratio with basic psychophysical features in sportspeople, in particular in men [4], has not been confirmed by us. It is possible that this was affected by the fact that the group of sportspeople examined by us was too small.

CONCLUSIONS

Index Finger (2D:4D) correlates with an active body mass in women and has limited prediction in men.

REFERENCES

1. Voracek M. Special issue preamble: Digit ratio (2D:4D) and individual differences research. Pers Indiv Differ, 2011; 51: 367-370.
2. Manning JT. The Finger Book. Farber & Farber, 2008.
3. Wilson GD. Finger length as an index of assertiveness in women. Pers Indiv Differ, 1983; 4: 111-112.
4. Manning JT. Digit ratio: a Pointer to Fertility, Behavior and Health. New Jersey: Rutgers Univ. Press, 2002.
5. Putz DA, Gaulin SJC, Sporter RJ. Sex hormones and finger length. What does 2D:4D indicate? Evol Hum Behav, 2004; 25, 182-199.
6. Manning JT, Scutt D, Wilson J. The ratio of the 2nd and 4th digit length: a predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and estrogen. Hum Reprod, 1998; 13: 3000-3004.
7. Pokrywka L, Rachon D, Suchecka-Rachon K. The second to fourth digit ration in elite and non-elite female athletes. Am J Hum Biol, 2005; 17:796-800.
8. Paul SN, Kato BS, Hunkin JL. The Bid Finger: the second to fourth digit ratio is a predictor of sporting ability in women. Br J Sports Med, 2006; 40: 981-983.
9. Burriss RP, Little AC, Nelson EC. 2D:4D and sexual dimorphic facial characteristics. Arch Sex Behav, 2007; 36, 3: 377-384.

10. Bennett M, Manning JT, Cook CJ. Digit ratio (2D:4D) and performance in elite players. J Sports Sci, 2010; 28, 13: 1415-1421.
11. Longman D, Stock JT, Wells JCK. Digit ratio (2D:4D) and rowing ergometer performance in males and females. Am J Phys Anthropol, 2001; 144, 3: 337-341.
12. Manning JT, Bundred PF. The ratio of 2nd to 4th digit length: A new predictor for disease predisposing? Med Hypotheses, 2000; 54, 5: 855-857.
13. Pongsak Noipayak. The ratio of 2nd to 4th digit length in autistic children. J Med Assoc Thai, 2009; 92: 1040-1045.
14. Fink B, Manning JT, Neave N. The 2nd 4th digit ratio (2D:4D) and neck circumference: implications for risk factors in coronary heart disease. Int J Obes, 2006; 30: 711-714.
15. Manning JT, Taylor RP. Second to fourth digit ratio and male in sport: implications for sexual selection in humans. Evo. Hum Behav, 2001; 22 ,1: 69.
16. Hoenekopp J, Watson S. Meta-analysis of digit ratio 2D:4D shows greater sex diffeence in the right hand. Am J Hum Biol, 2010; 22, 5: 619-630.
17. Malinowski A, Bożiłow W. Podstawy Antropometrii.Wyd. Nauk. PWN. Warszawa-Łódź, 1997.
18. Čabrić M, Krakowiak H, Sokołowska E. Badania zależności między wybranymi cechami morfologicznymi a sprawnością fizyczną u kobiet w różnym wieku. Scripta Periodica, 2000; III, 2, suppl.1/2: 541-546.
19. Čabrić M, Krakowiak H. Badania zależności między typem budowy ciała a składem ciała u młodych kobiet. Postępy Rehabilitacji, 2002; 2, 1: 1-5.
20. Pace N, Rathbun EN. Studies on Body Composition. III. The Body Water and Chemically Combined Nitrogen Content in Relation to Fat Content. J Biol Chem, 1945; 158: 685-691.
21. Forbes GB. Human Body Composition and Activity. London: Springer-Verlag, 1987.
22. Čabrić M, Krakowiak H, Krakowiak A. 2010. Traits of body musculature in students of medicine and physical education. Med Biol Sci, 2010; 24/1: 19-24.
23. Manning JT, Henzi P, Venkatramana P. Second to fourth digit ratio: ethnic differences and famiky sitze in English, Indian and South African populations. Ann Hum Biol, 2003; 30, 579-588.
24. Lutchmaya S, Baron-Cohen S, Raggatt P. 2nd to 4th digit ratio, fetal testosterone and estradiol. Early Hum Dev, 2004; 77: 23-28.
25. Danborno B, Adebisi SS, Adelaiye AB. Sexual Dimorphism and Relationship betweem Chest, Hip and Waist Circumference with 2D, 4D and 2D:4D in Nigerians. The Internet J Biol Anthropol, 2008; 1, 2.
26. Van Anders SM, Hampson E. Testing the prenatal androgen hypothesis: measuring digit rations, sexual orientation and spatial abilities in adults. Hum Behav, 2005; 47: 92-98.
27. McFadden D, Loehlin JC, Breedlove MC. A reanalysis of five studies on sexual orientation and the relative length of the 2nd and 4th fingers (the 2D:4D ratio) Arch Sex Behav, 2005; 34: 341-356.
28. Manning JT, Robinson SJ. 2nd to 4th digit ratio and a universal mean for prenatal testosterone in homosexual men. Med Hypotheses, 2003; 61: 303-306.
29. Neave N, Laing S, Fink B, M. Second to fourth digit ratio, testosterone and perceived male dominance. Pro Royal Society of London, 2003; Series B 270: 2167-2172.
30. Manning JT, Wood S, Vang E. Second to fourth digit ratio (2D:4D) and testosterone in men. Asian J Androl, 2004; 6: 211-215.
31. Vehmas T, Solovieva S, Leino-Arjas P. Radiographic 2D:4D index in females: no relation to anthropometric, behavioural, nutritional, health-related, occupational or fertility variables. J Negat Results Biomed, 2006; 5: 12.

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