MORPHOMETRIC STUDY OF THE DIGITAL LENGTH PATTERN AND RATIOS IN NORMAL MEN AND WOMEN

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ABSTRACT Purpose: This work was designed to establish the digital length pattern and the formula in randomly selected sample population. Methods: Digit lengths of 700 subjects (311 male and 389 female) were measured on the palmar surface, using vernier callipers. Results: We found that, the third digit was the longest and in turn came the fourth, second, fifth and first in our study population. The digital formula was as 3>4>2>5>1 for both hand. The distribution of ≤ and > of 2D:4D ratio showed that around 35% of the female population exhibited to 3>2>4>5>1 digital formula, as opposed to less than one fourth in males. Conclusion: We believe that the environmental, occupational, habitual factors may play as much role as the genetic elements and further studies should be carried out in various population of different age groups and occupations.

Antropoloji, 2004 (18): 15-25

KEY WORDS: Digital formulae, 2D:4D ratio.

KADIN VE ERKEKTE PARMAK UZUNLUKLARININ VE ORANLARININ MORFOMETRİK İNCELENMESİ

ÖZET Amaç: Çalışmamız rastgele seçilerek örneklenmiş bir toplulukta parmak uzunluklarını ve formülünü ortaya çıkarmak amacıyla yapılmıştır. Metod: 700 kişinin parmak uzunlukları (311 erkek ve 389 kadın) palmar yüzden vernier kumpası kullanılarak ölçülmüştür. Bulgular: Çalışma grubumuzda üçüncü parmağın en uzun olduğu, bunu

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dördüncü, ikinci, beşinci ve birinci parmakların takip ettiği tespit edilmiştir. Her iki elde de parmak formülü 3>4>2>5>1 dir. 2D:4D oranının ≤ ve > dağılımı incelendiğinde, kadınların %35 inde 3>2>4>5>1 olan parmak formülü, erkeklerin 1/4 ünden daha azında görülmektedir. Sonuç : Çevresel, mesleki ve alışkanlıklara bağlı faktörlerinde genetik etkenler kadar rol oynadığı düşünülmekte ve bu konuda daha kapsamlı çalışmalar yapılması uygun görülmektedir.

Anahtar Kelimeler : Parmak formülü, 2D:4D oranı.

INTRODUCTION

In his popular classic book "Hands", John Russell Napier (1993) emphasized the importance of the length of digits among other unique characteristics of the hand; like the shape and proportions, nerves, bones, fingerprints, gestures and handedness. He stated that if the digits continued to develop according to the basic pattern in embryo, the digital formula would be symmetrical, like 3>4 = 2>5 =1 and noted that the digits evolved differential functions in later life and the formula changed (Napier, 1993).

When the hand is laid on a flat surface, all fingers side to side (adducted), it is apparent that the thumb (1D) is shorter than the little finger (5D), the middle (3D) is unequivocally the longest while the lengths of index (2D) and ring (4D) fingers differ quite considerably from person to person.

According to Lewis (1982), the digital formula showed a sexual dimorphism: males with a single most frequent digital formula (3>4>2>5>1:69.6%) and females with two almost equally frequent formulae (3>2>4>5>1: 44.1% and 3>4>2>5>1: 42.3%).

Napier (1993), also mentioned a sexually dimorphic pattern, that a long index finger was a characteristic of females. Manning et al. (1998) presented evidence that a longer second digit than fourth was more common in females whereas a longer fourth digit than second was more common in males. They showed sexually dimorphic pattern of 2D:4D; in males mean 2D:4D=0.98 (longer fourth digit) and in females mean 2D:4D=1.00 (both equal or longer second digit), and claimed that this pattern was present from at least age 2 years, probably established in *utero* (Manning et al., 1998). They also stated that the low values of 2D:4D in the right hand were associated with high sperm numbers and high concentration of testosterone in males and high values of 2D:4D were correlated with high concentration of luteinizing hormone, oestrogen and prolactin in men and women (Manning et al., 1998).

In our work, we tried to established the digital length pattern and the formula, also explored the possible sexual dimorphism in ratio between the length of second and fourth digit, in our randomly selected sample population and compared our findings with those of other investigators.

MATERIAL AND METHODS

Digit lengths were measured in the right and left hands of 700 subjects who volunteered for this study. There were 311 males and 389 females, all of whom were the Faculty members and students. The distributions according to sex and age groups are shown in Table 1.

Digits were measured on the palmar surface of the hand, from the most proximal line of the basal crease of each digit to the tip, using vernier callipers by the same investigator. We measured all variables by mm. Repeated measurement were done on ninety five subjects –selected at random– as to ascertain the reliability of the measurements.

For statistical studies, we used One Way ANOVA, Student's t test, Paired t test and Chi-square test.

RESULTS

Of the 700 subjects, males were numbered 311 (44.4%) and females 389 (55.6%). The detailed information on the sex, age groups and percentages are given on Table 1.

Table 1: Demographic informations for sample

	MALE		FEMALE		TOTAL	
AGE	N	%	N	%	N	%
<20	44	40	66	60	110	15.7
20-24.9	150	47.9	163	52.1	313	44.7
25-29.9	63	52.1	58	47.9	121	17.3
30-34.9	26	32.9	53	67.1	79	11.3
>=35	28	36.4	49	63.6	77	11.0

Table 2 shows the maximum and minimum lengths of each digit (right and left hand) together with mean ± SD values regardless of sex. It was apparent here that the fourth and fifth digits were longer in the right hand as 72.12 ± 5.30 right to 71. 64 ± 5.43 left, and 58.48 ± 4.97 right to 58.04 ± 4.96 left for respective digits (P<0.001 for both). On the other hand, when the digits' lengths were compared according to sex in the

right and left hands the difference was statistically meaningful (p<0.001), the lengths of digits in females were shorter in both hands (Table 3). The lengths of fourth and fifth digits of both sexes were significantly longer in the right hand than the left (p<0.001). As far as the length of second digit in either hand is concerned, there was no statistically meaningful difference in males, however the length of the second digit was longer in the right hand in females (Table 3).

Table 2: Digital lengths of right and left hands, regardless of sex.

Finger	Right		Left		P*
	Mean ± SD	Min. – Max.	Mean ± SD	Min. – Max.	
1 st	51.35 ± 4.58	34.56 - 65.27	51.28 ± 4.47	39.95 – 65.70	>0.05
2 nd	70.39 ± 5.03	54.24 – 83.87	70.32 ± 5.12	55.42 – 88.41	>0.05
3 rd	77.78 ± 5.47	61.38 – 94.20	77.70 ± 5.60	61.64 – 94.74	>0.05
4 th	72.12 ± 5.30	56.92 – 89.93	71.64 ± 5.43	55.73 – 88.72	<0.001
5 th	58.48 ± 4.97	39.94 – 76.63	58.04 ± 4.96	41.18 – 78.75	<0.001

*Student's t test

Table 3: Digital lengths of right and left hands, male and female.

Finger	Male	Female	P*
	Mean X ± SD	Mean X ± SD	
1 st			
Right	54.59±3.52	48.37± 3.57	<0.001
Left	54.48 ± 3.44	48.32± 3.42	<0.001
P**	>0.05	>0.05	
2 nd			
Right	73.67± 4.30	67.76± 3.91	<0.001
Left	73.83± 4.51	67.51± 3.64	<0.001
P	>0.05	<0.01	
3 rd			
Right	81.54± 4.59	74.78± 4.10	<0.001
Left	81.60± 4.74	74.59± 4.08	<0.001
P	>0.05	<0.05	
4 th			
Right	75.78± 4.36	69.20± 4.01	<0.001
Left	75.46± 4.42	68.58± 4.06	<0.001
P	<0.001	<0.001	

5 th			
Right	61,79± 4,24	55,83± 3,78	<0,001
Left	61,35± 4,19	55,40± 3,80	<0,001
P	<0,001	<0,001	

*Student's t test

**Paired t test

In Table 4, the mean values of the length of digits in five different age groups were given for the right and left hands, regardless of sex. It featured some interesting values as follow: (1). There was statistically meaningful difference between the length of second and also fifth digits only in the right hand, whereas the same was seen between the length of the third digits in both hands when five age groups were compared ($p<0.01$) (2). The mean lengths of digits first, second, third, fourth and fifth were longer in both hands in age group 25–29.9 compared with other groups (3). There was a statistically meaningful difference in the length of the fourth digits only in the right hand of all five age groups compared ($p<0.01$). However, this was true for the age groups of 20–24.9, 25–29.9 and 30–34.9 when the length of fourth digits of both hands compared ($p<0.001$) (4). There was a statistically meaningful difference in the length of the fifth digits between the right and the left hands, only in age groups of 20–24.9 and 25–29.9 ($p<0.001$ and $p< 0.01$ respectively) and only in the right hand in all age groups ($p< 0.01$).

Table 4: Digital legths of right and left hands in five different age groups, regardless of sex.

Finger	<20	20-24.9	25-29.9	30-34.9	>=35	P*
	X ± SD	X ± SD	X ± SD	X ± SD	X ± SD	
1 st						
Right	51,11 ± 4,03	51,42 ± 4,50	52,11 ± 4,75	50,49 ± 5,09	51,13 ± 4,73	>0,05
Left	50,72 ± 3,78	51,25 ± 4,53	51,94 ± 4,35	50,90 ± 5,21	51,58 ± 4,46	>0,05
P**	<0,05	>0,05	>0,05	>0,05	>0,05	
2 nd						
Right	69,81 ± 4,63	70,90 ± 5,05	71,00 ± 4,98	68,96 ± 5,46	69,60 ± 4,78	<0,01
Left	69,80 ± 4,91	70,72 ± 5,09	71,04 ± 5,01	69,18 ± 5,68	69,64 ± 4,85	<0,05
P	>0,05	>0,05	>0,05	>0,05	>0,05	
3 rd						
Right	77,25± 5,03	78,32 ± 5,48	78,50 ± 5,31	76,19 ± 6,17	76,87 ± 5,09	<0,01
Left	77,21 ± 5,21	78,19 ± 5,62	78,52 ± 5,35	76,10 ± 6,33	76,39 ± 5,23	<0,01
P	>0,05	>0,05	>0,05	>0,05	>0,05	
4 th						
Right	71,50 ± 4,90	72,63 ± 5,24	72,84 ± 4,59	70,85 ± 6,42	71,14 ± 4,92	<0,01
Left	71,12 ± 4,96	72,06 ± 5,38	72,29 ± 5,27	70,28 ± 6,54	71,04 ± 5,02	<0,05

P	<0.05	<0.001	<0.001	<0.001	>0.05	
5 th						
Right	58.01 ± 4.34	58.89 ± 4.96	59.24 ± 5.10	57.19 ± 5.73	57.62 ± 4.41	<0.01
Left	57.63 ± 4.43	58.17 ± 4.89	58.78 ± 5.01	57.36 ± 6.16	57.64 ± 4.39	>0.05
P	<0.05	<0.001	<0.01	>0.05	>0.05	

*One Way ANOVA

**Paired t test

Table 5, gives the ratio of second digit to fourth (2D:4D), regardless of sex; as 0.98±0.04 range 0.8631–1.1191 in the right, and 0.97±0.03 range 0.8498–1.0978 in the left. The difference was highly significant ($p<0.001$). The same ratio (2D:4D) according to sex was as follows: 0.97±0.03 (right), 0.98±0.03 (left) in males and 0.98±0.04 (right), 0.99±0.03 (left) in females ($p<0.001$ and $p<0.01$ respectively) (Table 6). The differences between male–female and right–left were significant ($p<0.01$).

Table 5: Maximum and minimum values of 2D:4D of right and left hands, regardless of sex.

Finger's Proportion	Right		Left		P
	X ± SD	Min. – Max.	X ± SD	Min. – Max.	
2/4	0.98 ± 0.04	0.8631-1.1191	0.97 ± 0.00	0.8498-1.0978	<0.001

Paired t test

Table 6: 2D:4D ratios of right and left hands, male and female.

Finger's Proportion	Male Right	Left	P*	Female Right	Left	P*	P^a	P^b
	X ± SD	X ± SD		X ± SD	X ± SD			
2/4	0.97 ± 0.03	0.98 ± 0.03	<0.001	0.98 ± 0.04	0.99 ± 0.03	<0.01	<0.01	<0.01

P* result of ocompare between right and left hand (paired t test)

P^a result of compare between male and female's right hands (student's t test)

P^b result of compare between male and female's left hands (student's t test).

When 2D:4D ratios of right and left hands were compared in different age groups regardless of sex (Table7): (1) 2D:4D was less than

1, as 2D<4D, in all age groups. (2) Statistically significant difference (right–left) in 2D:4D ratio was seen in age groups of 20–24.9, 25–29.9 and 30–34.9 ($p<0.01$ in all).

Table 7: 2D:4D ratios of right and left hands in different age groups, regardless of sex

Finger's	< 20 Age		20-24.9 Age		25-29.9 Age		30-34.9 Age		>=35 Age	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Proportion	X ± SD	X ± SD	X ± SD	X ± SD	X ± SD	X ± SD	X ± SD	X ± SD	X ± SD	X ± SD
2/4	0,98 ± 0,03	0,98 ± 0,03[a]	0,98 ± 0,04	0,98 ± 0,03[b]	0,98 ± 0,04	0,98 ± 0,03[a]	0,98 ± 0,04	0,99 ± 0,04[b]	0,98 ± 0,04	0,98 ± 0,03[a]

[a] indicates not significance between right and left hand (paired t test)
[b] indicates significance at 0.05 level between right and left hand (paired t test)
[c] indicates significance at 0.01 level between right and left hand (paired t test)
[d] indicates significance at 0.001 level between right and left hand (paired t test)

Table 8 indicates the distribution of ≤ and > values of 2D:4D (right and left) in different age groups according to sex. Only in age groups 20–24.9, of 313 subjects; 121 males (80.7%) and 112 females (68.7%) showed ≤ in right hands as oppose to 113 males (75.3%) and 105 females (64.4%) in left hands. However the numbers and percentages were lower for > values as; 29 (19.3%) males and 51 (31.3%) females in the right hand as oppose to 37 (24.7%) males and 58 (35.6%) females in the left. The difference (≤ and > male–female) was significant as $p<0.05$ for both right and left. Finally, similar to Table 6, when 2D:4D ratios were compared in different age groups (Table 9) according to male–female and right–left, only in age group 20–24.9 the difference in 2D:4D between male and female in the right hand was statistically meaningful as $p<0.05$.

DISCUSSION

The term 'digital formula' was first introduced by Wood Jones (1949), and refers to the relative lengths of digits. He stated that 3>4=2>5>1 was found in large number of pentadactyle vertebrates and described by many artists and anatomists as ideal human hand (Wood, 19494). It is clear from various reports that the digital formula is somewhat constant as far as the third, fifth and first digits are concerned. The places for the third, fifth and first do not change in different formulae, however as for the second and fourth, it looks as if though there is a contest for superiority. In some people it would be 2>4 and in

others 4>2. Wood Jones (1949) named these; as 3>4>2>5>1 annularis dominant, and 3>2>4>5>1 index dominant. He further argued that the former formula was of the simian hand plan, whereas the later was definitely non-simian and showed characteristic human specialization (Wood, 1949).

Table 8 Distribution of ≤ and ≥ values according to sex in different age groups.

Age	Male								Female								P
	Right				Left				Right				Left				
	≤1		>1		≤1		>1		≤1		>1		≤1		>1		
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
<20	34	77,3	10	22,7	31	70,5	13	29,5	50	75,8	16	24,2	49	74,2	17	25,8	>0,05
20-24,9*	121	80,7	29	19,3	113	75,3	37	24,7	112	68,7	51	31,3	105	64,4	58	35,6	<0,05
25-29,9	69	77,8	14	22,2	47	74,6	16	25,4	43	77,6	13	22,4	36	62,1	22	37,5	>0,05
30-34,9	21	80,8	5	19,2	21	80,8	5	19,2	36	67,9	17	32,1	29	54,7	24	45,3	>0,05
≥35	22	78,6	6	21,4	22	78,6	6	21,4	35	71,4	14	28,6	35	71,4	14	28,6	>0,05

*p< 0.05

Table 9: 2D:4D ratios of right and left hands according to sex in different age groups.

Age	Male				Female			
	Right		Left		Right		Left	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<20	0,97	±0,03	0,98	±0,04	0,97	±0,05	0,98	±0,03
20-24,9*	0,97*	±0,04	0,97	±0,03	0,98*	±0,04	0,98	±0,03
25-29,9	0,97	±0,03	0,97	±0,03	0,98	±0,04	0,98	±0,03
30-34,9	0,96	±0,04	0,97	±0,03	0,97	±0,04	0,99	±0,03
≥35	0,97	±0,03	0,97	±0,04	0,98	±0,04	0,98	±0,03

*p<0,05 (paired t test)

In our randomly selected study population of men and women in general, the third digit was the longest and then in turn came the fourth, second, fifth and first so the digital formula looked like 3>4>2>5>1 for both hands. Although this was so in males and females, however when the distribution of ≤ and ≥ values of 2D: 4D ratio (right and left hands) were compared in different age groups according to sex: >1 value

(namely 2>4) was seen only 19.3% as opposed to 80.7% of 4>2 on the right, and only 24.7% as opposed to 75.3% of 4>2 on the left in males of age group 20-24.9. In females however, these were 31.3% as opposed to 68.7% of 4>2 and 35.6% as opposed to 64.4% of 4>2 respectively in the same age group. These meant that around 35% of the population showed 3>2>4>5>1 digital formula in females, whereas less than one fourth was as 3>2>4>5>1 in males in the age group of 20-24.9.

Our results could well be interpreted as similiar to those of Lewis (1982) who reported assessments on hand radiographs and stated a digital formula of males as 3>4>2>5>1 69.6%, and two almost equally frequent digital formulae of females as 3>2>4>5>1 44.1% and 3>4>2>5>1 42.3%.

Napier (1993) had referred to a study of 881 students predominantly male, stating in 28.6% the second digit was longer than the fourth and further pointing out that, when the female population was removed from the total, the score was lowered to 22.2% which meant that the females played greater part in keeping the percentage of long second digit high. Furthermore, in a similar study of 252 female students he quoted that the percentage of the longer second digit was as high as 45% (Napier, 1993).

All these above mentioned percentages and interpretation of those in terms of digital formula, may show that 3>2>4>5>1 is of more female characteristic than male, which is in part agreement with our statistical findings, at least in age group 20-24.9.

When, the ratios between second and fourth digit lengths were considered, 2D:4D showed a sexually dimorphic pattern as well. Willams (2000) tried to put forward a link between 2D:4D ratio and sexual orientation. Manning et al. (1998) also reported that in men low 2D:4D ratio was associated with high sperm counts, high levels of testosterone and low levels of oestrogen and high ratios were correlated with low sperm counts, low testosterone and high oestrogen concentration. In turn they suggested a possible link between 2D:4D ratio and fertility (Manning et al., 1998). Further, Manning and Bundred (2000) suggested that 2D:4D ratio could be useful predictor of disease predisposition.

It has been known for sometime that, in vertebrates *Homebox* or *Hox* genes family are essential for limb and genital development; including the testes, ovaries and the digits (Herault at al., 1997; Peichel at al., 1997). As Kondo et al. (1997) reported, deregulation of *Hoxd* in mice alters the relative lengths of digits and affect growth of the genital bud and differentiation of the penis. Accordingly, the suggestion was put forward by Manning et al. (1998) that the sexually dimorphic pattern was present from at least 2 years and 2D:4D was probably established in

utero. This may be explained by the actions of Hox gene family, however there was not enough evidence in their study to support this claim.

We do not oppose to their claim in general, which may well be that the digital length patterns and ratios were established in *utero*. However, it is more likely that other factors may play important role in eventual digital pattern. One should not disregard, environmental, occupational, habitual and dietary factors which may play an equal role -if not more- as the genetic elements.

It seems that the relative lengths of second and fourth digits in male-female and right-left hands may differ considerably, and any correlation with age groups may well be difficult to put forward; however, 2D:4D is more significant criterion than the actual length of the digits in females of age group 20-24.9, in left hand, and maybe interpreted as female characteristic at least in our study population.

There might be fundamental differences in environment, customs and daily life activities (i.e sports) of varying population which may effect the development of digits from childhood.

Further studies, similar in nature should be carried out in various populations of different age groups such as musicians, sportsmen (basketball players and weightlifters etc.) and people who do hand and heavy manual work.

REFERENCES

Herault Y, Fradeau N, Zakany J, Duboule D. 1997 "Ulnaless (Ul), a regulatory mutation including both loss-of-function and gain-of-function of posterior Hoxd genes.", **Development**, (124):3493-3500.

Kondo T, Zakany J, Innis JW, Duboule D. 1997 "Of fingers, toes and penises", **Nature**, (390):185-198.

Lewis S. 1982 "Morphological aspects of male and female hands", **Neuropsychologia**, 20(6):715-9.

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", **Human Reprod**, 13(11): 3000-3004.

Manning JT, Bundred PE. 2000 "The ratio of 2nd to 4th digit length: A new predictor of disease predisposition?", **Medical Hypothesis**, 54(5):855-857.

Napier J. 1993 **Hands.** Rev. Ed. Princeton, NJ. Princeton University Press: p.18-19.

Peichel CL, Prabhakaran B, Vogt TF. 1997 "The mouse Ulnaless mutation deregulates posterior HoxD gene expression and alters appendicular patterning", **Development**, (124):3481-3492.

Wood JF. 1949 **The Principles of Anatomy as Seen in the Hand.** 2nd ed. Baltimore. Williams and Wilkins, p.30-36.

Williams TJ. 2000 "Finger-length ratios and sexual orientation", **Nature**, 404:455-456.