Sexual Dimorphism in Manual Digit Proportions: Growth Patterns and the Digit Ratio

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Introduction

Biological variation is an accepted phenomenon in humans. Skin color, blood type, body size, and facial symmetry vary widely among and between populations. Sexual dimorphism is a type of variation that occurs between male and female humans. On average, most males have larger trunks, longer distal segments, and less body fat than females. In the past decade many studies (Manning, 2002; Neave, Laing, Fink, and Manning, 2003; Koehler, Simmons, and Rhodes, 2004) have concentrated on the sexual dimorphism that occurs among the manual digit proportions, specifically the ratio of the second digit vs. fourth digit. The existence of the ratio is established and accepted; the possible consequences and correlations of this ratio are debated and controversial. From perceived attractiveness (Neave et al., 2003) to homosexual proclivity (Manning, 2002), researchers have associated countless characteristics and pathologies with the digit ratio. According to Manning (1998, 2002), the ratio is a product of in-utero exposure to testosterone. After measuring radiographs of children aged 2.5 to 3 years, though I found some overlap in the sexes, the digit ratio difference measurably exists at this early age. This seems to be true across the board; thus defining a ratio in such a way that suggests causation for the above mentioned characteristics seems arbitrary at best. It is my hypothesis that the digit ratio is simply another sexually dimorphic trait that occurs between males and females. Different digit ratios are not the only such traits that show up early in life. For example, males are born with ulnae that are longer compared to their humeri than are females (Harrison, Tanner, Pilbeam, and Baker, 1993). If my hypothesis holds true, I would expect to see more pronounced ratio differences to occur after puberty, similar to long bone changes. After measuring the same subjects at the age of eighteen, results show that this does occur. Therefore, I believe that although males and females show patterns of sexual dimorphism early in life, they also follow separate growth trajectories, from birth through puberty, and age is highly correlated to hand shape differences.

Background

Manual digit proportions have become a topic of discussion among evolutionary psychologists and biological anthropologists (Manning, Scutt, Wilson, and Lewis-Jones, 1998; Peters, MacKenzie, and Bryden 2002; Neave et al., 2003). To calculate the digit ratio, the second digit (index finger) is measured and then divided by the measurement of the fourth digit (the ring finger). If the result is less than 1, the 2D:4D ratio is low. If the result equals 1, the 2D:4D ratio is even, and if the result is more than 1, the 2D:4D ratio is high (figures 1 and 2). Manning et al. (1998) determined that the 2D:4D digit ratio of men and women was a good predictor of testosterone and estrogen levels in the body. The study concluded that this sexually dimorphic characteristic was evident by the age of two. Neave et al. (2003) found that the 2D:4D ratio was specifically correlated with masculinity but that testosterone levels were not an indicator of this masculinity, and Koehler et al. (2004) found that although testosterone levels and masculinity are related, the 2D:4D ratio is not an indicator of these

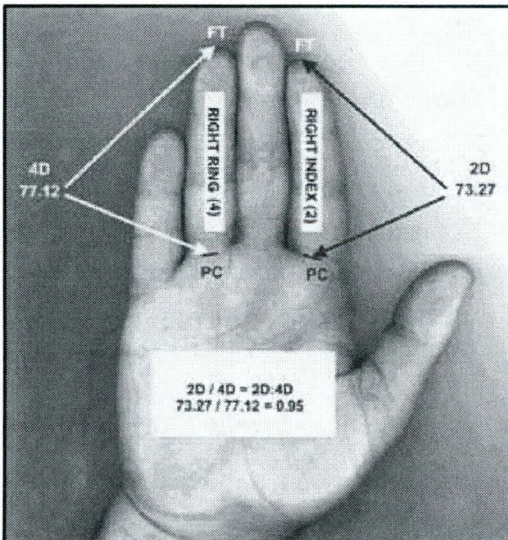

Figure 1: Calculating the Digit Ratio

testosterone levels. Manning (2002), claims to have found over 30 correlations related to digit ratio. These correlations include mother/child relationships, hip to waist ratios, cancer susceptibility, sexual fitness, and athletic ability. Furthermore, in 2006, McIntyre, Cohn, and Ellison found that the third digit was a better indicator of sex than the second when compared to the fourth digit especially in children, suggesting that manual digit proportions in general are sexually dimorphic, not just the 2D:4D ratio.

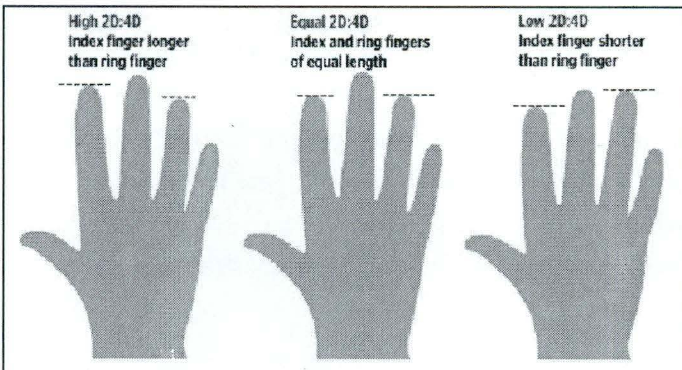

Figure 2: Examples of Digit Ratio

Methodologies

For their analysis, Manning et al. (1998) used measurements of finger lengths of live children aged 2-18 years old. That study measured finger lengths by having people place their hand flat on a table. The researchers used Vernier calipers to measure the finger lengths from the basal crease to the tip of the finger. Another method used photocopies of the hands of volunteers (Neave et al., 2003). McIntyre, Ellison, Lieberman, Demerath, and Towne (2005) used the Fels Longitudinal Study at Wright State University, which includes radiographs taken of the left hand of children every few years from birth to eighteen. These studies all have the same basic result in common: in general, males have lower 2D:4D ratios and females in general have higher 2D:4D ratios. I measured 30 subjects (15 male, 15 female) from a series of left hand radiographs in a growth study at the Oregon Health and Sciences University, held in the School of Dentistry. The radiographs were taken with subjects in standard position and with standard radiograph parameters. Using acetate paper, pencils, and a tracing box, I traced the hand radiographs and then measured the length of each metacarpal and phalanx separately with digital calipers. This rare method of measuring provides an accurate measure of the bones themselves, setting aside the possibility for confounding variables caused by moving subjects and soft tissue. I measured radiograph images taken of subjects when they were 2.5 to 3 years of age and radiographic images of the same subjects again when they were 16 to 18 years of age. The measurements and digit ratios are shown in Table 1. One-tailed Student's t-tests for unequal samples with unequal variance were used to evaluate the null-hypotheses that males and females had the same mean digit ratio.

Results

The digit ratio difference measurably exists at an early age, although the difference is slight. The average ratio for males at the first age was .89 while the average ratio for females at the first age was .91. The ratio shows a similar pattern after puberty. The average ratio for males at the second age was .92 and the average digit ratio for females at the second age was

.94. The t-tests rejected the null hypothesis in both age groups ($p = 0.03$ for the younger age group, 0.01 for the older age group), indicating that differences in male and female means are unlikely to be due to small sample size. The lowest digit ratio was found in subject number seventeen, a male at age 3 with a ratio of .82. The highest ratio found was with subject number ten, a female at age 20, with a ratio of .99. The ratios of the males at the younger age vary from .82 and .94, .12 mm. The younger female subjects vary from .84 to .96, also .12 mm. For the older subjects, the male ratio varies from .86 to .98, .12 mm and the females vary from .91 to .99, .08 mm. While some overlap existed between the digit ratio of males and females, overall ratios for males were lower in both age ranges. The older age range shows that the digit ratio difference indeed increases with age.

TABLE 1: Digit Ratios for Each Subject

Subject/sex	1/male		2/Female		3/Male		4/Male		5/Female	
Age	2	18	3	18	3	18	2	18	2	18
Digit Ratio	0.86	0.93	0.84	0.95	**	0.98	0.91	0.92	0.90	0.91
Subject/sex	6/Male		7/Female		8/Female		9/Male		10/Female	
Age	3	18	2	17	3	18	3	18	3	**20**
Digit Ratio	0.88	0.93	0.92	0.93	0.96	0.94	0.89	0.90	0.91	**0.99**
Subject/sex	11/Male		12/Male		13/Female		14/Male		15/Male	
Age	2	17	3	18	4	17	3	18	2	18
Digit Ratio	0.89	0.91	0.89	0.87	0.92	0.97	0.92	0.92	0.89	0.91
Subject/sex	16/Female		17/Male		18/Female		19/Female		20/Male	
Age	3	17	**3**	17	4	17	3	18	4	18
Digit Ratio	0.94	0.94	**0.82**	0.96	0.92	0.96	0.91	0.93	0.89	0.93
Subject/sex	21/Female		22/Male		23/Female		24/Female		25/Male	
Age	3	18	3	18	2	18	3	18	3	18
Digit Ratio	0.91	0.92	0.89	0.93	0.94	0.93	0.91	0.96	0.91	0.86
Subject/sex	26/Male		27/Female		28/Male		29/Female		30/Female	
Age	3	16	3	18	3	18	2	18	3	18
Digit Ratio	0.94	0.93	0.90	0.95	0.88	0.92	0.86	0.94	0.91	0.95

**Denotes incomplete information

Discussion

The importance of duplicating research cannot be stressed enough. What one researcher may interpret as a correlation, another may find is coincidence or completely unrelated. While Manning (2002) interprets the digit ratio to be related to personality traits, physical characteristics, and disease prevalence, it is certainly possible the digit ratio plays no distinct role in any of these issues. Because the digit ratio exists fairly consistently across the board, it is difficult, if not impossible to define at what point the digit ratio becomes significant. It is outside the scope of this paper to duplicate Manning's research, but if one wanted to, one could correlate the digit ratio to just about anything. The ratio does not prove causality, nor does a correlation. Age may play a larger role in hand shape variation and with additional measurements I hope to verify this hypothesis.

Future Research

Because males usually have longer distal segments, i.e., longer tibiae vs. femora, more in depth analysis of metacarpal lengths vs. phalanges is worth pursuing to see if the same rule holds true in the hands. I plan to revisit the Oregon Health and Science University and use the radiographs to measure more subjects as well as additional stages of development of the subjects used in this paper to answer such questions as: Does the ratio stay stable during childhood? Does it become more pronounced after puberty? Is overall hand shape more correlated to age or sex? The answers to these questions may prove my proposition that the digit ratio is just another example of growth differences between males and females.

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