Evidence for Androgenic Influences on Self-Rated Health

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Abstract

Background: According to most studies, males self-report being physically and mentally healthier than females. The present study sought to determine if androgens might influence health.

Methods: Self-reports of physical and mental health were obtained from college students in Malaysia (N = 2,058) and the United States (N = 2,511). Androgen exposure was assessed based on five self-reported measures that were then factor analyzed. A clear two-factor solution resulted from the analysis: muscularity, physical strength, and athletic ability loaded onto a muscular coordination factor, while adult height and 2D:4D finger length measure loaded onto a bone growth factor.

Results: As hypothesized, for males and females in both countries, self-rated physical and mental health were both positively correlated to a significant degree with the muscular coordination androgen factor. The only significant correlation between self-rated health and the bone growth androgen factor was negative among the Malaysian sample.

Conclusions: Androgenic influences on muscular coordination appear to coincidentally alter self-rated physical and mental health. This conclusion conflicts with proposals that men and women would provide the same self-ratings of health if it were not for sex role training and discrimination.

Keywords: Self-rated physical health; Self-rated mental health; Androgen-influenced traits; Sex differences; Sex roles

Introduction

Most studies have found self-reported physical health to be higher among males than among females [1-8], although some have failed to find significant differences, particularly studies based on college student samples [9,10]. Research suggests that the sex difference is found not only for perceptions of overall health, but for reports of symptoms and for rates of morbidity [11]. Whereas men tend to have higher rates of chronic disease and mortality, women tend to experience illnesses of a less serious and more transient nature [12].

In most studies of self-rated mental health, ratings by males are also higher than those provided by females [13-16]. Paradoxically, high self-rated health by males flies in the face of evidence that in nearly all countries men die 4 to 5 years earlier than women [17-19]. (It is true that some of the life expectancy difference between males and females is due to greater risk-taking among young males – a fact that would not be reflected in self-rated levels of health).

Three plausible explanations have been offered for sex differences in self-perceived health: First, some have asserted that the main cause is sex discrimination along with sex role training. For example, Molarus [7], argued that women’s self-rated health would be the same as that for men “if they had similar financial security as men and were not treated in a condescending manner to a larger extent than men”. Similar proposals have been made in recent years by Borrell [20,21]. In the case of sex differences in self-reported mental health, proposals that sex discrimination may also be an important determinant, especially regarding depression, have also been made [20,22-24].

Second, sex differences in self-assessed health have been attributed to differences in levels of activity and exercise [25]. Specifically, studies indicate that regular exercise is associated with elevated mood, reduced stress, and improved physical health [26-31]. This coincides with numerous studies showing that males are more physically active and more likely to regularly exercise than females [32].

A third proposal is that exposure to androgens (male sex hormones) could contribute to average sex differences in self-reported health [33]. Support for this view is currently fragmentary. It includes studies linking various physical disorders with measures of 2D:4D finger length ratio, a reputed measure of prenatal testosterone exposure (as will be discussed in more detail below). For example, high 2D:4D finger length ratios have been found associated with high ratings of various types of joint pain, including osteoarthritis [34], and temporomandibular joint (TMJ) disorders [35]. Four direct lines of evidence linking self-rated health and androgens were located. One came from a study of women in which a significant positive correlation was found between circulating testosterone and self-rated physical health as well as a reduction in depression symptoms [36]. Another was
a study of men in which circulating testosterone was positively correlated with self-rated health [37]. The remaining two studies were of elderly men, both reporting significant positive correlations between age-controlled circulating testosterone and self-rated health [38,39]. Men might report high levels of physical and mental health due to testosterone’s reduction in sensitivity to aches and pain, and to its tendency to elevate mood [33,40].

Given that androgen studies of self-rated health have been limited to circulating levels of testosterone, the present study was undertaken to explore the relationship between organizational androgens and self-assessed health. This was done by obtaining self-reported measures of five biomarkers for high androgen exposure (2D:4D, adult height, muscularity, physical strength, and athletic ability) along with self-ratings of physical health and mental health. We hypothesized that self-ratings of physical and mental health would be positively correlated with androgen exposure, even within each sex.

Method
The study’s sample was comprised of undergraduate college students in Malaysia (N = 2,059) and the United States (N = 2,247). These two populations were chosen in order to see if results would be robust across two very different cultures. The proportional representation of respondents in terms of gender, marital status, and ethnicities are shown in Table 1 along with their average ages. Greater numbers of females than males in both countries were largely due to more females attending college in both Malaysia and the United States in recent years [41,42] (Table1).

The questionnaire
The questionnaire used in this study was developed and refined in English. It was then translated into Bahasa Malaysia, Malaysia’s official language since its independence from Great Britain in 1957. To ensure that the Malaysian translation was equivalent to the English version, the Malaysian questionnaire was back-translated into English until discrepancies were eliminated. Both questionnaires were four pages in length and covered a wide variety of topics, only a few of which are part of the present study.

Androgen-Influenced variables
Since it was first identified as a likely biomarker of prenatal androgen exposure in the late 20th Century [43], a subtle but fairly easily observed trait known as the 2D:4D ratio (or simply 2D:4D) has come to be widely utilized in research on traits that are suspected as being influenced by prenatal androgens. Among the findings are that there are well-established sex differences in 2D:4D, with males having lower ratios, meaning that the relative length of their 4th finger compared to their 2nd finger is slightly longer than for most females [44-49]. These sex differences are present even among newborns, albeit to a slightly lesser degree than among adults [50,51].

Studies have also shown 2D:4D to be statistically associated with several other sexually dimorphic physical traits such as birth weight [52,53], adult height [54,55], physical strength and muscularity [56-58], and athletic ability [59-62]. Consequently, it is reasonable to consider them physical biomarkers for androgen exposure. In the research questionnaire, respondents were asked to provide estimates of 2D:4D as well as estimates of their height, physical strength, muscularity, and athletic ability.

The r2D:4D Measure
Most studies that have compared the relative finger lengths on

<table>
<thead>
<tr>
<th>Demographic Traits</th>
<th>Malaysian Sample</th>
<th>United States Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>652 (31.7%)</td>
<td>1,027 (40.9%)</td>
</tr>
<tr>
<td>Females</td>
<td>1,406 (68.3%)</td>
<td>1,484 (59.1%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,058</td>
<td>2,511</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (standard deviation)</td>
<td>20.86 (2.36)</td>
<td>23.96 (9.27)</td>
</tr>
<tr>
<td>Range</td>
<td>18-42</td>
<td>17-81</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,058</td>
<td>2,511</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single (including engaged, domestic partners)</td>
<td>1,971 (95.7%)</td>
<td>2,004 (79.8%)</td>
</tr>
<tr>
<td>Married</td>
<td>37 (1.8%)</td>
<td>341 (13.6%)</td>
</tr>
<tr>
<td>Divorced/separated/widowed/single mom</td>
<td>1 (0.0%)</td>
<td>80 (3.2%)</td>
</tr>
<tr>
<td>No response or other</td>
<td>50 (2.4%)</td>
<td>86 (3.4%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,058</td>
<td>2,511</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/European Ancestry</td>
<td>0</td>
<td>1,394 (55.5%)</td>
</tr>
<tr>
<td>Black/African Ancestry</td>
<td>0</td>
<td>173 (6.9%)</td>
</tr>
<tr>
<td>Hispanic/Latin/Native American</td>
<td>0</td>
<td>745 (29.7%)</td>
</tr>
<tr>
<td>Malay/Bumiputra/Indonesian</td>
<td>1,474 (71.6%)</td>
<td>5 (0.2%)</td>
</tr>
<tr>
<td>East Asian (Chinese, &quot;Asian&quot; in US)</td>
<td>477 (23.2%)</td>
<td>66 (2.6%)</td>
</tr>
<tr>
<td>Other Asian (primarily Indian)</td>
<td>85 (41%)</td>
<td>51 (2.0%)</td>
</tr>
<tr>
<td>Other (Mixed, Arabic, Persian, Euro-Asian)</td>
<td>3 (0.1%)</td>
<td>64 (2.5%)</td>
</tr>
<tr>
<td>No (or unintelligible) response</td>
<td>19 (9.9%)</td>
<td>13 (0.5%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,058</td>
<td>2,511</td>
</tr>
</tbody>
</table>
both hands have concluded that the right hand provides a more reliable measure of prenatal androgen exposure than does the left hand [49,63-67]. Therefore, we limited our measurement to the right hand, and will use the term r2D:4D to reference it.

Exactly how the relative lengths of the second and fourth digits are altered by perinatal androgen exposure remains to be fully explained, but it is well established that testosterone promotes bone growth [68-71]. Also, a period when prenatal androgens normally rise seems to coincide with a growth spurt in the fourth digit [55,63,72].

Using a variety of research designs, several studies have confirmed that 2D:4D is a relatively valid biomarker for perinatal androgen exposure [48,63,73,74]. At least when measured with precise instruments, it is a reliable measure [75], but researchers have characterized it as “valid, though weak” [76], and “a very ‘noisy’ indicator” [77].

Although it is infrequently used, the “gold standard” for measuring the relative lengths of the 2nd and 4th digits involves obtaining X-ray images [67,78]. Much more common methods involve physically measuring the distance between the tip of the finger to the basal crease where the finger connects to the palm [79]. Additional measures have been obtained from photocopies or scanned images of the hand and then using calipers to estimate their relative lengths [55,80,81]. A few studies have relied on various self-estimates made by respondents themselves [66,82,83].

In the present study, respondents were asked to provide a self-estimate. They did so after reading the following: Hold up the back of your right hand so that you can see all five fingers. With your thumb as the first finger, compare the lengths of your 2nd (pointing) finger with your 4th (ring) finger. Which is longer? (check one of the five responses below)

- Index (pointing) finger considerably longer
- Index (pointing) finger slightly longer
- They are almost exactly the same length
- Ring (4th) finger slightly longer
- Ring (4th) finger considerably longer

For a subsample of 215 of the U.S. respondents, we obtained both the self-estimate just described and a measure using calipers of scanned images of the right hand. This yielded a modest positive correlation of r = .30 between the two measures. While highly significant statistically, and both measures no doubt contain measurement error, this coefficient suggests that our self-report measure was only modestly reliable.

In order to minimize confusion in interpreting the results, we inverted the r2D:4D self-ratings (relative to how they are normally presented). Thus, the higher r2D:4D ratios reflect higher androgen exposure. This pattern means that high r2D:4D scores conform to high scores for the other four androgen-influenced traits discussed below; all are in the positive direction.

### Four additional androgen-Influenced traits

As noted above, 2D:4D appears to be a valid indicator of prenatal androgen exposure although its reliability has been disappointingly low. Therefore, four additional biomarkers of androgen exposure were utilized, all of which have been found to be inversely correlated with 2D:4D: height [54,55], physical strength and muscularity [56-58], and athletic ability [59,61,62].

Adult height was measured by simply asking all respondents to report their height. In Malaysia, reports were provided in metrics, while the U.S. sample responded in feet and inches which were converted to metrics.

The remaining three traits were physical strength, masculinity, and athletic ability. To obtain these measurements, respondents were asked to use an eleven-point scale with the following instructions: Being as objective as possible, rate yourself on the following traits (0 meaning “not at all” to 10 meaning “the most extreme degree possible”):

- Physical strength _____
- Being muscular _____
- Athletic ability _____

From the standpoint of accuracy, it obviously would have been preferable to have had each of these traits measured with objective instruments overseen by trained researchers. However, to provide anonymity, and to save time and expense given large sample sizes in both countries, we relied entirely on self-reports.

### Correlating and factor analyzing the Androgen-Influenced traits

As already documented, 2D:4D is inversely associated with adult height, physical strength, masculinity, and athletic ability. Such findings are predictable since all of these traits are influenced by exposing the body to testosterone and/or other androgens [53,84]. Table 2 provides confirmation of these findings with respect to the present study. Specifically, in both Malaysia and the U.S., the inverted r2D:4D variable positively correlates with adult height, physical strength, muscularity, and athletic ability, and these variables in turn all positively correlate with one another. All but two of these correlations were statistically significant, i.e., in the Malaysian sample, the associations between physical strength and the inverted r2D:4D and height variables both fell slightly short of statistical significance.

To determine how closely linked the five androgen-influenced traits were interrelated, we subjected them to factor analysis. Because we inverted all of the r2D:4D scores, all five androgen-influenced traits were in the same direction: i.e., high scores for each trait meant high androgen exposure.

The results of the factor analysis appear in Table 3 for each sex. Without having any limits imposed regarding the number of factors to be extracted, the same factors emerged for both males and females. Our inverted r2D:4D measure loaded very heavily along with adult height onto Factor 2. Since both of these traits pertain to skeletal structures (i.e., growth of the fingers and
growth of the body as a whole), we named this second factor the bone growth factor.

The remaining three androgen-influenced traits – physical strength, muscularity, and athletic ability – all loaded unambiguously onto Factor 1. The communality of these three traits suggested that they would be appropriately named the muscular coordination factor. Even though androgens play important roles in affecting both skeletal growth and muscularity, our findings are consistent with evidence that bone growth and muscular coordination result from substantially different androgenic regimens and/or biochemical pathways [85,86].

Dependent variables

To assess health, research participants were asked to answer the following two questions: Being as objective as possible, rate yourself on the following traits (0 meaning “not at all” to 10 meaning “the most extreme degree possible”):

Physical health ______
Mental health ______

Data analyses

In order to determine how well the androgen-influenced traits were associated with one another and with the health measures, we used correlation. Spearman correlation was used since the relevant variables were measured at the ordinal level. Two-tailed tests of significance were utilized throughout.

As noted earlier, to make interpretation of findings easier, the scores for the r2D:4D measure were inverted. Therefore, our r2D:4D measure is henceforth referred to as inverted r2D:4D. The androgen-influenced traits (and factors) were correlated with the two self-ratings of health.

Results

Before addressing the study’s hypotheses, attention is drawn to Table 4. This provides a comparison of averages for all of the variables (and factors) according to gender and country. As one would expect, scores for the five of the independent variables (and for the two factors derived from these variables) were all significantly higher for males than for females. However, only physical health for the U.S. sample was significantly higher in males. As noted in the introduction, this is similar to a couple of other studies limited to college student populations [9,10].

Androgen biomarkers and self-rated physical health

The evidence bearing on the hypothesis that self-rated physical health would be positively correlated with androgen exposure is presented in Table 5a. According to this table, statistically significant positive correlations exist with respect to Factor 1 (the muscular coordination factor), comprised of physical strength, muscularity, and athletic ability. However, Factor 2 (the bone growth factor – comprised of adult height and the 2D:4D measure), was not correlated with self-rated physical health. The pattern holds for both countries sampled and for both males and females.

Androgen biomarkers and self-rated mental health

Table 5b presents evidence bearing on the possible relationship between self-rated mental health and androgen
Table 4: Sex differences in the androgen-influenced traits and the physical and mental health measures by country and gender.

<table>
<thead>
<tr>
<th>Trait (or Factor)</th>
<th>Country</th>
<th>Males</th>
<th>Females</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Inverted r2D:4D</td>
<td>Malaysia U.S.</td>
<td>3.42</td>
<td>3.78</td>
<td>1.08</td>
<td>0.93</td>
</tr>
<tr>
<td>Adult height (centimeters)</td>
<td>Malaysia U.S.</td>
<td>169.77</td>
<td>178.46</td>
<td>6.99</td>
<td>9.31</td>
</tr>
<tr>
<td>Physical strength</td>
<td>Malaysia U.S.</td>
<td>6.73</td>
<td>6.70</td>
<td>2.27</td>
<td>2.17</td>
</tr>
<tr>
<td>Muscularity</td>
<td>Malaysia U.S.</td>
<td>4.75</td>
<td>5.65</td>
<td>2.53</td>
<td>2.45</td>
</tr>
<tr>
<td>Athletic ability</td>
<td>Malaysia U.S.</td>
<td>5.03</td>
<td>6.73</td>
<td>2.75</td>
<td>2.55</td>
</tr>
<tr>
<td>Factor 1: Muscular Coordination</td>
<td>Malaysia U.S.</td>
<td>0.21</td>
<td>0.51</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>Androgen Factor</td>
<td>Malaysia U.S.</td>
<td>0.05</td>
<td>0.87</td>
<td>0.79</td>
<td>0.87</td>
</tr>
<tr>
<td>Factor 2: Bone Growth Androgen Factor</td>
<td>Malaysia U.S.</td>
<td>7.59</td>
<td>7.70</td>
<td>2.04</td>
<td>1.89</td>
</tr>
<tr>
<td>Physical health</td>
<td>Malaysia U.S.</td>
<td>7.83</td>
<td>8.04</td>
<td>1.97</td>
<td>2.00</td>
</tr>
<tr>
<td>Mental health</td>
<td>Malaysia U.S.</td>
<td>5.03</td>
<td>6.73</td>
<td>2.75</td>
<td>2.55</td>
</tr>
</tbody>
</table>

Table 5a: Spearman ranks between self-rated physical health and the five androgen-influenced traits (and the two derived factors) by country and gender.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Country</th>
<th>Androgen-Influenced Traits</th>
<th>Androgen-Influenced Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Physical Strength</td>
<td>Muscularity</td>
</tr>
<tr>
<td>Both Sexes</td>
<td>Malaysia</td>
<td>.553***</td>
<td>.155***</td>
</tr>
<tr>
<td></td>
<td>U.S.</td>
<td>.386***</td>
<td>.311***</td>
</tr>
<tr>
<td>Males</td>
<td>Malaysia</td>
<td>.621***</td>
<td>.281***</td>
</tr>
<tr>
<td></td>
<td>U.S.</td>
<td>.460***</td>
<td>.408***</td>
</tr>
<tr>
<td>Females</td>
<td>Malaysia</td>
<td>.520***</td>
<td>.103***</td>
</tr>
<tr>
<td></td>
<td>U.S.</td>
<td>.331***</td>
<td>.242***</td>
</tr>
<tr>
<td>* p &lt; .05; ** p &lt; .01; *** p &lt; .001, two-tailed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5b: Spearman rank correlations between self-rated mental health and the five androgen-influenced traits (and two derived factors) by country and gender.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Country</th>
<th>Androgen-Influenced Traits</th>
<th>Androgen-Influenced Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Physical Strength</td>
<td>Muscularity</td>
</tr>
<tr>
<td>Both Sexes</td>
<td>Malaysia</td>
<td>.514***</td>
<td>.075**</td>
</tr>
<tr>
<td></td>
<td>U.S.</td>
<td>.286***</td>
<td>.169**</td>
</tr>
<tr>
<td>Males</td>
<td>Malaysia</td>
<td>.594***</td>
<td>.227***</td>
</tr>
<tr>
<td></td>
<td>U.S.</td>
<td>.333***</td>
<td>.215***</td>
</tr>
<tr>
<td>Females</td>
<td>Malaysia</td>
<td>.480***</td>
<td>.022</td>
</tr>
<tr>
<td></td>
<td>U.S.</td>
<td>.259***</td>
<td>.145**</td>
</tr>
<tr>
<td>* p &lt; .05; ** p &lt; .01; *** p &lt; .001, two-tailed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

exposure. Its results are similar to those for self-rated physical health. Factor 1 – incorporating physical strength, muscularity, and athletic ability – is significantly and positively correlated with mental health self-ratings. As with physical health ratings, this pattern holds for both countries and for both sexes and it holds true for all three androgen measures comprising Factor 1.

In the case of the remaining two androgen exposure measures – i.e., those comprising Factor 2 (the bone growth factor) – there
is actually a negative correlation for the Malaysian sample, but not for the U.S. sample. This finding is contrary to our hypothesis, and the lack of relevant research leaves us unable to explain the unexpected

Discussion

As noted in the introduction, most studies have found that males report being healthier than females, both physically and mentally, with a few exceptions involving samples drawn from college students. In the present study of college students, U.S. males rated their physical health significantly higher than did females, but no significant difference was found amongst the Malaysian students regarding physical health. Self-ratings of mental health were not significant different for males and females in either country (Table 4). Obviously, there is a need to discover why sex differences are found in self-rated health among broad populations but sometimes not among college students.

The main purpose of this study was to determine if variations in physical and mental health self-ratings could be partly due to exposure to organizational androgens. Five androgen exposure measures were utilized: 2D:4D, adult height, physical strength, muscularity, and athletic ability. These measures were factor analyzed and shown to load unambiguously onto two factors: Factor 1, termed the muscular coordination factor, and Factor 2, named the bone growth factor. For this study, values for the 2D:4D measure were inverted, so that high scores would correspond with high androgen exposure. In all cases, males scored significantly higher than females on all five androgen measures and on both androgen exposure factors (Table 4).

Results from this study strongly support the conclusion that androgens do have effects on self-ratings of both physical health and mental health. This conclusion directly contradicts those who argue that sex differences in self-ratings of health can actually be entirely explained in terms of sex role training and societal discrimination [7,21]. Our findings are also consistent with the view that organizational androgens improve health indirectly via increased physical exercise.

The strongest apparent effects of androgens on self-rated health were positive, as we hypothesized. This finding coincides with three prior studies indicating that circulating testosterone levels are positively correlated with self-rated health [36,38,39]. However, the positive effects we observed were based on indirect, rather than direct, measures of androgens, and our findings indicate that only the effects of androgen regimens pertaining to muscular coordination affected self-ratings of health. At least in our Malaysian sample, there was also a weak but still significant negative effect of androgen regimens associated with bone growth factor that also appears to have affected self-rated health. This was entirely unexpected and obviously needs to be replicated.

Without attempting to offer a detailed explanation for these findings, it is almost certainly relevant to note that the biochemical pathways whereby androgens promote muscular development and skeletal growth are not the same [86,87]. For example, to promote bone growth, testosterone needs to be converted to estradiol (via the enzyme aromatase). After making this conversion, estradiol operates in conjunction with the human growth hormone, to elongate and strengthen the bones [88-91]. As a steroid, testosterone appears to promote muscular development and functioning more directly, although estrogens may still have some role to play in the process [91-95].

Among the limitations of this study are that measures are based on single-item, self-rated responses. This is all but unavoidable for measuring self-reported health in a non-clinical setting, but the androgen-influenced traits could have been measured more precisely with physiologically-based instruments. Nonetheless, as an exploratory study, our findings are suggestive with respect to some new directions that may be taken to understand how androgens may influence traits such as self-assessed health. We also see our indirect measurement of androgens as actually being advantageous over direct measurements of testosterone and other androgens, since direct measures only tap into the levels of these hormones over a short period of time. Our indirect measurements gauge much more long term prenatal exposure to androgens.

Another limitation was that only college students were sampled. Because a significant sex difference in self-rated health was found only among the U.S. male sample, our study probably provides a minimal estimate of the extent to which androgens play a role in self-rated health. Moreover, the 2D:4D digit ratio is recognized as a “noisy” biomarker of androgen exposure, thus providing a low-reliability marker for prenatal androgen exposure. Nonetheless, evidence presented here that androgens are related to physical and mental health suggests that further research along these lines is in order.

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References


44. Gillam L, McDonald R, Ebling FJ, Mayhew TM. Human 2D (index) and 4D (ring) finger lengths and ratios: Cross-sectional data on linear growth patterns, sexual dimorphism and lateral asymmetry from 4 to 60 years of age. J Anat. 2008; 213: 325-335.


72. Malas MA, Dogan S, Hidal Ercil E, Desiccioglu K. Fetal development of the hand, digits and digit ratio (2D:4D). Early Hum Dev. 2006; 82:469-475.


81. Trivers R, Manning J, Jacobson A. A longitudinal study of digit ratio (2D:4D) and other finger ratios in Jamaican children. Hor Behav. 2006; 49: 150-156.


