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Digit ratio (2D:4D) and muscular strength in adolescent boys

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ABSTRACT

Using a cross-sectional design, this study quantified the relationship between the digit ratio (2D:4D) and muscular strength in 57 adolescent boys. 2D:4D was very likely a moderate negative correlate of handgrip strength, even after adjustment for age and body size. This result may reflect the organizational benefits of prenatal testosterone.

1. Introduction

Digit ratio (2D:4D) is the ratio of the length of the second digit (2D) to the length of the fourth digit (4D). Males typically display lower 2D:4Ds than females, the likely result of the balance between prenatal testosterone and estrogen as the fetal 4D has a higher number of receptors for androgen [1,2]. 2D:4D is essentially fixed in utero [3] and remains reasonably stable across the lifespan [4].

2D:4D is considered a proxy of prenatal testosterone [2]. Prenatal testosterone has numerous long-term organizational effects on the body, including growth and development of the cardiovascular, musculoskeletal, and urogenital systems [2]. 2D:4D is a negative correlate of performance in sports (e.g., basketball, fencing, rowing, soccer [football]), athletics (e.g., running), and on fitness tests (e.g., handgrip strength), although considerable variability exists across different activities [5,6,7]. Muscular strength (operationalized as handgrip strength) has been linked with 2D:4D, albeit with inconsistent results. Fink and colleagues [8] found that men with lower 2D:4Ds had substantially better handgrip strength. Correlational research indicates that the 2D:4D-handgrip relationship is: (a) weak to moderate and negative in men [9,10]; (b) negligible to weak and typically positive in women [9–11]; (c) negligible to weak and typically negative in male and female college students [12]; and (d) negligible in boys and girls aged 8–12 years [13]. Negligible relationships between 2D:4D and other strength measures (e.g., static strength [upper and lower body] and explosive strength [lower body]) have also been reported for adolescent girls aged 13–18 years [14]. Unfortunately, the relationship between 2D:4D and handgrip strength in adolescent boys is unknown. The aim of this study was to quantify the relationship between 2D:4D and handgrip strength in adolescent boys.

2. Methods

This study used a cross-sectional design. Boys aged 13–18 years from Sacred Heart School in East Grand Forks, MN, USA, were invited to participate. Written informed consent was obtained from parents or legal guardians, and participants provided assent. Only participants of Caucasian ethnicity were included because of known ethnic differences in 2D:4Ds [15], with those self-reporting a major injury (e.g., a break) to either the second digit (2D) or fourth digit (4D) excluded. The Institutional Review Board of the University of North Dakota approved this study.

Age was self-reported, height was measured to the nearest 0.1 cm using a stadiometer, body mass was recorded to the nearest 0.1 kg using a digital weighing scale, with body mass index (BMI) subsequently derived. Right handgrip strength was measured as the better of two maximum voluntary contractions to the nearest 0.1 kg using a Takei TKK 5401 digital handgrip dynamometer (Takei Scientific Instruments, Niigata, Japan). Participants were instructed to grip the dynamometer, place it overhead, and then squeeze as hard as possible while moving it down in a 180° arc (in the sagittal plane) to the count of three. Digit lengths were measured (blind to handgrip strength) from digital photographs of the palmar surface of each participant's outstretched right hand using procedures described elsewhere [7]. This method demonstrates very good repeatability and validity (vs. direct caliper measurements) [5,7]. Using a sub-sample of 20 boys, intra-tester repeatability for right hand 2D:4D was very good, with negligible systematic error (change in means [95% CI]: −0.05% [−0.40, 0.30]), negligible random error (typical error [95% CI]: 0.52% [0.38, 0.73]) and nearly perfect test-retest correlation (intraclass correlation [95% CI]: 0.99 [0.97, 1.00]).

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Descriptive characteristics were calculated as means and standard deviations. Partial correlation was used to quantify the linear relationship between 2D:4D and handgrip strength adjusted for age and body size (operationalized as the BMI). A negative correlation indicated that boys with lower 2D:4Ds had better handgrip strength and a positive correlation that boys with lower 2D:4Ds had poorer handgrip strength. Correlations of 0.1, 0.3, and 0.5 were used as thresholds for weak, moderate, and strong [16]. The chances of the true correlation being negligible, substantially positive, or substantially negative were calculated, with chances qualitatively interpreted using the following scale: < 0.5%, most unlikely; 0.5–5%, very unlikely; 5–25%, unlikely; 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; and > 99.5%, most likely [16].

3. Results

Fifty-seven adolescent boys volunteered for this study. Means (SDs) for the sample were: age, 15 (2) years; height, 173 (10) cm; mass, 70 (18) kg; BMI, 23 (5) kg/m^2; 2D:4D, 1.00 (0.05); and handgrip strength, 35 (10) kg.

The age- and BMI-adjusted partial correlation between 2D:4D and handgrip strength was very likely moderate and negative (r [95%CI]: −0.32 [−0.57, −0.04]) (Fig. 1), indicating that boys with lower 2D:4Ds had better handgrip strength irrespective of their age and body size. Each one standard deviation decrease in 2D:4D was associated with a 3 kg increase in handgrip strength.

4. Discussion

This study was the first to quantify the relationship between 2D:4D and muscular strength in adolescent boys. It showed that 2D:4D was very likely a moderate negative correlate of handgrip strength, even after adjustment for age and body size. This relationship is similar in magnitude and direction to that observed in men [8–10], and is similar in direction yet substantially larger in magnitude to that observed in younger boys (aged 8–12 years) [13]. While the observed relationship likely reflects the long-term organizational benefits of prenatal testosterone, especially its effect on growth and development of the musculoskeletal system [2], it may also reflect the short-term activational benefits of adolescent testosterone. This may help explain why the 2D:4D-strength relationship is substantially stronger in adolescent boys (this study) and men (i.e., pubertal and post-pubertal males) [8–10] than in younger boys (i.e., males who are probably pre- or peri-pubertal) [13]. Given that muscular strength is an important determinant of success in many youth sports and athletic events, our finding suggests that 2D:4D may predict performance in youth sports and athletic events requiring high strength. However, longitudinal studies following children and adolescents—especially during adolescence at the time when potential talent are first identified and recruited into high-performance sports and/or athletics programs—are required before the usefulness of the 2D:4D to talent identification is known.

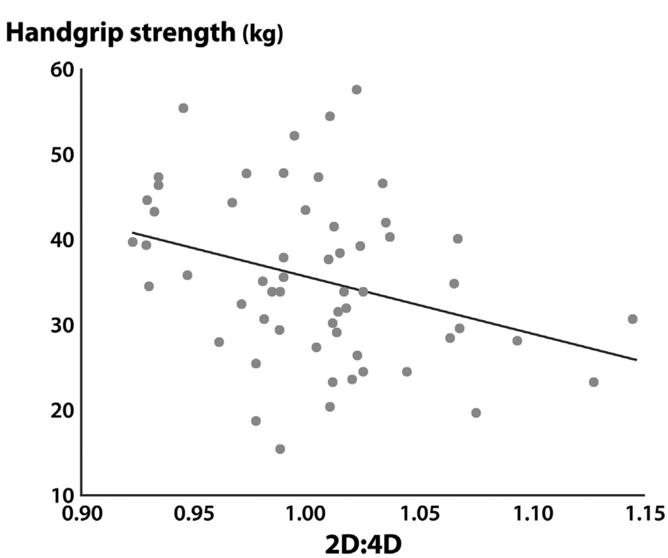

Fig. 1. The relationship between 2D:4D and handgrip strength in 57 adolescent boys.

Muscular strength is also an important summative indicator of good health. In adolescents, favorable associations have been reported between muscular strength and cardiometabolic disease risk, fatness, bone health, mental health, and cognition [17]. Direct evidence shows that low muscular strength in adolescence is significantly related to all-cause mortality in adulthood [18]. While research into the relationship between 2D:4D and health is required in adolescents, our finding suggests that adolescent boys with lower 2D:4Ds have better general health.

This study has several strengths. It used a validated photographic technique and Cartesian coordinate geometry to measure digit lengths, thus avoiding the potential confound of placing fingers downwards onto a glass surface, which may distort the fat pads of the finger tips and influence 2D:4D [19]. It controlled for ethnicity, which contributes to variability in 2D:4D [15]. It also adjusted the 2D:4D-strength relationship for age and BMI, both of which were favorably related to handgrip strength. The study is limited by the potential for unmeasured confounding (e.g., biological maturation, handedness, and training status). It is important to note however, that calendar age was used as a proxy for maturational age, and because left handers typically have equal strength in both hands [20], handgrip strength was unlikely to be systematically biased. It is, however, unknown whether exercise training (e.g., resistance training) modifies the 2D:4D-strength relationship. While limited to only the right hand 2D:4D, the right hand 2D:4D is however considered a better indicator of prenatal testosterone than is the left hand 2D:4D [21].

5. Conclusion

This study found a moderate age- and BMI-adjusted negative (and theory-consistent) relationship between 2D:4D and handgrip strength in adolescent boys. This result is likely due to the long-term organizational benefits of prenatal testosterone. This study adds to a limited body of research examining the 2D:4D-fitness relationship in adolescents, and encourages additional 2D:4D research in girls and other ethnicities before drawing confident conclusions as to the true relationship.

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Contributors

JMT and GRT developed the research question, designed the study, had full access to the data, and take responsibility for the integrity of the data. JMT collected the data. GRT conducted the statistical analysis and wrote the report. Both authors contributed to the interpretation of results, editing and critical reviewing of the final report, and approved the final report.

Conflicts of interest statement

None declared.

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