Early Human Development 89 (2013) 589–592

Contents lists available at SciVerse ScienceDirect

Early Human Development

journal homepage: www.elsevier.com/locate/earlhumdev

Reliability of a field based 2D:4D measurement technique in children

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ARTICLE INFO

Article history:
Received 30 October 2012
Received in revised form 27 February 2013
Accepted 5 March 2013

Keywords:
Digit ratio
Coefficient of variation
Correlation coefficients
Limits of agreement
Children
Health-related fitness

ABSTRACT

Background: There is limited literature on the relationship between second to fourth finger digit ratio (2D:4D) and health- and skill-related fitness in children. To examine this relationship it is important to establish a reliable method of assessing 2D:4D for use with large groups of children.
Aim: The aim of the study was to examine the reliability of a field-based 2D:4D measure in children.
Methods/research design: Fifty 8–11 year olds had 2D:4D of the right hand measured using a Perspex table top, a digital camera, and Adobe Photoshop software. Second to fourth finger digit ratio (and 2D and 4D) intra-observer and inter-observer reliabilities were assessed on the same day and intraobserver reliability was measured between days. Limits of agreement (LoA), coefficient of variation (CV) and Pearson's correlation coefficient were used for statistical analysis.
Results: High correlation coefficients ($r = 0.95–0.99$) and low CV's (0.4–1.2%) were reported for intra- and inter-observer reliabilities on the same day and between days. LoA revealed negligible systematic bias with random error ranging from 0.02 to 0.12.
Conclusion: These findings suggest that 2D:4D (and 2D and 4D) assessment in children using digital photography provides a reliable measure of 2D:4D that can be used during field-based testing.

1. Introduction

The second and fourth digit ratio (2D:4D) of the hand is established during foetal development and caused by prenatal androgens [1,2]. The digit ratio has been related to a number of attributes and behaviours in health-related fitness and sporting attributes in both males and females [3], in females only [4] and males only [5]. Digit ratio has been shown to be negatively associated with ability in sports such as skiing, football, middle distance and endurance running, which are dependent upon an efficient cardiovascular system [6]. Most of the current literature on 2D:4D and sporting performance are based on rankings or selection which may be prone to bias. Research investigating performance outcomes are rare but 2D:4D was positively related to maximum voluntary contraction using a hand grip dynamometer in men but not women [7] but 2D:4D was not related to $\dot{V}O2max$ in boys [8]. The 2D:4D literature is limited in children, particularly in large cohorts. In order to examine the relationship between digit ratio and fitness in children it is important to establish a reliable method of measuring 2D:4D that can be used in the field when undertaking fitness testing with a large group of children. Previous methods are unsuitable for measuring 2D:4D in the field, as it is well established that children are less cooperative than adults [9].

The measurement of 2D:4D needs to be sensitive enough to detect the lengths of the second (2D) and fourth (4D) digits accurately to enable the precise calculation of 2D:4D [2]. Second digit and 4D lengths have been measured in a number of ways, both directly and indirectly, for example using callipers [10,11,5], rulers [12], market tubes [13], radiography [14], or computer software [15–17], from actual hands, their scans, photocopies, or photographs, and all have their limitations (financial and feasibility), especially for use with children. A range of statistical analyses have been employed to assess the reliability of the various 2D:4D measurement techniques. These have included intraclass correlation coefficients (ICC) ranging from $r = 0.91$ to 0.98 for the measurement of hands using photographs [10,11,5] and correlation coefficients $r = 0.93–0.97$ using scans of the hand and Adobe Photoshop software [18]. Similarly Manning et al. [2] reported correlation coefficients of $r = 0.96–0.97$ for 2D and 4D measured separately using callipers directly on the hand. Historically a significant test–retest correlation coefficient of $r \geq 0.8$ has been used to indicate that equipment and tests are suitably reliable [19]. However, this method of assessing reliability has been criticised, since a high correlation coefficient indicates the strength of the relationship between the test–retest values, not the agreement between them [19–21]. Statistical methods to assess reliability have evolved and authors advocate the use of various tests, and calculations, to determine whether a method is reliable. Atkinson and Nevill [22] support the use of limits of agreement (LoA) to assess reliability but this has been criticised as the method has been reported to be biased

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0378-3782/$ – see front matter
http://dx.doi.org/10.1016/j.earlhumdev.2013.03.002

[23,24]. Instead standardised typical error (TE) and raw measurement error (SEM) have been proposed, as they are less stringent and the use of ICC advocated to test repeated trials and to test inter-observer differences. The coefficient of variation (CV) has also been used to assess reliability in multiple trials as it provides a dimensionless comparison of reliability and therefore permits easy comparisons between studies [23].

Previous studies reporting the reliability of digit ratios are limited due to the methods used to determine the reliability of 2D:4D assessment. In addition, few studies have measured individual digit lengths, allowing the actual reliability of the measurement to be determined before masking the error by calculating a ratio and no studies have examined the reliability of a field-based measure of 2D:4D in children. Therefore the aim of the study was to examine the reliability of a field-based 2D:4D measure in children.

2. Method

2.1. Participants

Fifty children (25 boys and 25 girls) participated in the study. The participants were aged 8–11 years. The boys were all Caucasian, aged 9.12 ± 0.54 years, had a mean stature of 1.34 ± 0.07 m, a mean body mass of 32.84 ± 7.81 kg and mean BMI of 17.71 ± 2.73 kg·m^2. Whereas, the girls (all Caucasian) were slightly older (9.33 ± 0.72 years), taller (1.36 ± 0.07 m), heavier (33.84 ± 7.42 kg) and had a higher BMI (18.14 ± 2.89 kg·m^2) compared to the boys. Prior to participation written parental consent and child assent were gained. The University Ethics Committee approved the study.

2.2. Procedures

Digit ratio was measured using procedures similar to those outlined by Honekopp et al. [16]. To comply with health and safety regulations and to improve the portability of the equipment for field-based testing Perspex replaced the glass used in the original study. Unlike some devices used to measure finger length the equipment was fully portable and did not require mains power. A sheet of A1 paper was used as a template on which the table legs and camera were placed to ensure consistency between measurements. A photograph (Sony Cyber-shot; Singapore:DSC-S930) was taken from underneath the Perspex table top of the ventral surface of the stretched right hand [2,11,17]. A 'hood' was placed over the child's hand to reduce glare from overhead lights and to improve the quality of the photograph. A 30 cm ruler was placed on the table top in the camera shot for scaling and calibration purposes (Fig. 1). The pronated hand was placed lightly on the Perspex sheet and 3 photographs of the ventral surface of the hand were taken, with the sharpest picture selected to measure digit length, thus eliminating the need to exclude poor quality images and maximizing the sample size.

The second and fourth digits of the right hand were measured using Adobe Photoshop 5.0 (Adobe systems, San Jose, CA) [12,18]. Measurements were taken from the ventral proximal crease to the fingertip [2,16]. Digit ratio (2D:4D) was calculated by dividing the length of the 2nd digit by the length of the 4th digit [2].

2.3. Reliability

Inter-observer reliability was assessed by repeatedly measuring the second and fourth digit lengths and digit ratio on the same photograph

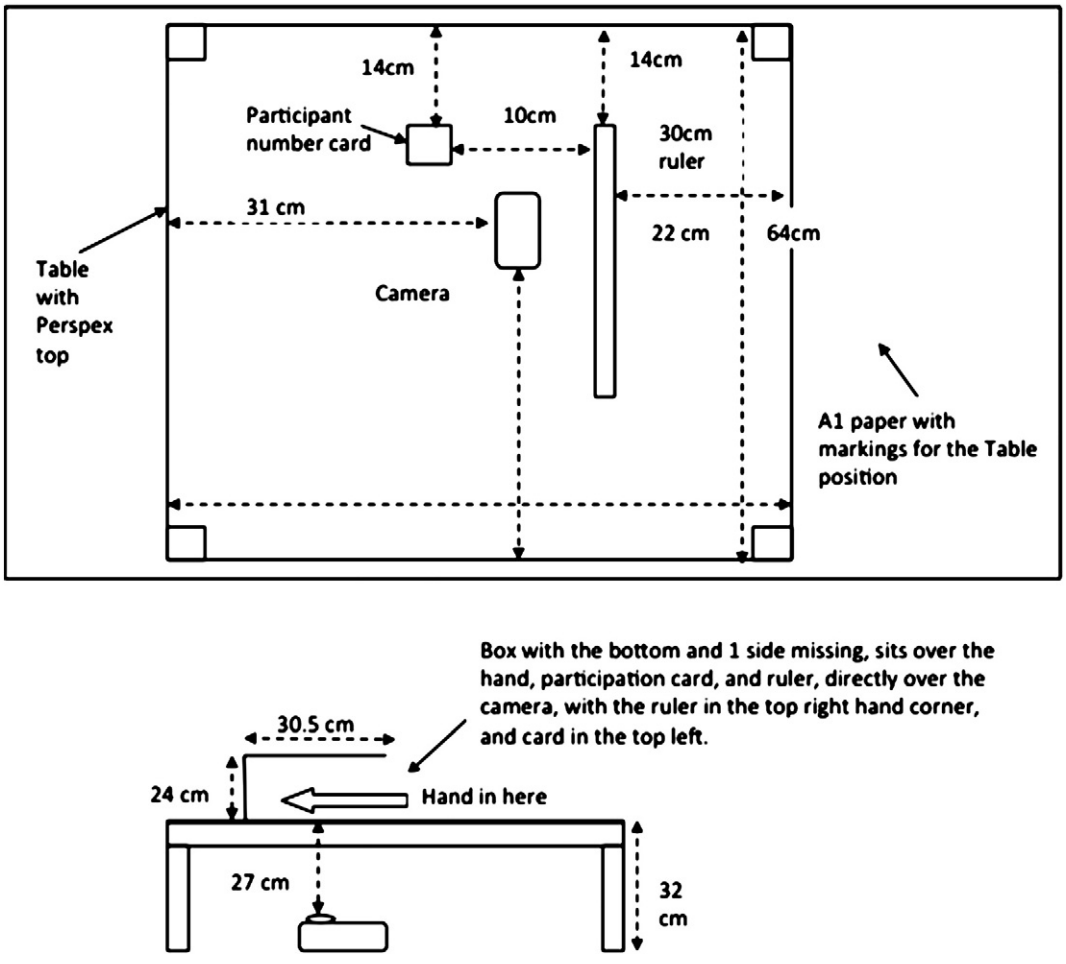

Fig. 1. Schematic diagram of the equipment used to measure 2D:4D.