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Short communication

Reliability of the *ATD* Angle in Dermatoglyphic Analysis

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ABSTRACT

The »ATD« angle is a dermatoglyphic trait formed by drawing lines between the triradii below the first and last digits and the most proximal triradius on the hypothenar region of the palm. This trait has been widely used in dermatoglyphic studies, but several researchers have questioned its utility, specifically whether or not it can be measured reliably. The purpose of this research was to examine the measurement reliability of this trait. Finger and palm prints were taken using the carbon paper and tape method from the right and left hands of 100 individuals. Each »ATD« angle was read twice, at different times, by Reader A, using a goniometer and a magnifying glass, and three times by a Reader B, using Adobe Photoshop. Inter-class correlation coefficients were estimated for the intra- and inter-reader measurements of the »ATD« angles. Reader A was able to quantify ATD *angles on 149 out of 200 prints (74.5%), and Reader B on 179 out of 200 prints (89.5%). Both readers agreed on whether an angle existed on a print 89.8% of the time for the right hand and 78.0% for the left. Intra-reader correlations were 0.97 or greater for both readers. Inter-reader correlations for »ATD« angles measured by both readers ranged from 0.92 to 0.96. These results suggest that the »ATD« angle can be measured reliably, and further imply that measurement using a software program may provide an advantage over other methods.*

Key words: *dermatoglyphics,* ATD *angle, reliability*

Introduction

Dermatoglyphic traits are widely used markers in analyses of fetal development, developmental disturbances, disease and genetics[1-22]. The most commonly analyzed dermatoglyphic traits include descriptions of finger and hypothenar patterns; measurements of ridge counts between triradii, points formed by the convergence of three patterns of ridges; and measurements of the *ATD* angle, the angle that exists between the a, d, and t triradii on the palm (Figure 1).

In relation to the *ATD* angle specifically, although this trait is widely used in dermatoglyphic studies, several researchers have questioned its utility, specifically whether or not it can be measured reliably[23-27]. Measurement of the *ATD* angle involves locating three triradii and then measuring the angle between these points. Each step in this process increases the possibility of reader error, including inconsistent identification of landmarks. Measurement of angles is occasionally further complicated by the presence of additional a, d or t triradii on some prints. The purpose

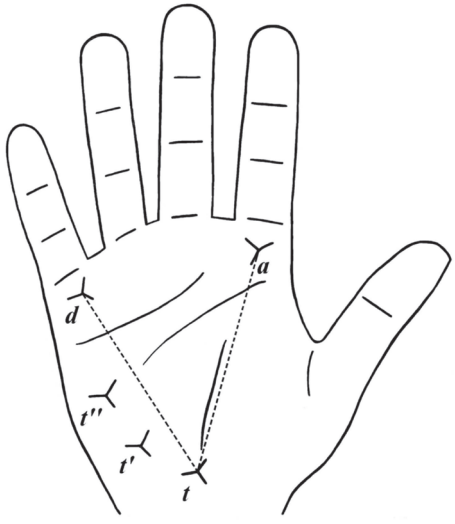

Fig. 1. Landmarks used to measure the ATD *angle.*

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of this research was to determine the reliability of *ATD* angle measurements within and between readers.

Materials and Methods

Palm prints were taken using the carbon paper and tape method[28] from the right and left hands of 100 individuals. *ATD* angles from these 200 prints were read by two readers (A and B) using the criteria set forth for *ATD* angle measurement by Elbualy and Schindeler[29]. Each angle was read twice by Reader A, through the process of placing enlarged photocopies of the prints into a transparent plastic sleeve, locating and marking the a, d and t triradii on the sleeve, and drawing straight lines from a to t and from d to t. The *ATD* angle was then read using a basic goniometer. Reader B read each angle three times from images created by digitally scanning each print at a resolution of 400 dots per inch (DPI). The prints were digitally enlarged so that the a, d and t triradii could be marked, and then the Photoshop (version 8.0, Abobe Systems, Inc., San Jose, CA) angle measurement tool was used to measure the resulting angle. All angle measurements were rounded to the nearest 0.1 degree.

To increase independence between successive measurements of the prints, each set of readings was made at different times: weeks or months apart. Markings from previous readings were not saved by either reader to ensure that subsequent readings were completely independent. Prints were read in a random order; and right and left prints from the same individual were not read at the same time.

When two a or two d triradii were encountered, the more radial and more ulnar triradius, respectively, was used to determine the angle. When more than one t triradius was encountered in a single print, only the most proximal triradius was used (t instead of t' and t' instead of t") in accordance with the methods proposed by David[30].

To determine if the two readers measured the same *ATD* angle, a type of randomization test was used. For each print, one of the two readings from Reader A and one of three readings from Reader B were randomly selected. A two-tailed t-test (γ=0.05) was then used to test whether the mean of the difference between pairs of readings (Reader A – Reader B) was significantly different from zero. This procedure was repeated one million times, and the number of times the sum of the difference was significantly different from zero was counted. Intraclass correlation coefficients (ICC) were then estimated to determine the degree of association within and between readers.

Results

Triradii were not readable on all prints; therefore, *ATD* angles could not be determined for all 200 prints. Reader A was able to read *ATD* angles on 149 out of 200 prints (74.5%), and Reader B on 179 out of 200 prints (89.5%). Both readers agreed on whether an angle existed on a print 89.8% of the time on the right hand and 78.0% on the left.

TABLE 1
SUMMARY STATISTICS FOR »ATD« ANGLE MEASUREMENTS BY READER

Reader*	A1	A2	B1	B2	B3
Right hand data, N = 77					
Mean (SD)	45.6 (6.7)	46.8 (6.8)	45.4 (8.0)	45.7 (8.0)	45.6 (7.9)
Left hand data, N = 71					
Mean (Sd)	45.2 (5.8)	46.1 (5.8)	44.4 (6.0)	44.7 (6.1)	44.5 (6.1)

* A1= Reader A's first reading, B1= Reader B's first reading

TABLE 2
RELIABILITY COEFFICIENTS FOR »ATD« ANGLE MEASUREMENTS

Intra-observer reliability						
Reader*	A1/A2	B1/B2	B1/B3	B2/B3		
Right hand	0.97	0.99	0.99	0.99		
Left hand	0.97	0.99	0.99	0.99		
Inter-observer reliability						
Reader	A1/B1	A1/B2	A1/B3	A2/B1	A2/B2	A2/B3
Right hand	0.96	0.96	0.96	0.94	0.95	0.95
Left hand	0.96	0.96	0.96	0.92	0.92	0.92

* A1= Reader A's first reading, B1= Reader B's first reading

For angles that both readers were able to measure, Reader A's readings tended to be slightly higher (mean 45.6°) than Reader B's (mean 44.8°), but Reader A's readings were less variable (SD 6.3°, compared to SD 7.4° for Reader B). These trends remained true even when measurements from the right and left hands were examined separately (Table 1). The randomization test yielded no significant differences (0 out of 1,000,000 times) strongly suggesting that Reader A's and Reader B's readings are interchangeable – that is, the slight upward bias in Reader A's readings relative to Reader B's readings is not significant.

Reliability within readers, as assessed by ICC analysis, showed that both readers were consistent in their measurements. Reader A had an ICC of 0.97 and Reader B had an ICC of 0.99 for all three pairwise comparisons (reading 1 vs. reading 2, reading 1 *vs.* reading 3, and reading 2 *vs.* reading 3). Considering the reliability of *ATD* angle measurements between readers, the ICC analysis suggested that there is more variability between readers than within the same reader, but that the correlations were still well above 0.9, ranging from 0.92 to 0.96 (Table 2).

Discussion

The purpose of this study was to assess the reliability of measuring the *ATD* angle. The high ICCs obtained in this analysis suggest that »ATD« angles can be measured reliably both within and between readers. The results of the randomization test further suggest that two different readers, using different measurement tools (a goniometer versus a digital angle measurement tool), can measure *ATD* angles without bias. These findings lend support for a trait that has been widely used in the literature on birth defects, neurological disorders and diseases. A reader who is well-trained in recognizing the landmarks and measuring the angle should provide results consistent with those of other readers equally well-trained.

In addition, these findings lend support for the use of software programs, such as Adobe Photoshop, to measure dermatoglyphic traits on digitized images. Using such a method, Reader B was able to measure *ATD* angles on 30 more prints (15% of the total sample) compared to Reader A, who used a magnifying glass and goniometer to measure the angles on photocopies of the prints. Because both readers were trained using the same methodology and because they cross-checked their methods during training to ensure they were reading the prints with the same methods and a comparable level of accuracy, the differences in the number of prints each reader was able to read likely reflect the differences in the tools used.

Advantages of Photoshop in reading *ATD* angles in this research included the ability to magnify prints, beyond the magnification possible with a magnifying glass, and the ability to enhance the lines of the palms when necessary. The angle measurement tool in this program also was convenient in that it reduced the error that could have occurred from Reader B misreading an angle on a goniometer. Based on these results, we recommend that future researchers consider digitally scanning prints and then using some type of software program to digitally measure *ATD* angles and even other dermatoglyphic traits. Prints in this research were scanned using an ordinary flat-bed scanner to scan the images at 400 DPI using an eight-bit grayscale.

Conclusion

This research has shown that the *ATD* angle can be measured reliably whether the readings are made by one individual or multiple readers. It further suggests that the reliability of this measurement may be improved by reading digitized prints with the help of a software program such as Adobe Photoshop.

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POUZDANOST *ATD* KUTA U DERMATOGLIFSKOJ ANALIZI

S A Ž E T A K

ATD kut je dermatoglifskiha osobina koja nastaje crtanjem linija između triradii ispod prve i zadnje znamenke i najbližeg triradiusa na hypothenar regiji dlanu. Ovaj potez se naširoko koristi u dermatoglifskih istraživanjima, ali nekoliko istraživača je ispitalo njegovu korisnost, posebno da li se može pouzdano izmjeriti. Svrha ovog istraživanja bila je ispitati pouzdanost mjerenja ove osobine. Otisci prstiju i dlanova su snimljeni metodom ugljičnog papira i metodom trake za desne i lijeve ruke kod 100 pojedinaca. Svaki *ATD* kut je Čitač A očitao dva puta, u različitim vremenima, koristeći Goniometar i povećalo, a tri puta je očitao Čitač B, pomoću Adobe Photoshopa. Koeficijenti korelacije Inter-klase su procijenjene na intra- i inter-čitačkim mjerenjima za *ATD* kutove. Čitatelj A je bio u mogućnosti kvantificirati *ATD* kutove na 149 od ukupno 200 otisaka (74,5%), a Čitač B na 179 od ukupno 200 otisaka (89,5%). Oba čitača su se složili da postoji kut na ispisu u 89,8% slučajeva za desnicu i 78,0% za lijevicu Korelacije Intra-čitača bile su 0,97 ili više i za oba čitača. Korelacije Inter-čitača za *ATD* kutove su izmjerene kod oba čitatelja u rasponu od 0,92 do 0,96. Ovi rezultati sugeriraju da se *ATD* kut može pouzdano izmjeriti, i dalje podrazumijeva da mjerenje pomoću softverskog programa može pružiti prednost u odnosu na druge metode.