

Intra- and Inter-rater reliability of Ultrasound Measurements of Achilles Cross-sectional Area

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ABSTRACT

Purpose: To examine the intra- and inter-rater reliability of Achilles tendon cross-sectional areas from ultrasound (US) measurements.

Methods: The Achilles tendon cross sectional images of thirty-nine healthy female participants were evaluated. One scan was obtained per subject. For each image, four raters performed five blinded cross sectional area measurements. The cross-sectional Achilles area measurements were scaled and traced with Image J software. Intra-rater reliability was assessed by examining the intraclass correlation coefficients of each examiner. Inter-rater reliability was examined by averaging the 5 measures of each rater and using an intraclass correlation coefficient.

Results: The intraclass values ranged from .745-.854 using single values. Inter-rater reliability based on the four examiners was .551.

Conclusions: Our analysis indicates that Achilles tendon ultrasound measurements taken by a single rater has good to excellent reliability. The inter-rater reliability for our 4 examiners was moderate.

INTRODUCTION

Measuring the cross-sectional area of the Achilles tendon provides valuable information. Ultrasound (US) and magnetic resonance imaging (MRI) are the most frequently used imaging methods to measure the cross-sectional area (CSA) of tendons¹. Although MRI has often been the preferred imaging modality^{2,3}, reliability analyses of measurements of the Achilles Tendon CSA have been reported that demonstrated predominantly good to excellent reliability for US applications^{4,5}. To ensure high reliability in US examinations of the Achilles tendon, subject positioning, joint fixation, probe alignment and pressure should be taken into account^{4,5}.

The aim of this study was to examine the intra- and inter-rater reliability of Achilles tendon cross-sectional areas from ultrasound (US) measurements. Intraclass correlation coefficients (ICC) were used to assess the intra-rater reliability of each examiner and used to determine the inter-rater reliability of single measurements and averages of five measurements by each rater. We expected that the intra-rater reliability would be higher than inter-rater reliability.

MATERIALS AND METHOD

Participants: Thirty-nine healthy females (Table 1).

Table 1. Mean (\pm SD) and ranges of subject characteristics

	Mean (\pm SD)	Range
Age (years)	21.5 \pm 1.8	19-24
Height (cm)	169.3 \pm 5.6	160-181
Weight (kg)	64.2 \pm 9.7	46.5-84.5

Protocol: Ultrasound images of the AT were obtained, from a single examiner, for each participant using GEP-6 ultrasound (Figure 1-3). One image was obtained for each participant. Achilles tendon cross-sectional area measurements were obtained from the ultrasound images by scaling and tracing the Achilles tendon using Image J software. Five blinded cross-sectional area measurements were performed by four examiners for each image.

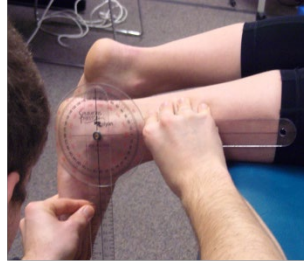


Figure 1. Ankle positioned at 90°



Figure 2. Ultrasound probe placement



Figure 3. Transverse ultrasound image obtained

Statistical Analysis: An intraclass correlation coefficient (ICC) was used to examine the intra- and inter-rater reliability. A standard error of measurement (SEM) was used to determine the reliability of measurements. $SEM = s_x \sqrt{1-r_{xx}}$ (where s_x is the standard deviation and r_{xx} is the reliability coefficient). A minimal detectable change (MDC) was used to distinguish between a true change and change due to variability in measurement. $MDC = 1.96 \sqrt{2} (SEM)$.

RESULTS

An initial comparison was made between individual trial and average Achilles-tendon cross-sectional areas overall and for each rater (see Figures 4-8).

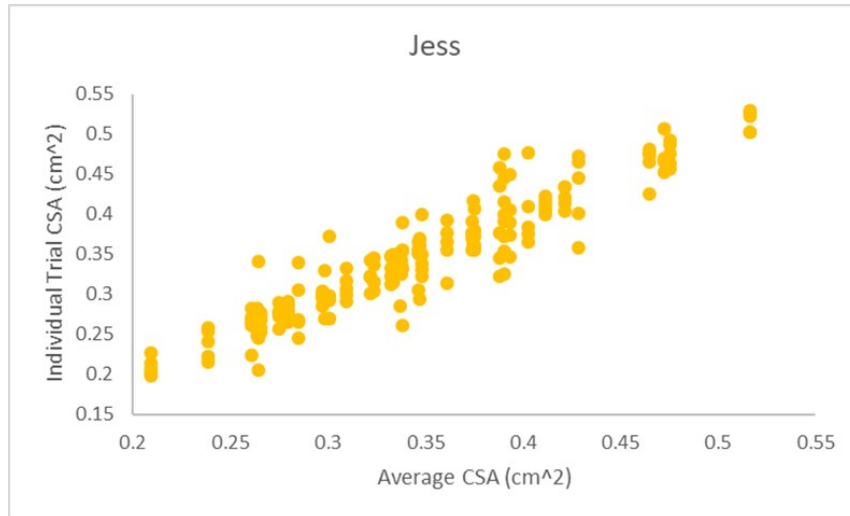


Figure 4.

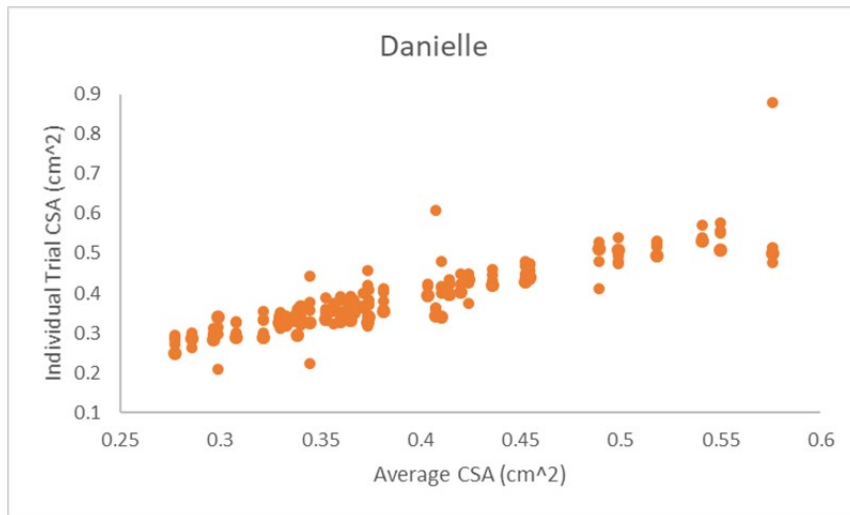


Figure 5.

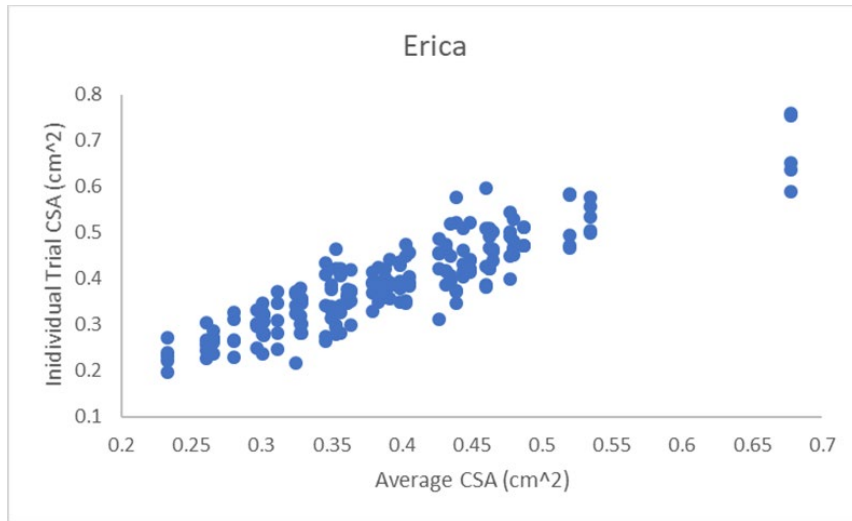


Figure 6.

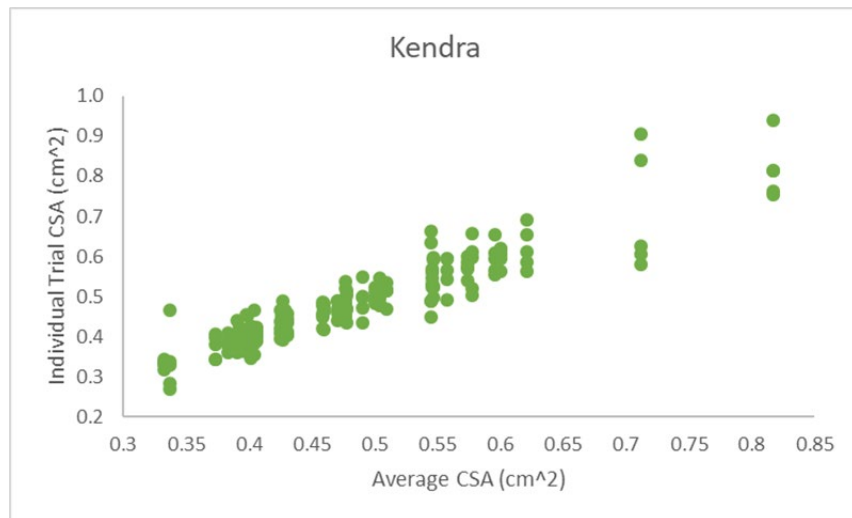


Figure 7.

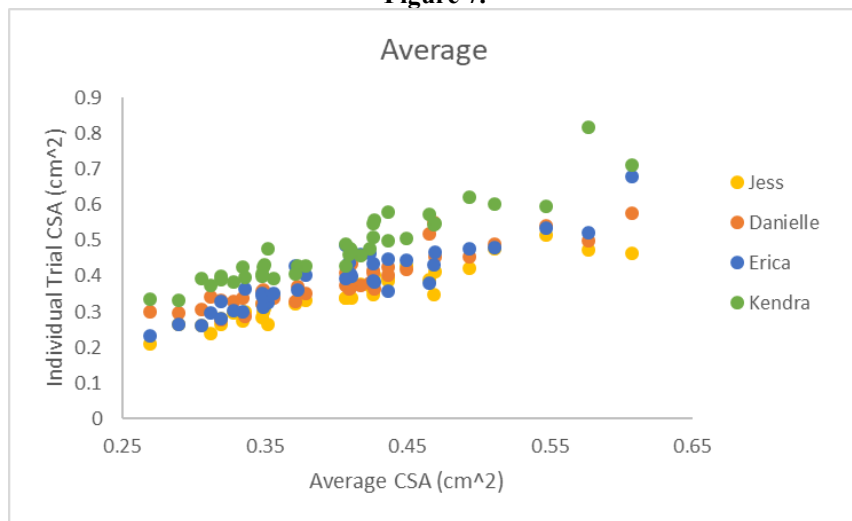


Figure 8.

We used ICC, SEM and MDC calculations in order to compare the reliability of raters against their own measurements as well as in comparison to the measurements of other raters. WE found that reliability varied among raters. However, in all cases, the intra-rater reliability value was higher than the inter-rater reliability value (see Table 2).

Table 2. Summary intraclass correlation coefficient (ICC), standard error of measurement (SEM), minimal detectable change (MDC) for Achilles tendon cross-sectional images.

	ICC (single measure)	SEM (cm ²)	MDC (cm ²)	ICC (average measure)	SEM (cm ²)	MDC (cm ²)
Jess	0.854	0.0282	0.0739	0.967	0.0126	0.0348
Danielle	0.745	0.0425	0.117	0.936	0.0189	0.0523
Erica	0.759	0.0479	0.133	0.940	0.0183	0.0506
Kendra	0.831	0.0443	0.123	0.961	0.0197	0.0546
Single Trial Interrater	0.497	0.0694	0.192	0.798	0.0440	0.122
Average Interrater	0.551	0.0647	0.179	0.831	0.0397	0.110

DISCUSSION

Kruse, et al.⁶ reported intra- and inter-rater reliability of cross-sectional areas of Achilles tendons using ultrasound imaging.

Intra-rater ICC values of 0.89-0.97.

Inter-rater ICC values of 0.84-0.89.

Schneebeil, et al.³ reported intra- and inter-rater reliability of thickness and cross-sectional area of supraspinatus muscle using ultrasound images. They concluded for cross-sectional area measurements:

Intra-rater ICC values were high (0.9 and 0.85 for two raters)

Inter-rater ICC values were moderate 0.70.

Auliffe, et al.⁷ reported a systematic review of the reliability of diagnostic ultrasound imaging in measuring tendon size. Eight electronic databases were searched using an agreed set of keywords and they found:

Intra-rater ICC values were (0.59-0.99).

Inter-rater ICC values were (0.45-0.99).

Across the board they reported intra-rater ICC values to be higher overall than inter-rater values.

Our data reports intra-rater ICC values of 0.745-0.967 and inter-rater ICC values of 0.497-0.831. Both single and average measures were considered. The data shows high and very high ICC values for intra-rater reliability and low to moderate ICC values for inter-rater reliability. SEM values ranged between .0126-.0440. MDC values ranged between .0348-.122.

CONCLUSIONS AND IMPLICATIONS

Our analysis indicates that Achilles tendon ultrasound measurements taken by a single rater had good to excellent reliability. The inter-rater reliability for our 4 examiners was moderate.

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