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RELIABILITY AND VALIDATION OF THE ACHILLES TENDON LENGTH MEASURED BY ULTRASONOGRAPHY

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SUMMARY

This study aims to evaluate the reliability of the Achilles tendon length (ATL) measurements using the EFOV US comparing to skin measures, commonly used. Furthermore, to validate extended field-of-view ultrasonography (EFOV US) measurements with a phantom. The sample consisted of 10 healthy subjects. The reliability of the ATL values showed a CV ranging from 1.93 to 3.03%; an ICC 0.94 to 0.98 and a TEM 0.32 to 0.49cm. These values demonstrate satisfaction reliability in the assessment of ATL. The mean values of the phantom length by EFOV US were 13.85±0.39cm and reliability was for TEM of 0.27cm and CV of 2.80%, showing that the EFOV US images were valid.

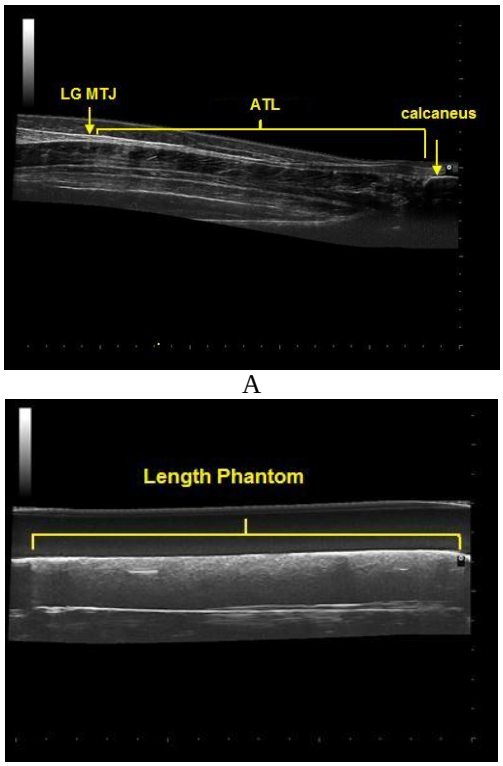
INTRODUCTION

Ultrasonography has gained importance as a reliable and relatively less expensive instrument than magnetic resonance tomograph to obtain images of muscle tendon unit. One disadvantage of the ultrasound is its limited field of view [1], as generally the US probe has a 40-mm length. The EFOV US technique uses an algorithm to automatically fit series of images and allows scanning of entire structures, such as fascicle length [2] and muscle cross-sectional area. Some studies report EFOV data for the vastus lateralis cross-sectional area [3] and Achilles tendon length [4]. The accuracy of EFOV US has been shown in some studies of reliability and validity with the use of phantoms [5,6]. The Achilles tendon (calcaneal) is characterized by a superficial long structure with variable thickness [7]. The assessment of the Achilles tendon size can provide important information about its mechanical properties, and its change after application of a stimulus, such as a stretching program [7]. Thus, this study aims to evaluate the reliability of the Achilles tendon length (ATL) measurements with the EFOV US and skin measurements, as well as to validate the EFOV US measurements with an ultrasonic phantom.

METHODS

The study included 10 subjects (25.50±2.01 years, 68.30±11.42kg and 1.72±0.10m). Conventional and EFOV images were obtained with an US equipment MyLab25® Gold (ESAOTE SpA, Italy), with a 40-mm transducer of 18 MHz. A Gel (Ultrex gel; Farmativa Industry and Trade Ltd., Rio de Janeiro, RJ, Brazil) was used for acoustic coupling on the skin surface. The ATL was measured in the right lower limb and the subjects were positioned in the prone position, with the feet relaxed and off the bed. Initially, a guideline connecting the midpoint of the lateral gastrocnemius, in the region of 30% proximal leg length (between the knee joint to the lateral malleolus), to the distal insertion point of the Achilles tendon was drawn on the skin. Both points were identified by ultrasound conventional images [8]. The transducer was positioned longitudinally along this guideline to locate and mark on the skin the lateral gastrocnemius muscle-tendon junction. The ATL was defined as the distance between the most distal insertion point tendon (calcaneus) and lateral gastrocnemius muscle-tendon junction (Fig. 1A). First, the ATL was tape-measured on the skin by using the points described above. Next, the ATL by EFOV US was acquired with the ultrasound probe positioned longitudinally on the skin, starting from the distal tendon insertion to lateral gastrocnemius muscle-tendon junction and following the guideline, at an approximately constant low speed. Three EFOV US images were acquired at each visit and the program ImageJ (version 1.42; National Institutes of Health, Bethesda, MD, USA) was used to measure the ATL. The reliability of ATL measurements by EFOV US was made between images of the same day and two different days, with a minimum interval of 72hr between them. The tape-measured on the skin was compared only between two days. EFOV US validation study was carried out with 60 images of a phantom of PVCP + 2% graphite material, with dimensions of 14-cm length, 3-cm width and 5-cm height. For the image EFOV US, the phantom length comprised the horizontal distance of its ends, also measured by ImageJ (Fig. 1B). The reliability of the ATL and phantom length measurements was evaluated by the coefficient of variation (CV),

intraclass correlation coefficient (ICC) and typical error of measurement (TEM). The normal distribution of data was verified by the Kolmogorov–Smirnov test. The t-test for dependent samples was used to assess the ATL measurements on the skin between days. The repeated measures ANOVA was used to analyze the ATL measurements by EFOV US between images and days as well as to compare the measurements made by skin and EFOV US. The adopted level of significance was $p<0.05$. Statistical analyses were performed with the program Prism5® (version 5.00 for Windows, GraphPad Software, San Diego California, USA).



A

B

Figure 1: A) EFOV US image Aquilles tendon length (ATL), from the lateral gastrocnemius myotendinous-junction (LG MTJ) to the distal insertion of the tendon (calcaneus). B) EFOV US image length phantom.

RESULTS AND DISCUSSION

No significant differences were found in the ATL measurements between the images and days by EFOV US and between days on the skin. Also, no significant differences were found between the ATL measurements by EFOV US and on the skin. The reliability of the ATL measurements between images and the days by EFOV US and on the skin is detailed in Table 1. The reliability of the ATL values show a CV ranging from 1.93 to 3.03%; an ICC 0.94 to 0.98 and a TEM 0.32 to 0.49cm. The mean values of the phantom length by EFOV US were 13.85±0.39cm and reliability was for TEM of 0.27cm and CV of 2.80%. The results of the ATL measurements by EFOV US and on the skin showed a high reliability, since the ICC values were above 0.9, CV below 10% and TEM was near zero [9]. Ying and Shing studied reliability by comparing the images of phantom by EFOV US and dual-image (split screen) technique and found a CCI of 0.998 and 0.946, for the EFOV US and dual-image, respectively [5]. In this study, we found values slightly superior for measures of ATL on the skin (Table 1), however indicates the use EFOV US because providing full view of the long regions, such as the Achilles tendon, in a single image. In relation to the EFOV US validation, the values of the length of the phantom (13.85±0.39cm) were similar to the original length (14cm). This means that the EFOV US is a valid method for the assessment dimensions of the Achilles tendon. Pang *et al.* [4] assessed the ATL by EFOV US and found for a sample (20-30 years) value of 11.16±2.93cm, which is less than the mean of this study (Table 1). These authors do not explain the exact region of the muscle-tendon junction marking which may explain the difference in results.

Table 1: Mean±SD values and reliability of the Aquilles tendon length (ATL) between images (i1, i2, i3) and days (d1 and d2), by EFOV US and skin. TEM: typical error of measurement, CV: coefficient of variation, ICC: intraclass correlation coefficient and CI: confidence interval.

		Mean±SD (cm)	TEM (cm)	CV (%)	ICC (95% CI)
ATL Skin	**d1**	22.54±2.36	0.46	2.30	0.977 (0.907-0.994) – p<0.001
	d2	21.82±2.83			
ATL EFOV US	**i1d1**	23.16±2.60	0.49	3.03	0.940 (0.760-0.985) - p<0.001
	i2d1	23.30±2.46			
	i3d1	23.62±2.93			
	i1d2	22.45±1.72	0.32	1.93	0.982 (0.928-0.996) - p<0.001
	i2d2	22.85±2.93			
	i3d2	21.88±1.72			
	d1	23.34±2.52	0.45	2.79	0.951 (0.801-0.988) - p<0.001
	d2	22.41±2.42			

CONCLUSIONS

EFOV US and measurements on the skin has a higher [9] reliability in the assessment of ATL. Furthermore, the EFOV US technique showed that is valid to length measurements.

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