Reliability of dynamic measurements of strain in the Achilles tendon using ultrasonographic speckle tracking

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INTRODUCTION

Biomechanical studies of Achilles tendon load and deformation have previously been performed using invasive methods such as ultra-sonomicrometry[1], optic fibers[2], fiber confocal laser scanning microscopes[3], and strain gauges[4]. Although differential dynamics in different segments in the Achilles tendon have been demonstrated[2,5], few studies have followed up this information. A new ultrasound (US) method based upon speckle tracking provides the possibility to study segmental strains in the tendon non-invasively. The purpose of this study was to evaluate the inter- and intraobserver reliability of the speckle tracking method and to describe the differential dynamics within the Achilles tendon.

METHODS

Ultrasound registrations (GE, Vivid7, Horten Norway, 12MHz linear probe) of the Achilles tendon of 12 healthy males were conducted. Two consecutive standardized passive dorsal-plantar flexion movements (range of motion (ROM): 20 degrees dorsal flexion to 15 degrees plantar flexion at an angular velocity of 30 degrees per second) were performed. ROM and angular velocity of the movement were controlled by an isokinetic dynamometer (Isomed 2000, D&R Ferstl GMbH, Germany). Image analysis of the US images of the ankle movements was performed post-process (EchoPac, Horten, Norway).

Technical considerations

The US loops were analyzed with a pattern recognition method (speckle tracking) where unique scatter patterns provided from different parts of the tendon are followed frame by frame. Practically, a visible rectangle (approx 0,5 x 1.5 cm) representing a region of interest (ROI) is arbitrarily placed within the image. The ROI consists of three measuring sections (kernels) visualized as colored points. The displacement of each kernel is calculated frame by frame during the ROM.

Reliability of the method

The image data were evaluated by one experienced (Test person 1 (TP1)) and one less experienced analyzer (Test person 1 (TP2)) in terms of a test-retest procedure. Initially, the ROI was manually placed in the center of first frame, perpendicular to the length of the tendon. The kernels were vertically located, equally distributed, in the posterior, center and anterior portion of the tendon. The displacement value of each kernel was noted in the frame representing the end of the ROM. Subsequently, a retest was performed where the ROI was replaced as close to the previous location as possible and the values at the end of the ROM were re-noted. Test and re-test were performed by both analyzers. The test-retest procedure was repeated 2 weeks later. Inter- and intra-class correlation analysis (ICC) was used as a statistical evaluation method.

RESULTS AND DISCUSSION

The result showed excellent agreement (ICC=0.915-0.999, measurement error < 2%).

Inter-reliability TP1 – TP2 Compact variable	ICC	Mean (Std) (mm) displacement
Surface portion. Test (retest)	0,925 (0,950)	8,37 (0,28)
Center portion. Test (retest)	0,932 (0,972)	9,37 (0,27)
Deep portion. Test (retest)	0,915 (0,974)	10,44 (0,22)
Intra-reliability Compact variable	**ICC TP 1**	**ICC TP 2**
Surface portion. Test - retest	0,984	0,973
Center portion. Test - retest	0,995	0,985
Deep portion. Test - retest	0,994	0,978

The table also presents data for the mean displacements of the three measured portions of the tendon. In all registrations the movement of the deep portion of the tendon was greater that of the superficial ones.

CONCLUSIONS

The dynamics of the Achilles tendon can be defined in terms of shear strain, i.e. shear between the fiber bundles in the tendon during movement. The ultrasound based speckle tracking method was highly reliable. It could become an important non-invasive diagnostic contribution in clinical studies of the Achilles tendon.

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