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ESTABLISHING A NEW METHOD FOR MEASURING THE ACHILLES TENDON LENGTH

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SUMMARY

The purpose of this study was to confirm the repeatability and validity of a new method for measuring the Achilles tendon length. The Achilles tendon length was measured as the sum of distances between the adjacent markers that were attached on the skin over the longitudinal path of the Achilles tendon, and between the most proximal marker over the tendon and the distal end of the medial gastrocnemius muscle belly (located from ultrasonogram). This measurement was done at three ankle joint angles (20° dorsiflexion, anatomical position, 20° plantar flexion). After confirming day-to-day repeatability of the new method, the Achilles tendon length measured by the new method was compared to that measured by magnetic resonance imaging (MRI) to confirm its validity. Day-to-day repeatability of the new method was sufficiently high (coefficient of variation: 1.9 ± 1.3% and intraclass correlation coefficient: 0.97). Furthermore, although the Achilles tendon length measured by the new method (183.0 ± 24.6 mm) was significantly shorter (p = 0.009) than that measured by the MRI method (185.3 ± 24.5 mm), the root mean square error was not large (4.1 mm) and the coefficient of determination was quite high (R^2 = 0.97) between the values determined by two methods. These results indicate that the new method is useful to measure the Achilles tendon length with high accuracy.

INTRODUCTION

Attempts have been made to examine how the Achilles tendon works during dynamic movements such as jumping, by determining its length change by a combination of direct measurement of fascicle length and estimation of the muscle-tendon unit length [1]. However, its validity is questionable because the length change of the Achilles tendon has not been directly measured.

Achilles tendon length can be directly measured *in vivo* by using magnetic resonance imaging (MRI) [2]. The MRI method is however applicable only in static conditions (e.g. at rest or isometric contraction conditions) because of its poor time resolution, and consequently, cannot be applied to dynamic conditions. Thus, the purpose of this study was to examine the repeatability and validity of a new method using video camera and ultrasonographic images to measure the Achilles tendon length with better time resolution.

METHODS

Achilles tendon length was measured at three ankle joint angles (20° dorsiflexion, anatomical position, 20° plantar flexion) in ten young adults. First, markers were attached on the skin over the longitudinal path of the Achilles tendon (Figure 1), and recorded by two video cameras to obtain three-dimensional coordinates of markers. To identify the location of the proximal end of the Achilles tendon that moves by ankle joint angle changes, an ultrasonographic probe was placed over the distal end of the medial gastrocnemius muscle belly, and the three-dimensional coordinate of the proximal end of the Achilles tendon was calculated by considering the location and orientation of the ultrasonographic probe with respect to the laboratory coordinate system. From the three-dimensional coordinates obtained by the ultrasonographic image and video cameras, the Achilles tendon length was calculated as the distance over the coordinates of markers and the proximal end.

Day-to-day repeatability of the new method was investigated. Furthermore, the Achilles tendon length measured by the above new method was compared to that measured by magnetic resonance imaging (MRI) to examine the validity. Correlation analysis for the changes in Achilles tendon length obtained from 20° dorsiflexion to 20° plantar flexion between the new and MRI methods was also conducted.

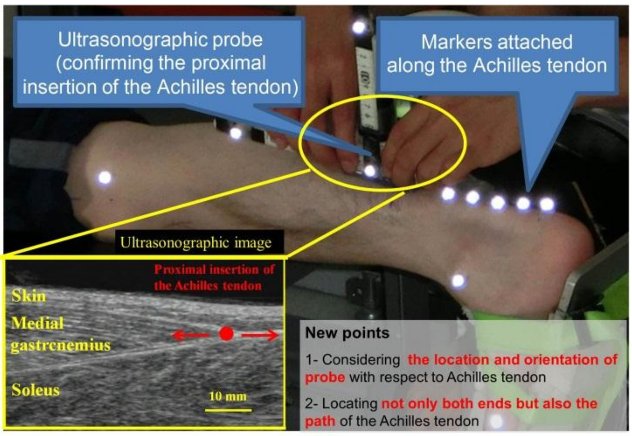

Figure 1: Experimental set up for the new method.

RESULTS AND DISCUSSION

Day-to-day repeatability of the new method was sufficiently high (coefficient of variation: 1.9 ± 1.3% and intraclass correlation coefficient: 0.97) (Figure 2). Although the Achilles tendon length measured by the new method (183.0 ± 24.6 mm) was significantly shorter (p = 0.009) than that measured by the MRI method (185.3 ± 24.5 mm), the root mean square error was not large (4.1 ± 2.9 mm) and the coefficient of determination was 0.97 (p < 0.001) between the values determined by two methods (Figure 3). In addition, Bland-Altman plot analysis indicated that there was no systematic error in the measurement of the Achilles tendon length between the new and MRI methods.

For the changes of Achilles tendon length, association between the values determined by the two methods was significant (p = 0.009), and the root mean square error was small (1.9 ± 1.3 mm), but the coefficient of determination was not high (R^2 = 0.60). This would be due to the fact that the length change in the Achilles tendon in our experimental setting was small.

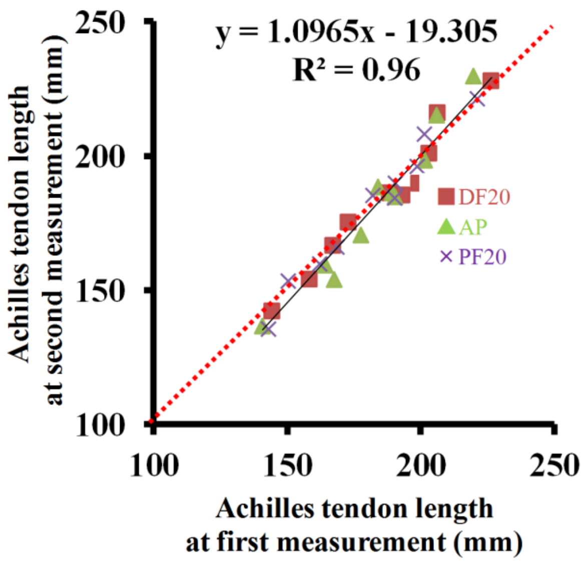

Figure 2: Day-to-day repeatability of the new method. DF20; 20° dorsiflexion, AP; anatomical position, PF20; 20° plantar flexion.

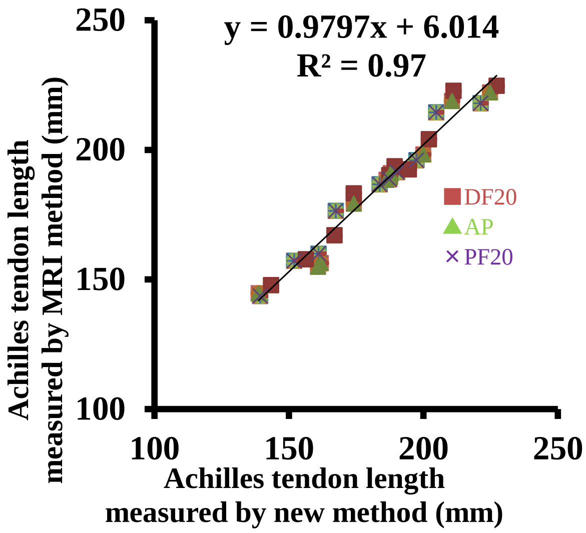

Figure 3: Achilles tendon length obtained by the new and MRI methods. DF20; 20° dorsiflexion, AP; anatomical position, PF20; 20° plantar flexion.

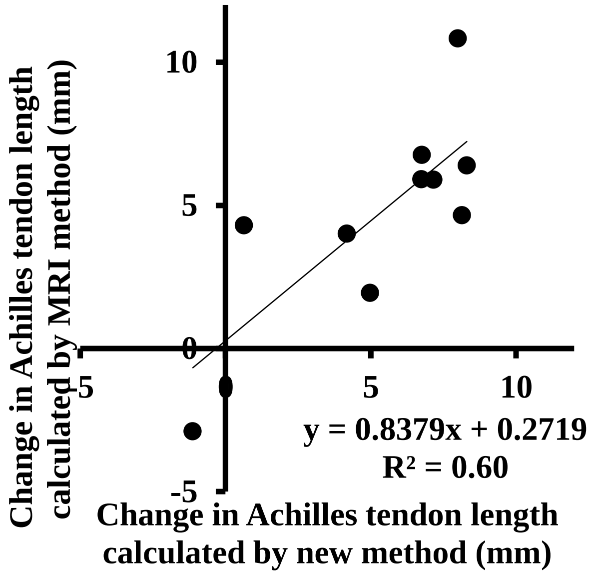

Figure 4: Changes in Achilles tendon length calculated by the new and MRI methods.

CONCLUSIONS

The present method for measuring the Achilles tendon length has sufficient repeatability and validity, and is potentially applicable under dynamic conditions because of its adequate time resolution.

ACKNOWLEDGEMENTS

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