ESTIMATION OF MYOTENDINOUS JUNCTION DISPLACEMENT USING A CROSS CORRELATION ALGORITHM FOR ULTRA-SOUND IMAGES

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INTRODUCTION

Ultrasound images have been used to investigate in vivo tendon properties as stress/strain relation, slackness and hysteresis, derived from myotendineous junction (MTJ) displacement (Muraoka, 2002, 2005; Muramatsu, 2001; Kubo, 2005). Although the medial gastrocnemius muscle (MG) MTJ structures are normally well visualized in US images, the quantitative approach often relies on identifying the same point in the beginning and in the end of the movement, which has potential methodological problems. Cross correlation algorithm for tracking an area of interest in US images was reported by Dilley for the median nerve mobilization (2001), and it was showed to be a suitable method for studies of the dynamics of soft tissues.

The aim of this study was to apply a cross correlation algorithm to calculate the displacement of the medial gastrocnemius MTJ during passive and active ankle movements.

METHODS

Images from the MG MTJ of five subjects (62.5 ± 11.62 kg, 168.4 ± 7.8 cm, 21.6 ± 3.84 years) were recorded in two conditions: passive and free active ankle movement from 80° (dorsiflexion) to 110° (plantarflexion). An ultrasound apparatus (EUB-405, Hitachi, Japão) with an electronic linear array probe of 7.5 MHz wave frequency was used to capture images, which were sampled with a rate of 5 frames per second and stored for analysis. A search algorithm was developed in LabView (National Instruments, Dallas, EUA) for estimating the MTJ displacement over the range of motion of the ankle.

The region of interest (ROI) in the first condition (the MTJ boundaries) was defined visually (Fig. 1a). For identifying its position within the frame corresponding to the end of movement, the ROI was cross-correlated iteratively with regions of same dimensions. The searching range changed laterally for each subject (≈200 pixels), and vertically (≈15 pixels), in order to assure MTJ identification. The indexes of the maximum value of the resultant correlation matrix (Fig 2) were multiplied by the spatial resolution (0.11 mm) for determining the MTJ displacement.

To provide some comparisons, a simplest method for the determination of MTJ, developed in LabView, was also applied. It consisted of visually tracing two lines, one over the deep aponeurosis and other over the superficial one. The crossing point P was referred to the MTJ and used to calculate the MTJ displacement, considering it the horizontal difference between the P points in the first and the last images.

Each procedure was repeated three times by the same examiner and the mean value was considered for comparison, using the non parametric Wilcoxon test for paired samples, with a significant level of p< 0.05.
RESULTS AND DISCUSSION

Table 1 presents the results for both methods.

<table>
<thead>
<tr>
<th>Cross-corr</th>
<th>P point</th>
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<tr>
<td>Pass(mm)</td>
<td>16.03 ± 4.25</td>
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<tr>
<td>Act (mm)</td>
<td>25.32 ± 3.11*</td>
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NS between methods
* p = 0.04 between passive and active

The correlations obtained from the method were 0.91 ± 0.07 for passive condition and 0.89 ± 0.05 for the active one.

Results from the literature related to passive MTJ displacement show values of approximately 22-24 mm for ankle angle amplitudes of about 45° (Muraoka, 2002; Kubo, 2005). Our results are lower than that likely because the range of motion adopted was of 30°. When analyzing the specific range used in our study, Kubo’s results (2005) were similar to ours (13mm).

The significant higher MTJ displacement during active conditions is reasonable as muscle contraction promotes an additional tension for tendon elongation. It was not found available data for GM free active conditions. The studies that used maximum voluntary isometric contractions with the ankle positioned at 90° report values around 10 mm (Muraoka, 2005; Kubo, 2005), which is acceptable as the displacement was limited to a specific ankle angle.

In relation to the method itself, some limitations have to be pointed out. Although already validated (Dilley, 2001), further validation of the algorithm using phantoms and anatomic pieces must be included, as well as its reproducibility with a higher N. These advances will attest the efficiency of the method in eliciting the calculation of displacements even when images are not sufficiently clear to visualize the MTJ.

CONCLUSIONS

The initial results show that cross correlation algorithm seems to be a promising method for studying passive and active elongation of tendinous tissues of human body in vivo.

REFERENCES