

ARE ULTRASOUND MEASURES OF MUSCLE THICKNESS REPRESENTATIVE OF MUSCLE ACTIVATION IN THE ABDOMINAL WALL?

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INTRODUCTION

Ultrasound (US) imaging is a valuable tool which, when applied appropriately, has the potential to provide significant insight into abdominal muscle contraction. Typically, changes in muscle thickness are obtained and interpreted. However, the link between ultrasound measures of muscle thickening and electromyographic (EMG) measures of activation is not clear. Abdominal bracing and hollowing are two widely used clinical training and rehabilitation exercises designed to re-educate faulty motor patterns and ensure sufficient spine stability. They have been shown to recruit the abdominal wall muscles in quite different manners, with abdominal hollowing focusing on the isolated recruitment of the transverse abdominis (TrA) and, to a lesser extent, the internal oblique (IO) [1], and abdominal bracing focusing on a more balanced recruitment across the entire torso musculature [2]. This study employed abdominal hollowing and bracing as two different means of recruiting the abdominal muscles, in order to compare interpretations of activation between US and EMG measures.

METHODS

Five healthy males, with no history of back pain or abdominal injury, volunteered for this study.

Ultrasound images were obtained in B-Mode (MicroMaxx, Sonosite Inc., Bothell, WA) with a 38-mm linear transducer (6-13 MHz). All images were taken with the probe at the level of the umbilicus on the left side of the body, with the lateral position adjusted to allow a clear view of the three layers of the abdominal wall musculature. The three probe orientations were: 1) horizontal along the transverse plane; 2) angled 35 degrees inferior-laterally (along the approximate line of the

IO fibres; 3) angled 60 degrees superior-laterally (along the approximate line of the EO fibres). The mid-point of the probe was positioned in the same location for each of the three orientations.

Participants were taught how to properly perform the abdominal brace and hollow maneuvers. All contractions were performed in a modified sit-kneel position, designed to keep the spine in a neutral posture. For the comparison of bracing and hollowing techniques, participants performed six abdominal hollow and six abdominal brace conditions, two at each of three orientations of the ultrasound probe.

Additionally, each participant then performed four isometric ramped torque contractions, two producing a net flexor muscle moment, and two producing a net extensor muscle moment. During these contractions ultrasound images were recorded solely with the probe oriented at the 35 degree angle (IO fibre line of action).

For all contractions, the thickness of the IO and external oblique (EO) was measured in both the relaxed state and at maximum contraction (Figure 1). The difference between these two measures was quantified, and divided by the rest thickness, to obtain a relative change in muscle thickness. Additionally, surface EMG of the IO and EO muscles was recorded on the right side of the body, throughout each contraction, and subsequently linear enveloped and normalized to the peak voltage obtained during standardized isometric contractions designed to elicit maximal activation from the muscles.

RESULTS AND DISCUSSION

Neither the IO nor EO muscle demonstrated any definitive relationship between ultrasound thickness

change measures and EMG activation measures during the abdominal bracing and hollowing contractions, and displayed even further discrepancies during the ramped flexor and extensor torque contractions. Figure 2 displays a scatterplot of ultrasound and EMG measures across all conditions and participants for the IO muscle.



Figure 1. Example of an ultrasound image captured for an abdominal brace trial during relaxation (A) and contraction (B). Arrowed lines indicate measures of the thickness of each muscle. The medial side of the body is to the right of the image.

CONCLUSIONS

It appears that there are very complex dynamics between abdominal wall muscles during different strategies of contraction. This is most likely due to the wall forming a mechanical composite with the fibres of one layer adhered transversely to an adjoining layer through an intervening sheet of connective tissue. This is akin to a “plywood-like” architecture. These connective tissues have the ability to transmit force between the layers, thus

providing a distinct mechanical linkage [3]. This composite nature of the abdominal wall muscles acts such that contraction in one layer will cause forces to be transmitted through the intervening connective tissue attachments to adjacent muscle layers, which can directly affect the amount of thickening that that muscle will experience. This severely limits the ability to assess muscle effort and/or force production from ultrasound measures of muscle thickness alone. Thus, it is not surprising that there is little relationship between activation (via EMG amplitude) and thickening (via US) measured in muscles of the abdominal wall.

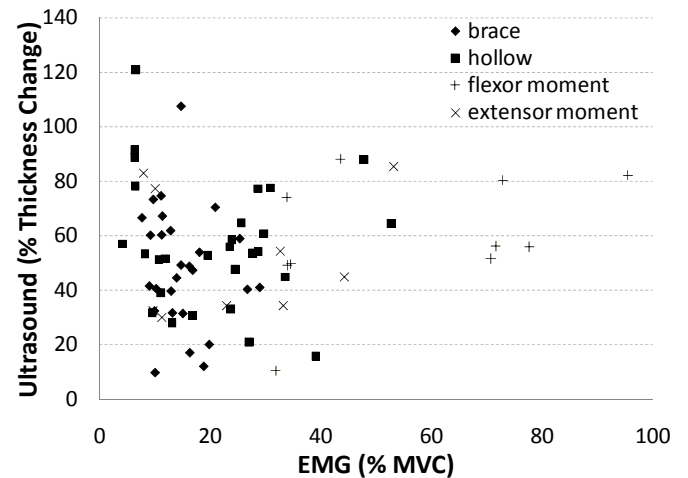


Figure 2. Scatterplot of internal oblique EMG muscle activation levels versus ultrasound muscle thickness percent changes during each of the abdominal brace, abdominal hollow, flexor moment and extensor moment contractions.

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