Rehabilitative ultrasound imaging for assessment and treatment of musculoskeletal conditions

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1. Background

Over the past decade, researchers have increasingly identified associations between neuromusculoskeletal disorders such as low back pain and underlying neuromuscular control deficits (Hodges and Moseley, 2003). However, reliable and valid non-invasive measurement strategies to assess neuromuscular control deficits that could be employed in a clinical setting have been scarce. Evidence for the use of ultrasound imaging as a strategy to assist with these patient populations is growing. The use of ultrasound technology for medical applications began in the 1950s and has proven to be an effective, safe, non-invasive, and relatively inexpensive tool for assessing morphologic characteristics and structural integrity of visceral organs and soft tissues. The use of ultrasound to assess muscle morphology and guide rehabilitation decision-making in physical therapy practice can be traced back to the late 1960s (Whittaker et al., 2007) and has been found to be reliable and valid (Koppenhaver et al., 2009) for specific muscles during particular movements. Over the last decade there has been rapid development of this technique with increased use both by clinicians and researchers.

2. Definition

The use of ultrasound imaging in the rehabilitation of neuromusculoskeletal disorders has been called rehabilitative ultrasound imaging (RUSI) and defined as “a procedure used by physical therapists to evaluate muscle and related soft tissue morphology and function during exercise and physical tasks. RUSI is used to assist in the application of therapeutic interventions aimed at improving neuromuscular function. This includes providing feedback to the patient and physical therapist to improve clinical outcomes. Additionally, RUSI is used in basic, applied, and clinical rehabilitative research to inform clinical practice” (Teyhen, 2006). Although b-mode ultrasound imaging is most commonly used for RUSI, other ultrasound technique such as m-mode, high-frame rate ultrasound imaging, and elastography may provide additional benefits in the assessment of tissue movement and deformation (Whittaker et al., 2007).

3. Clinical assessments

RUSI has been advocated to improve the understanding of the relationship between motor control and function, determine which patients may benefit from a specific exercise treatment approach, enhance treatment efficacy via augmented feedback, and document the benefits of specific exercise treatment approaches. For specific muscles and movements, RUSI has been found to be a valid measure to qualitatively and quantitatively assess muscle structure (morphology) and function (Koppenhaver et al., 2009). From an evaluation perspective, measurements of morphology include variables such as muscle length, thickness, width, cross-sectional area, and pennation angles (Whittaker et al., 2007). These measurements can be obtained at rest and during contraction and are commonly used as an indirect assessment of muscle activation.
In our research lab we have been able to determine that those with unilateral low back pain demonstrated a decrease change in muscular thickness of the transversus abdominis (TrA) muscle during the abdominal drawing-in maneuver and the active straight leg raise (Teyhen et al., 2009a,b). These measured differences may represent a diminished response of the TrA muscle during those tasks or an altered recruitment strategy. Qualitative assessment of muscular contractions can also provide valuable information; such as the impact of the muscular contraction on associated structures (i.e., fascia and/or organs such as the bladder). The ability to visualize these altered strategies helps to inform the clinician regarding underlying motor control deficits and may lead to improved clinical decision making.

One of the clinical utilizations of RUSI is related to prescribing interventions aimed at addressing these specific motor control impairments. For example, deficits in TrA and lumbar multifidus activation during motor control tasks such as the abdominal drawing-in maneuver and lumbar multifidus swell can be visually appreciated by the patient and the provider. Allowing the patient to actually “see” his or her muscle impairment may result in better patient understanding and improved commitment to their prescribed exercise treatment. Additionally, RUSI can be used as a biofeedback device during specific exercise performance which has been shown to result in improved performance and better retention (Henry and Teyhen, 2007). RUSI can also assist the development of individualized exercise prescriptions by allowing the clinician to watch the changes in muscular thickness during exercise performance to ensure the muscle targeted by the clinician is effectively recruited by the patient. Visual confirmation of proper performance of the prescribed exercises can lead to more precise exercise prescriptions, improved exercise progressions, and hopefully enhanced patient outcomes. Finally, RUSI can also be used to provide feedback regarding the impact of other interventions such as manipulation or dry-needling on the neuromotor control system. For example, RUSI could be utilized to measure changes pre- and post manipulation to assess the impact of manipulation on resting and contracted muscle thickness.

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References


