

Quantifiable Soft Tissue Manipulation (QSTM): A Requisite to Advance the Field of Manual Therapy

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Abstract

Quantifiable soft tissue manipulation (QSTM) that can characterize the motion and forces delivered during soft tissue examination and treatment of common musculoskeletal (MS) conditions in a real-time and clinically applicable manner is needed to achieve optimal outcomes. Soft tissue manipulation (STM), e.g. massage, is a type of mechanotherapy that has been used with benefit frequently by clinicians worldwide since ancient times. Instrument-assisted STM (IASTM) is a type of STM that uses rigid devices to assess and treat soft tissue abnormalities in a targeted and precise manner. Remarkably, however, the forces delivered during STM approaches have not been adequately quantified. Unlike other mechano-therapeutic approaches, e.g. ultrasound, traction, exercise, electrical stimulation, current manual therapy practice relies mostly on subjective description of STM evaluation findings and treatment parameters. This makes documentation, analysis, comparison, progression and optimization of this non-invasive intervention difficult to establish and validate. It is the authors' strong opinion that there is need for QSTM to objectively measure, characterize and record the 3-dimensional (3D) forces and motion trajectories of STM evaluation and intervention. Innovative technology aimed to help address this void in research, educational and clinical practice has been developed by our research team and introduced in this article. The QSTM system has two components: an electronic, handheld device (applicator) for 3D characterization of force and a computer with software for data acquisition and analysis. Preliminary testing has demonstrated that the QSTM prototype can provide accurate sensed values and good intra-, inter-rater reliability. Device revisions are in progress and further testing is planned in animals and humans. QSTM is an essential technology needed for the standardization, comparison and optimization of STM therapies and a requisite to advance the field of manual therapy.

Keywords: Soft tissue manipulation; Soft tissue mobilization; Manual therapy; Massage; Physical therapy; Rehabilitation

Introduction

Musculoskeletal (MS) conditions are frequently treated by clinicians, with low back pain (LBP) being the leading cause of disability in the United States [1,2]. Soft tissue manipulation (STM), e.g. massage, is a type of manual therapy often used to address MS conditions and a variety of other disorders [3,4]. Instrument-assisted STM (IASTM) is a type of STM that uses rigid devices with demonstrated benefits [5-14]. Although STM is an ancient intervention used worldwide with known positive effects, much remains to be understood about its mechanisms and optimal outcomes [3,15-17]. In essence, STM is a form of mechanotherapy that imparts a mechanical stimulus to the tissue [18]. Since cells are mechanosensitive, STM possesses the potential to directly influence cell and tissue structure and function [19,20]. Although STM dose-frequency studies are available, the literature is void of replicable clinically-applicable dose-pressure studies; in large part due to the lack of adequate quantification methods for STM motion and force in patients [21-24]. Attempts to quantify STM forces have been made in animals and in humans, but none of these methods are applicable for realistic, real-time clinical use [24-32]. This poses a significant gap in the current understanding of the underlying biological mechanisms of STM and markedly limits the ability (1) to document, replicate and reproduce STM applications, (2) to monitor, adjust, and advance the STM treatment methodology; and (3) to establish optimal STM dosing protocols specific to different clinical conditions. Other therapeutic modalities, e.g. ultrasound, electrical stimulation, traction, etc. have parameters that can be monitored objectively, but characterization of STM evaluation and treatment is mostly relegated to the use of subjective qualifiers. Thus, it is the opinion of the authors that

quantifiable soft tissue manipulation (QSTM) needs to become a new standard of patient care in soft tissue manipulation and is requisite to advance the field of manual therapy.

QSTM is an advancement in current STM practice and has important implications in research, clinical practice and education/training. It cannot replace the use of manual contact, nor serve as a substitute for the complexity of clinician's judgment in sensing soft tissue quality, monitoring patient response and adjusting treatment parameters. However, QSTM rehabilitation technology would significantly elevate the objectivity in soft tissue evaluation and treatment. QSTM is needed to complete dose-pressure response studies in a clinically relevant manner, to establish optimal dose parameters (e.g. pressure, rate, angle of force, stroke duration reflecting STM intensity and depth) and force patterns leading to optimal outcomes for various musculoskeletal disorders at different stages of healing and repair. For example, depending on the condition, or stage of tissue healing, it needs to be determined whether light force or more aggressive STM force is most indicated. Patterns of recovery can also be established in

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that some conditions may require diminishing or escalating STM force across treatment sessions. The implications of QSTM in research seem apparent; however, the availability of QSTM for clinical use is essential for applying research findings in evidence-based practice. QSTM is needed to foster consistency and replication within and between therapists and across sessions; comparison of protocols and resultant outcomes; provide objective measures demonstrating progression or regression in soft tissue quality; document and modify treatment parameters; and provide objective feedback to the patient, all of which will catalyze a paradigm shift in soft tissue treatment. Importantly, QSTM will facilitate education and training in manual therapy by providing objective feedback to the learner. In response to the need for more objective characterization of STM evaluation and intervention, our research team has designed, fabricated and initially evaluated a STM mechano-therapeutic motion and force sensing device system prototype that provides real-time quantification of motion and force.

Materials and Methods

An electronic, handheld quantifiable soft tissue manipulation (QSTM™) device system was developed based on established criteria (US Patent Filed: PCT/US2016/052164) [33,34]. It needed to be user-friendly, durable, water-proof, and provide information on treatment parameters (e.g. stroke force, angle, frequency, duration) in real-time, in a clinically relevant and applicable manner. The system includes an ergonomically designed IASTM device (applicator) (Figure 1) that uses modern sensor technologies, as well as state of the art computing and communication technologies to revolutionize the practice of STM. The QSTM™ system also consists of a data acquisition system and Windows/Android/OSX compatible computer technology. The sensed motion and force data are streamed to the computer that performs sensor fusion and displays the force, orientation angles, and manipulation motion pattern at skin-tool interface in real time (Figure 2). The QSTM system can also detect the reaction force disturbance caused by the tissue restrictions and irregularities assisting examination of soft tissue quality.

Results

Preliminary testing was conducted to test the accuracy of the device compared to an external reference scale for maximal compression with the device at 90° with respect to the scale plate, and then again at 45° with respect to the scale plate, and to initially evaluate the inter-rater and intra-rater reliability of the QSTM™ device force measurements between two novice clinicians with compressions of the device held at 90° against the force plate. With the QSTM device held at a 90° angle device to the plate, the average force was 21.88 (4.9 lbs) ± 4.18N (0.94 lbs), range 15.38 (3.46 lbs) -30.11N (6.77 lbs) (n=60 trials), and the accuracy of the device was excellent for determining compressive force, within 1N, as compared to the external device (at 90°, $\rho=0.92$; at 45°, $\rho=0.97$). Intra-rater reliability was better for examiner B than A (n=15 trials) (Examiner A, ICC=0.220, $p=0.324$, 95% CI=1.323-

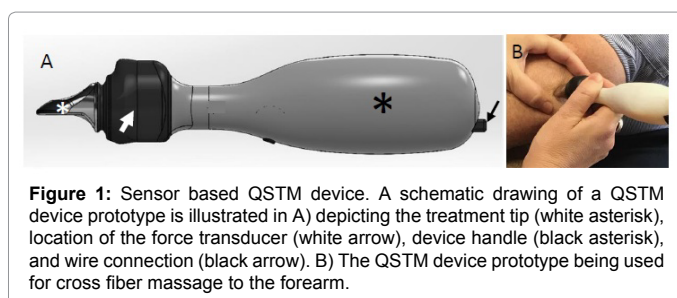


Figure 1: Sensor based QSTM device. A schematic drawing of a QSTM device prototype is illustrated in A) depicting the treatment tip (white asterisk), location of the force transducer (white arrow), device handle (black asterisk), and wire connection (black arrow). B) The QSTM device prototype being used for cross fiber massage to the forearm.

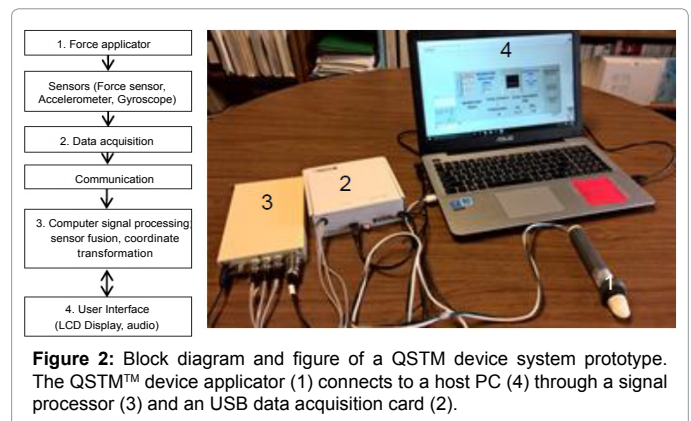


Figure 2: Block diagram and figure of a QSTM device system prototype. The QSTM™ device applicator (1) connects to a host PC (4) through a signal processor (3) and an USB data acquisition card (2).

0.738; Examiner B (ICC=0.619, $p=0.041$, 95% CI=-0.136-0.872), and inter-rater reliability was good (Cronbach's $\alpha=0.653$, ICC=0.653, $p=0.003$, 95% CI=0.271-0.835). Based on initial findings, device revisions are in progress. Future studies will further validate the system in animals and humans.

Conclusion

QSTM is essential to advance the field of manual therapy to the level of a mechanotherapy prescription. Novel QSTM technology will permit STM protocols to be better established, validated, standardized and compared for a wide variety of diagnoses across the life span.

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