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FASCIA SCIENCE AND CLINICAL APPLICATIONS: CONNECTIVE TISSUE STUDY

Effect of MELT method on thoracolumbar connective tissue: The full study

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Summary Altered connective tissue structure has been identified in adults with chronic low back pain (LBP). A self-care treatment for managing LBP is the MELT method. The MELT method is a hands-off, self-treatment that is said to alleviate chronic pain, release tension and restore mobility, utilizing specialized soft treatments balls, soft body roller and techniques mimicking manual therapy. The objective of this study was to determine whether thickness of thoracolumbar connective tissue and biomechanical and viscoelastic properties of myofascial tissue in the low back region change in subjects with chronic LBP as a result of MELT. This study was designed using a quasi experimental pre—post- design that analyzed data from subjects who performed MELT.

Using ultrasound imaging and an algorithm developed in MATLAB, thickness of thoracolumbar connective tissue was analyzed in 22 subjects. A hand-held digital palpation device, called the MyotonPRO, was used to assess biomechanical properties such as stiffness, elasticity, tone and mechanical stress relaxation time of the thoracolumbar myofascial tissue. A forward bending test assessing flexibility and pain scale was added to see if MELT affected subjects with chronic LBP.

A significant decrease in connective tissue thickness and pain was observed in participants. Significant increase in flexibility was also recorded.

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Introduction

Background information

Low back pain (LBP) is the leading cause of work-related disabilities and increase in health costs around the world (De Luca, 1997; Williams et al., 1998). It has been estimated that approximately 31 million adults in the U.S. suffer from LBP (Jensen et al., 1994). Chronic LBP is defined as pain that lasts for three or more months (Wheeler and Berman, 2014).

An abnormal thoracolumbar connective tissue structure with increased thickness and disorganization of connective tissue layers have been reported in chronic and recurrent LBP subjects by Langevin et al. (2009). Langevin and Sherman (2007) have suggested that alternative treatments such as massage, chiropractic manipulation, movement therapies and acupuncture needle manipulation may be effective in connective tissue remodeling that could reduce LBP. These therapies work by changing the biomechanical properties of affected connective tissue such as stiffness, viscoelasticity and density (Smith, 2005).

Myofascial release (MFR) is another such alternative treatment that is said to assist in restoring connective tissue structure. This technique causes a stretch in affected connective tissue after application of pressure on the tissue barrier for about 120 s (Barnes, 1997). As a result, the tissue exhibits histological length changes that are felt as a release. This release is followed up into other affected tissue barriers. After a few releases, the tissue is said to become softer with restored mobility. A similar treatment, fascial unwinding, uses the mechanism of touch and stretch on to connective tissue to relax the tissue and activate the parasympathetic nervous system (Minasny, 2009). These manual fascial techniques (MFTs) served as basis for the creation of the MELT method.

Like other MFTs, MELT is proposed to release collagen fibers that causes their reorganization in the underlying substance, whose viscosity changes permit tissue remodeling (Cantu and Grodin, 2001). This change in viscosity allows an increase in hyaluronic acid production, along with flow and drainage of inflammatory mediators and metabolic wastes (Schultz and Feitis, 1996). Till date, no scientific research study has examined whether MELT reduces chronic pain by the aforementioned mechanisms or if there is connective tissue remodeling as a result of treatment.

A method of visualizing whether MELT and other treatments are effective in changing the structure of connective tissue would be done by using an ultrasound. Multiple studies have shown that ultrasound can be used to assess connective tissue structure in a quantitative manner. Langevin and Yandow (2002) performed a B-scan visualization of anatomical details of connective tissue while inserting an acupuncture needle in human arm. Langevin et al. (2009) also undertook measurements of connective tissue thickness by converting ultrasound raw radio frequency data echoes into B-scan images. Chaudhry et al. (2008) devised a three-dimensional mathematical model that identified the relationship between mechanical forces and deformation of connective tissue under manual therapy. However, deformation is difficult to evaluate without the use of elastography, a technology that utilizes echo reflections to measure the mechanical response or mechanical property of tissues under stress. An alternative to elastography is the use of a hand-held myometer that measures state of tension, biomechanical and viscoelastic properties of myofascial tissue.

Myometric devices have become popular in research studies because of its non-invasiveness, portability and easy to use qualities. Several studies have shown the reliability of the myometer for biomechanical and viscoelastic properties. Lam et al. (2015) performed stiffness, elasticity and state of tension measurements of eleven muscle sites. They used intra-class correlation coefficient to observe reliability of measurements within the same day and between two consecutive days and found that the within-day measurements were more reliable than inter-day measurements. Zinder and Padua (2011) measured myometric stiffness of rectus femoral muscles after subjects were exposed to maximum voluntary isometric contraction of 10%, 20%, 30%, 40% and 50%. They found that stiffness measurements were consistent with previous literature and were reliable with the use of intra-class correlation coefficients. Hence, a myometer along with B-mode ultrasound imaging was used in this study for observing structural change and biomechanical change in myofascial tissue.

Objective

This study is the full length paper of the abstract presented at the Fourth International Fascia Research Congress, with results from 7 subjects before and immediately after MELT (Sanjana et al., 2015). Langevin et al. (2009) reported that chronic and recurrent LBP human subjects had a 25% higher than average connective tissue thickness. This study was used to find out if the increased connective tissue of LBP subjects would decrease as a result of MELT. The reduction in thickness was hypothesized to occur due to increased fluid (hyaluronic acid) produced in tissues, suggesting rehydration or due to increased stretching caused by elongation of connective tissue in the lateral direction. Furthermore, if connective tissue remodeling occurred as a result of MELT, then the biomechanical and viscoelastic properties of the tissue would change. Therefore, investigation of a decrease in stiffness and state of tension and increase in elasticity and mechanical stress relaxation time of myofascial tissue, due to MELT was conducted. This change would typically be shown by taking connective tissue thickness and myofascial properties' measurements before and immediately after MELT treatment and after a long-term, 4 week of MELT treatment.

Methods

Human subject recruitment and recruitment criteria

The study was approved by New Jersey Institute of Technology Institutional Review Board (HHS FWA 00003246). The recruitment of 22 subjects, aged 25–65 with non-specific chronic LBP, occurred via online, phone and in-person advertisements in doctor's offices, pain clinics and associated locations in the New York City area. All subjects provided informed consent. Inclusion criteria consisted of subjects having chronic pain for at least 12 months and pain index of 2 (out of 10). Exclusion criteria of subjects were: BMI over 28.5, major structural spinal deformity, severe back or low extremity injury or surgery, ankylosing spondylitis or rheumatoid arthritis, neurological disorders, intake of spinal corticosteroid injections, pregnancy and less than 8 months postpartum.

Ultrasound imaging

Images were taken with Terason T3000 (Terason, Burlington, MA). Baseline measures were taken from the subjects' back, at a location where the ultrasound transducer was centered at 2 cm lateral to the middle of L2-3 interspinous ligament on left and right sides, while they lay on a prone position. This location was selected according to the prior study of Langevin et al. (2009) in which they found that at the L2-3 level, the fascia planes were most parallel to the skin.

Thickness of TLF was calculated after converting the raw ultrasound data in MATLAB (The MathWorks, Natick, MA) by a program developed and used by Langevin et al. (2009). The program identifies a 1 cm region centered at the middle of the image, located between the deep border of the dermis and superficial border of the muscle. Three areas within the region are prompted to be selected, the skin depth, fascia band top and the muscle depth. After that the program calculates the thickness of the subcutaneous, perimuscular and combined zones. Perimuscular zone thickness is the thickness between the more echogenic layered structure closest to the muscle separated by the nearest superficial echogenic layer by more than 2 mm (Langevin et al., 2009). Subcutaneous zone thickness is measured between the dermis and superficial border of the perimuscular zone (Langevin et al., 2009). Combined subcutaneous and perimuscular zone thickness is the thickness between the deep border of the dermis and superficial border of the muscle (Langevin et al., 2009).

MyotonPRO

A hand-held digital palpation device (myometer), called the MyotonPRO (Myoton AS, Tallinn, Estonia), was used to measure the biomechanical and viscoelastic properties of the myofascial tissue at the low back. The properties measured were tone (oscillation frequency in Hz), elasticity (logarithmic decrement with no units), stiffness (N/m) and mechanical stress relaxation time (ms). Tone represents the state of tension of tissue in its passive state without any voluntary contraction, elasticity represents the ability of tissue to restore back to its original shape after the removal of an external force, stiffness represents the resistance of tissue to a contraction or external force, and mechanical stress relaxation time represents the time of the tissue to restore its original shape after a contraction or external force is removed (Bailey et al., 2013).

The Myoton was placed on low back areas, while the participant lay in a prone position, perpendicular to the target myofascial tissue, which was in a relaxed state. The testing end of the device, which is a probe of 3 mm diameter, applies a constant pre-pressure (0.18 N) on the skin surface that causes the tissue beneath it to be compressed (Lam et al., 2015). The pre-pressure applied by the probe is felt on the subject's skin as a small tap. A mechanical impulse (0.40 N, 15 ms) is released by the Myoton on the compressed subcutaneous tissue. The tissue responds back to the impulse by a damped oscillation that is recorded by the accelerometer in the Myoton. The damped oscillation from the measured tissue causes co-oscillation of the tissue being measured, subcutaneous tissue layers above the tissue being measured, the probe, measurement mechanism and the accelerometer attached to the measurement mechanism. The oscillation signal is processed by the Myoton to give values of the biomechanical properties mentioned above (Lam et al., 2015). The probe taps the skin 5 times (i.e. subcutaneous tissue is pre-compressed 5 times producing 5 mechanical impulses and therefore 5 damped oscillations) and the average value of the results are given by the Myoton. In order to test whether the Myoton results are consistent, this procedure was done three times and an average value out of the three was calculated.

The areas of low back used in this study were 3 cm lateral to the spinous process of L1 that targets the fascia above the paravertebral muscles, 5 cm lateral to the spinous process of L3 that targets the fascia above the quadratus lumborum muscle and the area below the 12th rib that targets the fascia over the latissimus dorsi (Ercole et al., 2010). These particular areas were chosen because previous investigators have found changes in pain in LBP patients after using the Fascial Manipulation techniques (Ercole et al., 2010).

Flexibility test and pain scale

In order to assess flexibility, participants were asked to stand on a step tool, bend forward and reach down as much as they could without bending their knees. A measuring tape was used to calculate the distance from the floor to the tip of the participants' fingers to measure their forward flexion. The height of the tool was taken into account during measurement.

A Numerical Pain Rating Scale (NPRS) was used to assess intensity of pain on a scale of 0–10, with 0 being no pain and 10 being most severe pain, and how it affected their ability to lead their daily life activities.

Statistical methods

Paired t-test was used to compare participants' connective tissue thickness, flexibility tests and all biomechanical properties measured by the Myoton. Significance level was set at $\alpha = 0.05$. Microsoft Excel 2013 (Microsoft, Redmond, WA) was used to perform the t-tests and correlation scatter plots to identify any connection between thickness, pain or flexibility. Wilcoxon signed-rank test was used to compare the pain scale in participants.

MELT protocol and testing procedures

MELT (formerly known as Myofascial Energetic Length Technique) is a hands-off, self-treatment that aims to release tension, decrease pain and restore mobility for LBP patients. Specialized soft treatment balls, soft body roller and self-care techniques that mimic manual therapy are used to reduce chronic pain by rehydrating connective tissue and rebalancing the regulators of the nervous system (Hitzmann, 2013). The MELT Method was created by Sue Hitzmann, who is a nationally recognized educator, manual therapist, exercise physiologist, and NY Times Bestselling author. She created MELT in 2004 and has been empowering her clients to teach themselves hands-off bodywork to actively eliminate chronic pain.

All participants had to come in for two days of testing. The first day consisted of ultrasound, Myoton, flexibility and pain scale recording before MELT. Participants did MELT self-treatment, while watching a 30 min video and rested for 5 min after which they were re-measured with the ultrasound and Myoton and their flexibility and pain scale were recorded again. During that 30 min period, subjects performed four sequences that are outlined and referenced below, using MELT treatment balls and body roller. A certified MELT instructor, who handles program development for the MELT method and has 3 years of experience teaching MELT to the public, was in the room to assist participants with the sequences. After their treatment, participants were given all the required MELT tools and a 4-week MELT plan each week. The same MELT method instructor was in touch with each participant, weekly via email and phone to check up on their progress and to answer any questions they had. The participants came back after 4 weeks and re-measured in the same manner as their initial measurement. On that visit, they were given a questionnaire to assess if they had been following the MELT plan accordingly.

The 4-week MELT plan for MELT group participants were explained in detail in DVDs and the MELT method book provided to them. The plan consisted of:

a) Mini Soft Ball Foot Treatment (Hitzmann, 2013, pp. 159–164) and Rebalance Sequence (Hitzmann, 2013, pp. 150–159) for 4 times in the first week taking 1 day off between the days they MELT
b) First week's treatment with the addition of Upper and Lower Body Compression (Hitzmann, 2013, pp. 232–239) for a minimum of 4 times a day in the second week
c) First two weeks' treatment with the addition of Lower Body Length and Low Back Release Sequence (Hitzmann, 2013, pp. 241–244) for a minimum of 5 times a day varying the order of sequences each time they MELT in the third week
d) All the previous weeks' sequences in a specific order in the fourth week

Results

Ultrasound imaging

Results presented are for the perimuscular zone, the subcutaneous zone and the combined subcutaneous and perimuscular zone thickness of the connective tissue before and after (immediately after and 4 weeks after) MELT treatment.

Perimuscular zone thickness

A significant decrease from 0.036 cm to 0.026 cm was observed in perimuscular zone connective tissue thickness on left ($p = 0.004$) and from 0.034 cm to 0.025 cm on right ($p = 0.026$) sides of L2 paraspinal muscles immediately after MELT (Fig. 1). A significant decrease in perimuscular zone thickness of same degree was also seen after subjects were exposed to 4 weeks of MELT on both left ($p = 0.004$) and right ($p = 0.026$) sides of L2 paraspinal muscles (Fig. 1).

Subcutaneous zone thickness

A significant change from 0.832 cm to 0.762 cm was seen in subcutaneous zone connective tissue thickness after 4 weeks of MELT on the left ($p = 0.026$) side of the L2 paraspinal muscles. Other changes were not significant (Fig. 2).

Combined subcutaneous and perimuscular zone thickness

A significant decrease from 0.868 cm to 0.810 cm was observed in thickness of combined subcutaneous and perimuscular zone connective tissue on left ($p = 0.043$) and from 0.848 cm to 0.796 cm on right ($p = 0.026$) sides of L2 paraspinal muscles immediately post MELT (Fig. 3). There was a significant decrease from 0.868 cm to 0.788 cm on the left side ($p = 0.013$) but not on the right side ($p = 0.144$) 4 weeks after MELT (Fig. 3).

MyotonPRO

Only one area on the left side showed significant change for mechanical stress relaxation time values. The remaining properties, stiffness, elasticity and tone were also measured for participants in the three areas mentioned above. No significant changes were observed in either properties (not pictured).

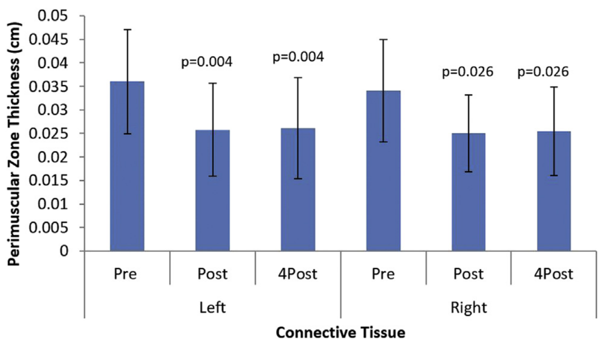

Figure 1 Perimuscular zone thickness of connective tissue pre-MELT, immediately after MELT and 4 weeks post MELT on left and right sides of L2 paraspinal muscles. **Pre** = before MELT; **Post** = immediately after MELT; **4Post** = 4 weeks after MELT.

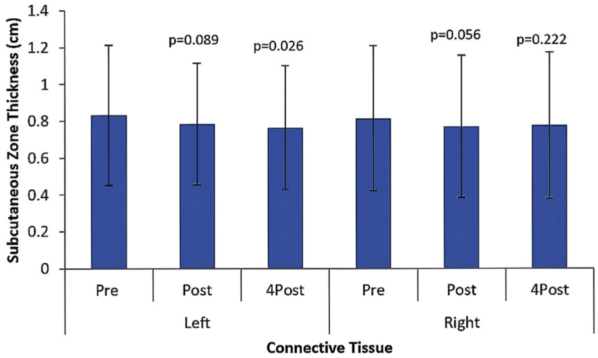

Figure 2 Subcutaneous zone thickness of connective tissue pre-MELT, immediately after MELT and 4 weeks post MELT on left and right sides of L2 paraspinal muscles.

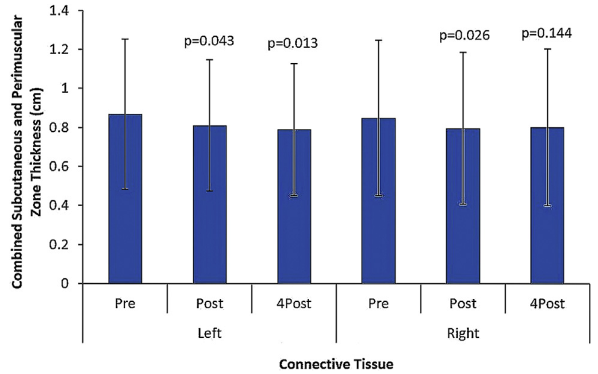

Figure 3 Combined subcutaneous and perimuscular zone thickness of connective tissue pre-MELT, immediately after MELT and 4 weeks post MELT on left and right sides of L2 paraspinal muscles.

Mechanical stress relaxation time

A significant increase in mechanical stress relaxation time was seen on the left side of the region below the 12th rib in treatment participants immediately after from 17 ms to 18.3 ms ($p = 0.004$) and 4 weeks after from 17 ms to 18.2 ms ($p = 0.048$) MELT (Fig. 4). The change in right side in these treatment participants was not statistically significant (Fig. 4).

Flexibility test

Flexibility tests were conducted by participants performing trunk flexion reaching down to the floor. Flexibility increased significantly in participants from -17.64 ± 7.2 inches to -16.05 ± 6.5 inches ($p = 0.012$) immediately after MELT. Flexibility also increased significantly from -17.64 ± 7.2 inches to -13.41 ± 4.5 inches ($p = 0.002$) after 4 weeks of MELT.

Pain scale

Pain scale of participants in both treatment and control groups were determined by Numerical Pain Rating Scale.

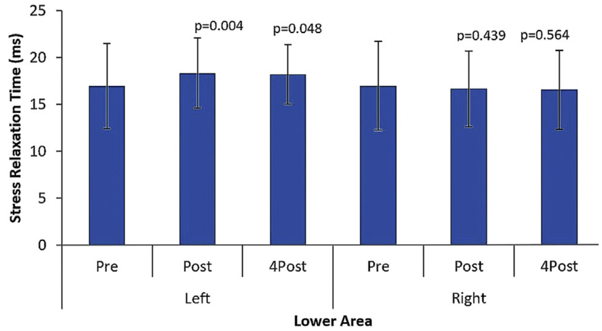

Figure 4 Mechanical stress relaxation time in before, immediately after and 4 weeks after MELT in the region below the 12th rib (lower area) on left and right side.

There was a significant reduction of pain in treatment participants from 4.4 (range 2–8) to 2.5 (range 1–6) after initial MELT treatment ($p = 0.00014$, Wilcoxon Signed Rank Test). There was also a significant reduction of pain in the same group from 4.4 (range 2–8) to 3.0 (range 0–7) after 4 weeks of MELT treatment ($p = 0.0124$, Wilcoxon Signed Rank Test).

Discussion

The goal of this study was to demonstrate whether thoracolumbar connective tissue and biomechanical and viscoelastic properties of myofascia in the low back region of chronic LBP subjects change as a result of MELT. Results from ultrasound imaging showed that the perimuscular zone thickness of connective tissue decreased 26.4% on the left side and 27.8% on the right side of L2 paraspinal muscles in participants. This decrease was significant ($p < 0.05$) (Fig. 1) and can be visualized in Fig. 5.

There was barely any significant change in subcutaneous zone connective tissue thickness. For combined subcutaneous and perimuscular zone connective tissue thickness, about 6% decrease was seen immediately after MELT on left and right sides and 9.21% and 5.54% decrease was seen 4 weeks after MELT on left and right sides respectively. All changes were significant ($p < 0.05$) except for the post 4-week decrease on the right side. Although there were no significant decreases in subcutaneous zone thickness, the perimuscular zone thickness decrease was so profound that its change transmitted into the combined subcutaneous and perimuscular zone thickness bringing it down by a significant level.

After averaging for both left and right sides of perimuscular zone connective tissue thickness, the decrease came about to be 27%. This percentage decrease coincided with Langevin et al. (2009) study where they showed that chronic LBP patients had a 25% increased perimuscular zone thickness.

With this observation, it cannot be said that, connective tissue was being remodeled as a result of MELT, since remodeling of tissues cannot occur so fast and can take from several weeks to months for tissues affected by chronic pain (Langevin et al., 2009). Rehydration of

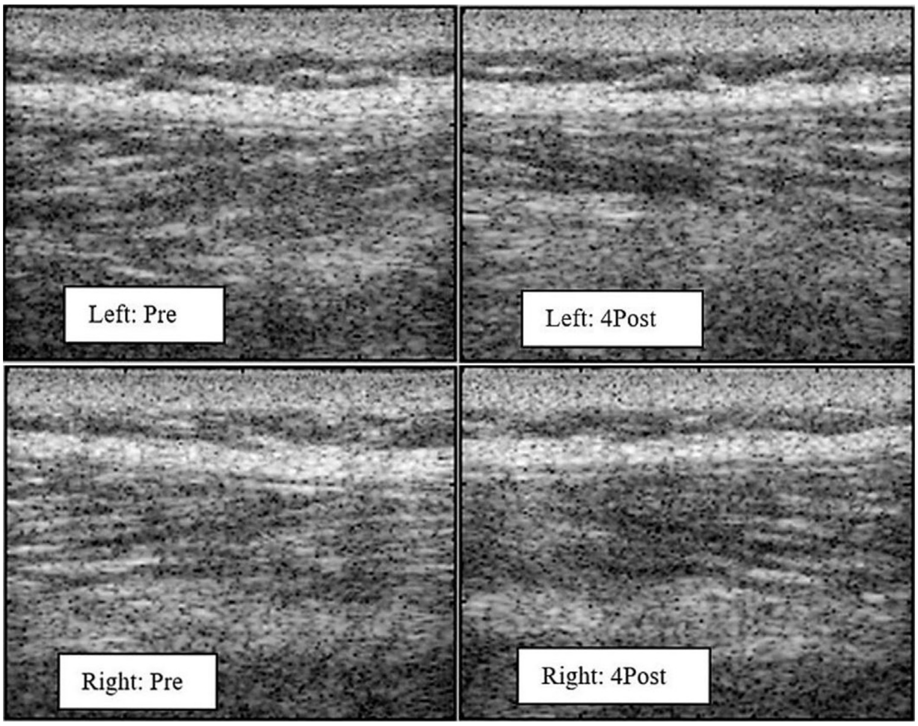

Figure 5 Ultrasound images showing connective tissue thickness change. Image on the left shows thickness before application of MELT. Image on the right shows thickness change 4 weeks after MELT.

connective tissue due to increased hyaluronic acid production is also unlikely as this would increase the volume of the tissue and cause swelling, as opposed to the observed reduction of thickness. It was also not in the scope of this study to measure amount of hyaluronic acid produced if any. This could be a future aspect to look into if follow up studies are conducted.

A more plausible reason for the decrease in connective tissue thickness can be attributed to the stretch of tissue in the lateral direction. Manual fascial techniques, as mentioned in the "Background Information" section, contribute to stretching of tissue, as a result of tension, where touch or pressure is applied. This causes a permanent deformation of tissue, making it elongated in the lateral direction. Connective tissue mobility is changed by breaking the links between adjacent bundles of collagen fibers in tissue. The term "microfailure", is used to describe the breakage of individual collagen fibers and fiber bundles when placed under tension (Threlkeld, 1992). If the force is removed, then the broken fibers do not add to tissue recoiling. Some fibers remain intact and do not break, causing tissue recoiling. The resulting connective tissue structure reaches a new length that exhibits the balance between intact fibers that were elastically recoiled and the breakage of fibers due to elongation.

In this study, only the thickness i.e. the height in transverse direction was studied. Due to limitation in measuring the elongation, lateral strain could not be obtained. Assuming that biological tissue has a Poisson's ratio between the ranges of 0.3—0.4, the reduction in perimuscular zone connective tissue thickness of 27% (ratio of 0.27) would seem reasonable. With a value of 0.3 for Poisson's ratio, for a 30% decrease in strain in the transverse direction, a 70% increase in strain in the lateral direction would be expected. Therefore, for future studies, a mechanism to measure the elongation of connective tissue would be highly desirable. By measuring the elongation as well as the thickness, the cause of decrease in thickness can be understood more clearly.

Connective tissue is a viscoelastic material, i.e. it is composed of solid-fluid components. Viscoelastic materials disperse energy when stretched, which causes fluid to be pushed out of tissues (Özkaya et al., 2012). This flow of fluid out from connective tissue can be another reason to explain why thickness of tissue decreased. The deformation caused by lateral elongation of tissue is time-dependent on the load applied. A viscoelastic material responds to applied load with a steady increase in deformation (Özkaya et al., 2012). The material deforms under high stress initially but undergoes a gradual decrease in stress with time under constant deformation (Özkaya et al., 2012). The decrease in stress with time is called stress relaxation. Hence, structural changes in connective tissue would depend on stress applied as a result of MELT. For this reason, the effect of discontinuing MELT after 4 weeks should be studied to see if the connective tissue had deformed permanently as a result of stress relaxation or if the deformation was reversed after the stress was removed. Given our understanding of viscoelastic materials, elongation in subjects' connective tissue of this study was more likely caused by the stress applied from curvature of the soft body roller used at the back.

The Myoton measurements showed a significant increase of 8% and 7.2% immediately after and 4 weeks after MELT respectively, in mechanical stress relaxation time on the left side in the lower area below the 12th rib. The area below the 12th rib consists of the fascia over the latissimus dorsi. It is unclear why the myofascia in this particular region would be in a relaxed state after MELT for a longer time than other areas, suggesting a new aspect of research. Moreover, significance in one site among twelve sites tested can be a result of statistical variation as opposed to the tissue being in a relaxed state for a longer period of time.

A sample size calculation was performed according to the subjects' mean difference and standard deviation and it was found out that at least 120 subjects in MELT group alone, would be needed to achieve a significant reduction in stiffness with a 95% confidence interval. Therefore, the absence of significant change in stiffness (as well as elasticity and tone) could be due to the fact that the target sample size had not been met.

Conclusion

Correlation scatter plots showed very little correlation between reduced thickness and pain or flexibility (not pictured). Therefore, it can be said that these were independent measures. While it could be theorized that rolling the back might narrow the tissues temporarily from applied pressure, this explanation would not hold 4 weeks post measure of MELT. Hence, we are left with the conclusion that subjects have reduced thickness and pain, and increased flexibility. Examination of the correlations between these three variables in individual data does not suggest any mechanism tying them together at the individual level.

This study is the first to report the effect of the MELT method on chronic LBP subjects by seeing changes in thoracolumbar connective tissue thickness and biomechanical and viscoelastic properties of thoracolumbar myofascia. Although, positive changes have been observed in the form of reduced connective tissue thickness, increased flexibility and reduced pain, further research needs to be done in order to validate the claim that MELT reduces chronic pain by rehydrating connective tissue and rebalancing the regulators of the nervous system.

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