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**Effects of Foam Rolling on Tissue Stiffness in Back Muscles After a Rowing Workout: A  
Case Series**

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Capstone Project

Winter 2024

Fascia is a relatively new realm of research. Only in recent decades have research developments regarding fascia been applied to better understand musculoskeletal dynamics, rehabilitation, and recovery. Fascia is an anatomical term that refers to many of the body's soft fibrous connective tissues. It can be found throughout the body. As fascia has not been extensively researched, its contributions to musculoskeletal dynamics and rehabilitation methods have largely been overlooked. However, recent research suggests that the contributions of fascia are far greater than previously estimated. Additionally, the effects of exercise and forms of myofascial release on fascia have yet to be fully understood. This study seeks to understand the implications of these variables on tissue stiffness in the muscles of the back.

### **Literature Review**

Often, fascia has been understood to only act passively. However, new research is showing that fascia may have the capacity to actively contract. This has many effects on musculoskeletal dynamics, including muscle stiffness and motor coordination. It has been known that passive muscle stiffness is influenced by intramuscular filaments such as titin. Research suggests that passive muscle stiffness may also be influenced by connective tissue, such as fascia. Schleip et al. (2006) outlines evidence supporting this suggestion. The paper suggests that there is a strong possibility that the perimysium may actively contract and therefore allow muscle stiffness to adapt to different tensions, especially in tonic muscles. Schleip et al. writes that tonic muscles contain more perimysium than phasic muscles and that this perimysium is designed for load-bearing due to the size and arrangement of collagen fibers. Additionally, within the perimysium it seems there is a higher concentration of myofibroblasts than in other layers, such as the epimysium or endomysium. These myofibroblasts allow for the fascia to actively contract and therefore exhibit a stiffness adaptation response to mechanical stimulation. This concept of

active contractility of fascia and its influence on passive muscle stiffness may have implications for treatment of muscle pathologies related to muscle stiffness, such as chronic pain and instability.

Active contraction of the fascia not only affects muscle stiffness, but research suggests that mechanical and chemical stimulation of the fascia may impact the stiffness of the fascia itself. A study done by Schleip, et al. (2019) sought to understand how actively contractility of the fascia may impact musculoskeletal dynamics. To understand the contractility capabilities of fascia, myofibroblast presence in samples from humans and rats were measured via immunohistochemical staining. Samples from humans were obtained from 41 cadavers, mostly male, and included fascia from many areas of the body. Animal samples were obtained from the lumbar fascia in 20 rats. The immunohistochemical staining targeted the number of actin in the smooth muscle of the fascia. Additionally, mechanographic force understanding was obtained by measuring contraction response to different pharmacological stimulants. In human fascia, there were more myofibroblasts found in the lumbar fascia than in the plantar fascia or fascia lata. No significant correlation was found between myofibroblast presence and the age of subjects. In rats, there was a moderate positive correlation between myofibroblast presence and age. Additionally, mechanographic stimulation revealed a significant positive correlation between myofibroblast density and contractile response. The study was unable to determine that active contractility of the fascia may have short-term effects on musculoskeletal dynamics. However, they did find that fascia stiffness may change over time in response to mechanical stimulation, and may have a long-term effect on motor coordination, especially in the lumbar fascia. Fascia stiffness is related to many pathologies, especially in the low back, so further investigation regarding active fascia contractility is warranted. With a deeper understanding of fascia and its

contractile capacity, in turn there is a better understanding of musculoskeletal function and a new lens to approach pathologies.

In recent years, there has been developments in the extent to which fascia provides strength, stability, and functionality to the body, especially in the trunk and back. Generally, it is understood that muscles throughout the body provide stability, but research suggests fascia assists greatly as well. In the trunk, abdominal muscles are important for lumbar stability. This is achieved through the thoracolumbar fascia, however the exact mechanism is not easily understood. A study done by Fan et al. (2018) sought to understand the transversal continuity between the external abdominal oblique muscles and the thoracolumbar fascia. First, an anatomical study was conducted on 10 cadavers, 5 males and 5 females, to understand connections between the thoracolumbar fascia and the abdominal muscles. Then, a computer tomography study was done on 27 participants, 12 males and 15 females, with no experience with back or musculoskeletal pain. The imaging also assessed the relationship between the thoracolumbar fascia and the abdominal muscles at various vertebral levels. The study determined that there is direct continuity between the fascia of the abdominal muscles and the thoracolumbar fascia. This explains how tension may be transmitted between these areas of the body and the mechanisms by which stability of the lumbar region is maintained. There were no significant differences observed between males and females or between different sides of the body. Therefore, this continuity between fascia of the abdominal muscles and thoracolumbar region helps ensure synchronized movement of muscles of the trunk. This study demonstrates the continuity of fascia throughout the body and its importance in movement coordination and passive force transmission.

Furthermore, the thoracolumbar fascia and its deformation qualities may have implications regarding acute back pain and functionality. Previous research has found that deformation of the thoracolumbar distinguishes healthy individuals from those suffering from back pain. A study done by Brandl et al. (2023) sought to investigate thoracolumbar fascia deformation (TLFD) in trained and untrained individuals with and without acute low back pain (aLBP). Adult participants were split into three groups—one group of participants with acute low back pain, one group of untrained healthy individuals, and another group of track and field athletes. Each group had 16 participants, split evenly by sex. Participants performed a trunk extension test as well as a deadlift exercise while erector spinae muscle thickness and TLFD were measured via ultrasound imaging. Additionally, during the deadlift exercise, mean deadlift velocity and deviation of barbell path were measured using a gyroscope. The track and field athletes had the most TFLD, followed by the untrained healthy individuals, and the aLBP patients had nearly no TFLD. This indicates that TFLD, with consideration of training status, may be an appropriate metric to differentiate individuals with low back pain from healthy individuals. This understanding of TFLD as an indication of healthy back function is useful but the mechanism by which it contributes to functionality is not understood and should be further investigated. Though we have known that stability and strength is provided by the muscles of the body, the mechanisms by which fascia contributes and how tightness or injury to the fascia may affect strength and stability needs to be further investigated.

As it has been established that fascia contributes to stability and musculoskeletal function, it is important to rehabilitate and treat the fascia just as one would with the muscles of the body. Myofascial release has been found to improve musculoskeletal performance, reduce pain, and improve flexibility. It also may improve power and force production. Myofascial

release seeks to optimize tissue stiffness. The stiffness of tissue is important as it plays a large role in stability and performance. According to McGill (2001), tissue that is not stiff due to damage or disease can lead to a lack of stability. On the other hand, tissue that is too stiff can be too stable and lead to injury. Wells (2013) writes that increased stiffness in tissue leads to increased tension exhibited by the sarcomeres. This increased force production due to increased stiffness in the tissue may lead to adhesions in the fascia that require methods such as myofascial release to remedy.

A study done by Devereux et al. (2019) sought to understand the effects of myofascial trigger point release on power and force production in the lower limbs. Participants included 40 male college field sport athletes with the presence of latent myofascial trigger points in their rectus femoris and gastrocnemius muscles. Subjects were randomly divided into four groups and their maximum jump heights were tested via loaded squat jumps. The results of this test determined the intervention they received. One group received myofascial trigger point release via dry needling in just the rectus femoris muscle, one group received treatment in the gastrocnemius muscle, the third group received treatment in both muscle groups, and the last group did not receive any treatment. Squat jump height was tested again 48-, 72-, and 96-hours following treatment. The gastrocnemius muscle group was the only group to result in a statistically significant increase in jump height. However, it should be noted that this increase was preceded by an initial decrease in jump height following the dry needling. This indicates that while myofascial trigger point release can improve jump height, the treatment should not occur within 48 hours of performance. This allows the muscle time to rehabilitate following the treatment. Though there was not much statistical significance found in this study, the results may

help inform timing and method of treatment when considering myofascial trigger point release for improved musculoskeletal function.

Much of the research done regarding myofascial release focuses on the lower extremities. Foam rolling is a common rehabilitation tool used in a variety of settings. The literature suggests it may be an easy and accessible form of myofascial release. In 2017, Griefahn et al. conducted a study to understand how foam rolling may affect mobility in the thoracolumbar fascia of the back. Prior to conducting their study, they found evidence in previous literature demonstrating that foam rolling is an effective form of myofascial release for many reasons. The pressure exhibited by the foam roller as the subject places their body weight on the tool works to “roll out” the muscle and fascia. The process of rolling creates friction in the tissue that allows the fascia to be rehydrated, this increases lubricity of the tissue and can provide pain and tension relief. Additionally, Golgi receptors in the fascia are stimulated by the pressure provided by the foam roller and impart an inhibitory reflex that has been found to decrease muscle tone and provide further relief.

As previous literature has indicated that foam rolling is an effective technique of myofascial release, there have been numerous studies to try and better understand the application possibilities of foam rolling. A study done by Nakai, et al. (2023) sought to understand the effects of foam rolling as myofascial release of the lower back, specifically concerning myofascial gliding, flexibility, and muscle strength. Participants included 24 healthy college athletes with presence of back pain or other pathologies of the trunk. The mode of intervention for myofascial release in this study was a roller massager. The study took place over three days where each athlete participated in the respective intervention. The first day tested the roller massager, the second day tested static stretching, and the third day did not test an intervention.



As this study sought to determine the acute effects of myofascial release, myofascial gliding, lumbar flexibility, and trunk muscle strength were measured before and immediately after the applied intervention. Myofascial gliding was evaluated using an ultrasonic imaging technique. Lumbar flexibility was measured via the Sit and Reach Test and trunk muscle strength was measured using an abdominal trunk muscle strength-measuring device. This study found that only the roller massager intervention was able to improve all three measured variables indicating that myofascial release may be an important tool for optimizing trunk function. Another study done by Griefahn et al. (2017) sought to investigate the effects of foam rolling on specifically mobility in the thoracolumbar fascia. The study's participants included 38 healthy young adults who were regularly active. The participants were split into three groups—control, placebo, and intervention. The intervention group were instructed to do specific exercises with the foam roller, the placebo group received a pseudo treatment with the foam roller, and the control group received no treatment. Mobility of the thoracolumbar fascia was measured via sonographic assessment, while lumbar flexion and pain tolerance of the relevant muscles was also measured. There were no significant differences in lumbar flexion or pain tolerance observed between groups. But mobility of the thoracolumbar fascia in the intervention group increased significantly when compared to the other groups. Research indicates that fascia plays a large role in healthy muscular function and therefore myofascial release is an appropriate tool to improve and maintain strength, flexibility, and muscular performance.

Rowing is mainly an endurance sport and requires nearly all of the main muscle groups in the body for success. Competitors need to train aerobic and anaerobic energy systems, while also focusing on strength and endurance training. An article by Mäestu et al. (2005) conducted a review to understand rowing competition and training characteristics to better predict and

improve performance in rowing athletes. Mäestu et al. found that anaerobic and aerobic capacities are used to their maximum in rowing competition. Therefore, training must focus on enhancing aerobic performance while still considering strength and anaerobic training. In college-aged rowers, generally more than half of their training is specific rowing training, meaning it is out on the water and in the boat. This specific rowing training is also mostly aerobic endurance training, with blood lactate levels between 2 to 4 mmol/L. The rest of their training focuses on strength training and other general athletic training practices. Generally, rowing training is a balance in optimizing aerobic capacity while maintaining strength gains in relevant muscles.

As rowing requires nearly all of the main muscle groups of the body, consistent recovery and rehabilitation is needed. Mazzone (1988) writes that the primary muscles in the back used during rowing include the latissimus dorsi, trapezius, and rhomboids. As foam rolling has been indicated to be an effective rehabilitation tool for muscle and fascia tissue of the body in a young and healthy athlete population, it may be appropriate for recreational rowers as well. Healey et al. (2014) details where a foam roller can be used for effective myofascial release of the latissimus dorsi muscle. To roll out the latissimus dorsi, the subjects lie on their side with one arm outstretched and the foam roller placed in the axillary area of the body. Subjects roll over the area for 30 seconds and only need to roll minimally for the process to be effective. Espi-Lopez et al. (2022) describes where a foam roller can be used for effective myofascial release of the upper trapezius muscle. The subjects lie supine with the foam roller placed underneath their back just inferior to the scapulae. Then in a flexion-extension motion, the foam roller should be moved to just above the upper trapezius muscle before it is returned to the initial position in a fluid motion.

As research suggests, fascia is integral to healthy musculoskeletal function and when considered in training, it may even enhance performance. Though there is a general understanding that fascia assists in the strength and stability of the body, the mechanisms or performance effects are not clear. There are many attributes of the fascia that may affect function and performance, including the stiffness and elasticity of the tissue. As these effects are not well understood but it is clear that fascia contributes greatly to proper muscular function, these mechanisms warrant further investigation.

## **Methods**

Due to the fact that myofascial release and tissue stiffness in the back following exercise has not been studied extensively, the study focused on healthy subjects. The aim was to understand the effects of foam rolling on tissue stiffness in physically active subjects among two treatment groups, rest following the rowing session and the intervention, foam rolling, following the rowing session.

**Subjects.** For the study, three subjects between the ages of 18 and 25 were recruited. They were physically active male students at Western Washington University. Subjects were included if they confirmed they had not experienced the following: 1) no acute pain in the back at the start of the study, 2) no discomfort in the back at the start of the study, 3) no experience with regular foam roller use, and 4) no disability or injury to the back in the 12 months leading up to the study. Age and physical activity levels were self-reported by each subject. Height and weight measurements were taken using a scale in the laboratory prior to data collection. Subjects were randomly assigned into the rest or intervention group by a coin toss. There were two subjects randomly assigned to the foam rolling following exercise group and one subject assigned to the rest following exercise group.

**Procedure.** Following the collection of demographics, pre-exercise measurements using the Myoton Pro began. Immediately following pre-exercise measurement, subjects were instructed to row 1x2 on a stationary rowing machine, or 1000 meters in 4 minutes followed by 8 minutes of rest. In total, there were 2 work intervals.

Tissue stiffness in the back was measured using the Myoton Pro before the rowing session and after the rest or foam rolling session in both groups. Measurements occurred within two minutes of beginning or ending exercise. For the foam rolling group, the foam rolling on the two muscle groups occurred in the two minutes following exercise. The Myoton Pro is a handheld device that uses a mechanical impulse to measure tissue stiffness, elasticity, and tone among other factors. The pulse created by the testing probe leads to oscillation in the muscle that can provide information about the viscoelastic properties of the tissue (Chen et al., 2019). The muscles that were evaluated using the Myoton Pro were the latissimus dorsi and trapezius muscles. To measure stiffness of the latissimus dorsi muscle, the Myoton Pro was placed at a point 5 centimeters above the lower angle of the scapula with the shoulder flexed to 90 degrees and the subject seated (Kurashina et al., 2023). To measure the stiffness of the trapezius muscle, the Myoton Pro was placed at the midpoint between the C7 spinous process and the acromion of the clavicle with the subject sitting (Liang et al., 2022).

Following the rowing session, the intervention group used a foam roller on the muscle groups of interest. For each muscle group, the foam rolling was performed for 30 seconds at a time. For the latissimus dorsi muscle, the subjects lie on their side with one arm outstretched and the foam roller placed in the axillary area of the body. The subject only needed to roll minimally. To foam roll the trapezius muscle, the subject lies supine with the foam roller placed underneath their back inferior to the scapulae. Using a flexion-extension motion, the subject rolled the foam

roller to above the trapezius muscle before returning it to its initial position. All pre- and post-measurements were taken within two minutes of beginning and ending exercise. Foam rolling in the intervention group took place immediately following exercise and prior to measurement using the Myoton Pro.

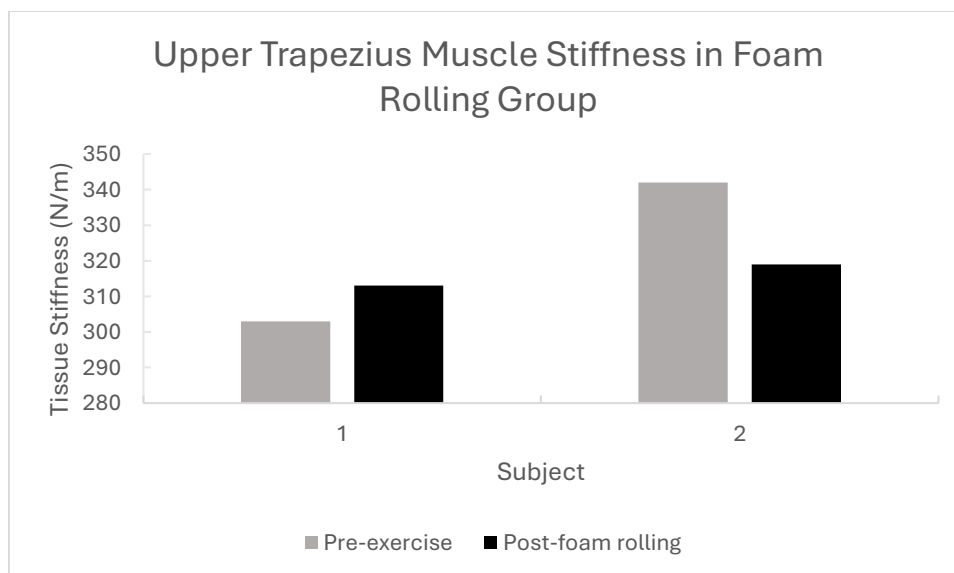
## Results

As there were only three subjects in this case series, statistical analysis was not applied. The data from the Myoton Pro were taken and presented in table and graph form to depict the results of the data.

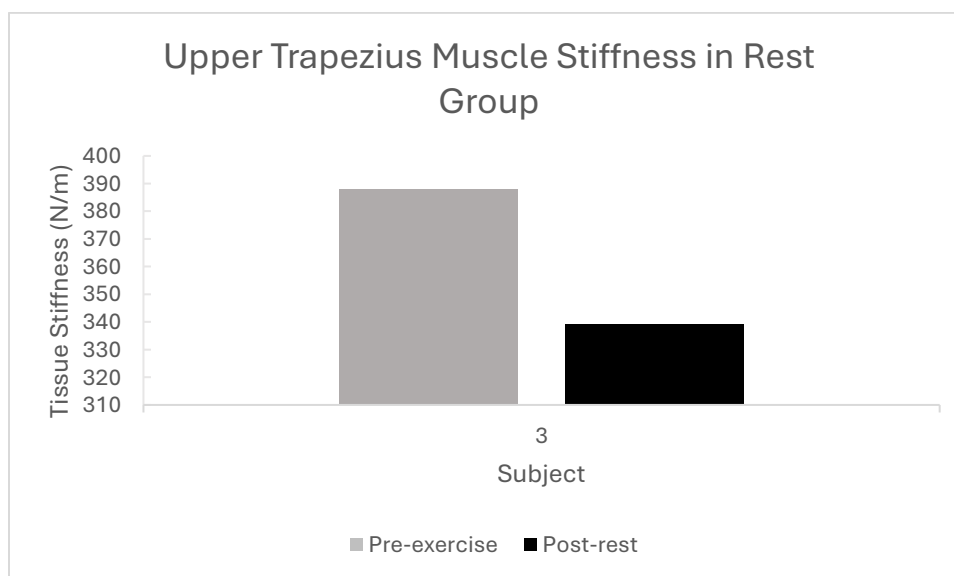
The measurements taken by the Myoton Pro in the upper trapezius muscle are represented by Table 1 depicted below. Two figures follow depicting the change in stiffness of the subjects who foam rolled and the subject that rested following exercise. The subject conditions are denoted next to the subject number in the table, rest (R) or foam rolling (FR). Additionally, there are figures below depicting changes in tissue stiffness in each subject in the upper trapezius muscle.

Subject	Pre-exercise tissue stiffness (N/m)	Post-intervention tissue stiffness (N/m)
1 (FR)	303	313
2 (FR)	342	319
3 (R)	388	339

**TABLE 1.** PRE-EXERCISE AND POST-INTERVENTION (REST OR FOAM ROLL) TISSUE STIFFNESS MEASUREMENTS TAKEN FROM THE UPPER TRAPEZIUS MUSCLE USING THE MYOTON PRO.



**FIGURE 1.** THIS FIGURE DEPICTS THE TISSUE STIFFNESS MEASUREMENTS IN THE UPPER TRAPEZIUS MUSCLE BEFORE AND AFTER EXERCISE IN THE SUBJECTS THAT FOAM ROLLED FOLLOWING EXERCISE.



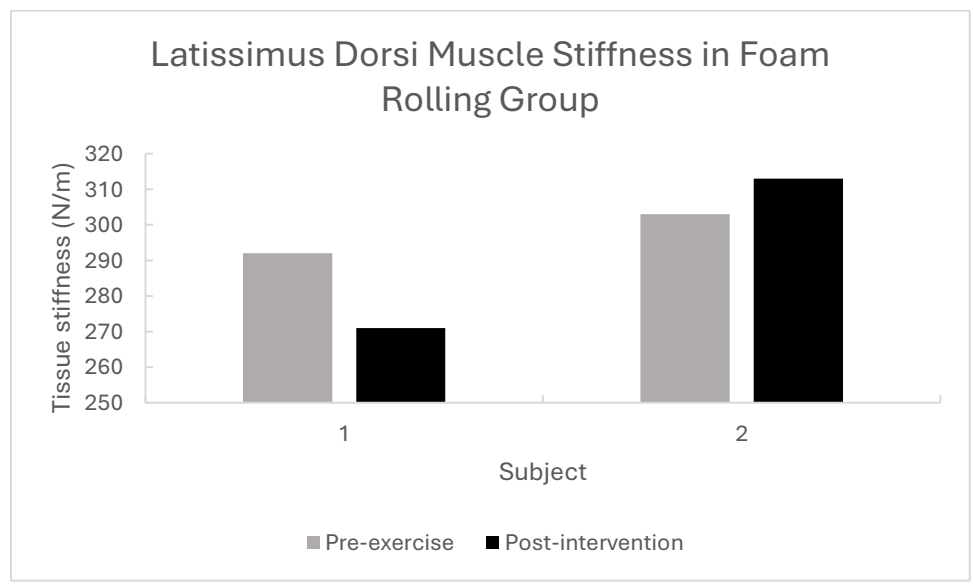
**FIGURE 2.** THIS FIGURE DEPICTS THE TISSUE STIFFNESS MEASUREMENTS IN THE UPPER TRAPEZIUS MUSCLE BEFORE AND AFTER EXERCISE IN THE SUBJECT THAT RESTED FOLLOWING EXERCISE.

The largest change in stiffness measured in the upper trapezius muscle was in the subject that rested following exercise, Subject 3. There was a decrease of 49 N/m. Additionally, stiffness decreased by 23 N/m in Subject 2 (FR) However, in Subject 1 (FR), there was a slight increase in tissue stiffness of 10 N/m.

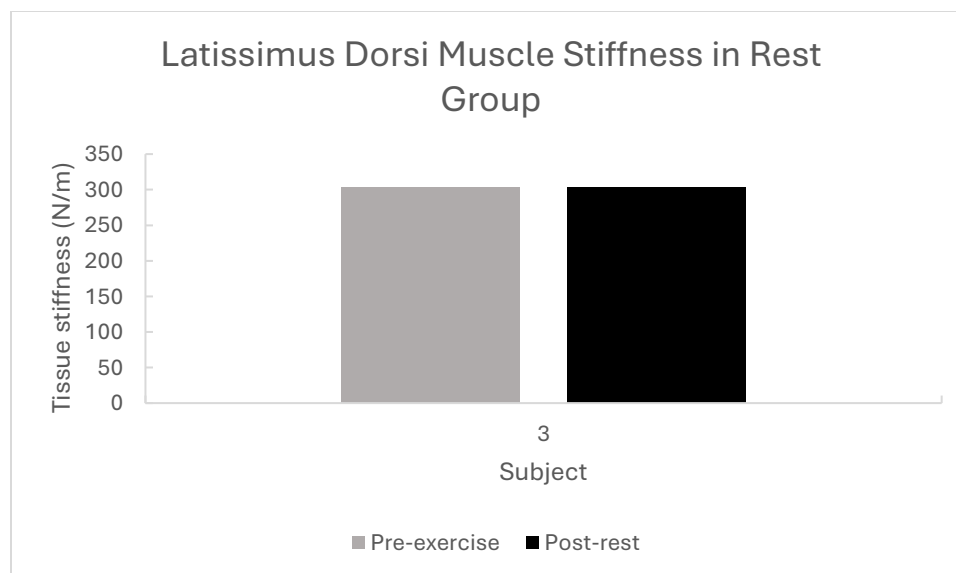
Table 2 follows below and displays the stiffness measurements taken from the latissimus dorsi muscle. Additionally, there are two tables that display changes in tissue stiffness in the latissimus dorsi muscle in the subjects who foam rolled and the subject that rested following exercise.

Subject	Pre-exercise tissue stiffness (N/m)	Post-intervention tissue stiffness (N/m)
1 (FR)	292	271
2 (FR)	303	313
3 (R)	303	303

**TABLE 2.** PRE-EXERCISE AND POST-INTERVENTION (REST OR FOAM ROLL) TISSUE STIFFNESS MEASUREMENTS TAKEN FROM THE LATISSIMUS DORSI MUSCLE USING THE MYOTON PRO.



**FIGURE 3.** THIS FIGURE DEPICTS THE TISSUE STIFFNESS MEASUREMENTS IN THE LATISSIMUS DORSI MUSCLE BEFORE AND AFTER EXERCISE IN THE SUBJECTS THAT FOAM ROLLED FOLLOWING EXERCISE.



**FIGURE 4.** THIS FIGURE DEPICTS THE TISSUE STIFFNESS MEASUREMENTS IN THE LATISSIMUS DORSI MUSCLE BEFORE AND AFTER EXERCISE IN THE SUBJECT THAT RESTED FOLLOWING EXERCISE.

There is more variability observed in the tissue stiffness measurement values taken from the latissimus dorsi muscle. The greatest change was in Subject 1 (FR) with a decrease in tissue stiffness of 21 N/m. Subject 2 (FR) had a slight increase of 10 N/m while Subject 2's (R) tissue stiffness remained the same.

## Discussion

Based on the results presented above, the data is variable and inconclusive. However, the data collected was minimal and it is still useful in determining how to precede with this research. It appears that the stiffness measurements in the latissimus dorsi muscle are more variable across subjects than the stiffness measurements in the upper trapezius muscle. There are a variety of factors that could have contributed to this variability that were not controlled during data collection.

The latissimus dorsi muscle should be more active throughout a rowing workout as it is a larger muscle with greater attachment points than the upper trapezius muscle. The latissimus



dorsi muscle attaches to the scapula and the humerus, both relevant areas of the body in a rowing workout. However, the relative actions of these muscle groups can change based on the form of the rower. Rowers may overcompensate in various ways including shoulder elevation to increase stroke speed. This may increase the action of the upper trapezius and impact tissue stiffness. These small changes in rowing form between subjects may be contributing the variability of the data. Additionally, form during the foam rolling may contribute. The subjects were explicitly told and shown how to roll out the specific muscles but small changes in form and different locations of the muscle groups could still be responsible. The latissimus dorsi muscle is closer to the body's center of mass. This has implications for the depth of tissue reached in the latissimus dorsi compared to the upper trapezius. As there is more weight on the foam roller when rolling the latissimus dorsi, a greater depth can be achieved and can impact the changes in stiffness that were observed. Two more factors that were not considered in this case series were physical activity prior to data collection and hydration levels of the participants. Based on the results of the subject that did not foam roll at all, it is apparent that exercise has an effect on tissue stiffness. Therefore, any physical activity that a subject may be participating in prior to data collection should be considered. Additionally, stiffness is affected by the water content in the tissue. Water content was not a factor considered in data collection and therefore was not measured or accounted for, but its effect on stiffness indicates that it should have been.

Though it is not possible to conclude how tissue stiffness is affected by exercise and foam rolling based on this data, it will assist greatly in how to move forward. There are multiple factors that may have contributed to the variability in this data, many of which can be controlled moving forward. In future research, it will be important to recruit more participants and control the many variables that have contributed to the unpredictability of the data. This includes proper

and consistent form across all subjects when rowing and foam rolling, refraining from physical activity 24 hours prior to data collection, and ensuring for similar hydration levels across subjects. Additionally, with more data and control of these variables the results can be considered alongside implications for performance and rehabilitation methods going forward.

## **Conclusion**

This data was variable and did not clearly indicate the effects of exercise and foam rolling on tissue stiffness due to a variety of factors discovered to be influencing it. However, it did indicate how to approach studies of this kind going forward. There are many variables influencing tissue stiffness that need to be considered and this case series helped inform what can be done next as there is still so much to be discovered regarding fascia. With more emphasis of fascia in research, we can better understand not only the function of the musculoskeletal system but how to approach treatment and rehabilitation methods going forward. In previous research, it has been shown that tissue stiffness can indicate the health and proper function of fascia, but it is still unclear how this knowledge can be applied in a variety of settings. Further research is necessary to determine the extent to which this understanding of fascia may be applied.

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