

**THE INFLUENCE OF LOCAL MUSCLE VIBRATION DURING FOAM ROLLING ON  
RANGE OF MOTION AND PAIN**

**Running Head: VIBRATION AND FOAM ROLLING ON RANGE OF MOTION**

## ABSTRACT

Myofascial trigger points (MTrP) result in range of motion restrictions and pain, which may lead to aberrant biomechanics. Foam rolling and vibration therapies effectively improve range of motion restrictions and reduce pain associated with MTrPs. When combined, these therapies may be more effective than when used in isolation. The purpose of this study was to identify the combined effects of foam rolling and vibration therapy on dorsiflexion range of motion and pain. Physically active adults ( $n=20$ ) with restricted weight-bearing lunge (WBL;  $<40^\circ$ ) and a minimum of one MTrP participated in this study. A crossover design was used, with participants receiving foam rolling with vibration during one session and foam rolling without vibration during the other session. Ankle dorsiflexion range of motion measurements (WBL, dorsiflexion-knee straight [DF-S], dorsiflexion-knee bent [DF-B]) and pain measurements (pain pressure threshold [PPT] and numerical rating scale [NRS]) were collected before and after the foam rolling interventions and passive stretching. A repeated-measures ANOVA was used to identify changes in range of motion and dependent t-tests examined changes in PPT and NRS ( $p<0.05$ ). There was a significantly greater increase in range of motion following foam rolling with vibration compared to foam rolling without vibration (WBL  $p=0.03$ ; DF-S  $p=0.02$ ; DF-B  $p<0.01$ ). There was no difference in change in pain between the interventions (PPT  $p=0.66$ ; NRS  $p=0.39$ ). Foam rolling with vibration more effectively improves range of motion restrictions than foam rolling alone, without causing a resultant increase in pain.

**Keywords:** Myofascial, Trigger Point, Release

## INTRODUCTION

Restricted ankle dorsiflexion range of motion contributes to lower extremity biomechanical patterns that may increase the risk of non-contact lower extremity injuries (11,12,34). These high-risk biomechanical patterns include less knee flexion, greater medial knee displacement, and greater ground reaction forces during a jump-landing task and less knee flexion and greater medial knee displacement during a squat task (11,12,34). Improving ankle dorsiflexion range of motion may be an important component of corrective exercise programs that aim to modify high-risk lower extremity biomechanics and mitigate injury risk. Thus, identifying the most effective treatments for increasing dorsiflexion range of motion is important for optimizing corrective exercise programs.

Myofascial trigger points are loci of hyperirritability in the muscle that have been linked to restricted range of motion and pain (38). Myofascial trigger points located in the ankle plantar flexors may limit active dorsiflexion range of motion (37,38). Myofascial adhesions may develop along with myofascial trigger points and further inhibit the movement of the muscle underneath the fascia, resulting in greater range of motion restrictions (2).

Several therapies can effectively treat myofascial trigger points and rectify their associated range of motion deficits (23,38). Direct compression technique involves applying prolonged pressure to a locus of hyperirritability within a muscle (23), which helps to break up fascial adhesions and restore normal neural function to the immediate surrounding area (25,36). Foam rolling applies direct compression to a myofascial trigger point and can increase range of motion without decreasing muscle activation or strength (25,36). Direct compression is also

effective in reducing myofascial trigger point pain, allowing for additional gains in range of motion (29).

Vibration therapy has also been proposed to increase range of motion and improve muscle function (9,18,30). Vibration therapy causes muscles to repeatedly eccentrically and concentrically contract resulting in increased blood flow, increased muscle temperature and viscoelasticity (5,20), increased pain threshold (17), and improved neural efficiency (7,10). Currently, there is no research examining local vibration therapy as a treatment for myofascial trigger points.

The purpose of this study was to compare the effects of foam rolling with and without vibration on dorsiflexion range of motion and pain in a population with restricted dorsiflexion range of motion. We hypothesized that foam rolling with vibration would cause greater gains in dorsiflexion range of motion and a reduction in subjective and objective pain. A secondary objective was to determine the effects of a static stretch after foam rolling with and without vibration. We hypothesized that the addition of a static stretch would cause greater gains in range of motion. Determining the most effective treatments for increasing range of motion will improve the effectiveness of corrective exercise programs and ultimately reduce injury risk.

## METHODS

### Experimental Approach to the Problem

A crossover study design was utilized to examine the effects of foam rolling combined with vibration on restricted dorsiflexion range of motion. All participants received both foam

rolling interventions and underwent the same testing procedures, but the order in which participants received each treatment was randomized (Figure 1). The effects of a static stretch after the foam rolling interventions were also examined. Dependent variables included changes in passive dorsiflexion range of motion as well as functional dorsiflexion in the weight-bearing lunge examined within subjects. Pain was measured using a pain pressure threshold and a numerical rating scale.

### **Figure 1 Here**

#### Subjects

A convenience sample of twenty individuals who reported participating in at least 30 minutes of physical activity 3 times per week for the past 6 months were included in this study (Table 1). Participants had a weight-bearing lunge measurement less than 40° and 1 or more active myofascial trigger points in the gastrocnemius or soleus of the dominant leg (the leg the participant reported to use to kick a soccer ball for maximum distance); participants were otherwise healthy. A weight-bearing lunge measurement of less than 44° has been associated with altered biomechanics (11), so a more conservative 40° measurement was selected for the current study. Participants were excluded if they had a history of lower extremity surgery or an injury within the past 6 months that limited physical activity for more than 2 consecutive days. Participants with known neurological conditions were also excluded.

### **Table 1 Here**

Participants were randomly allocated to groups predetermined to include 10 individuals in each. One group received foam rolling with vibration during the first testing session ( $n_1=10$ ), while the other group received foam rolling with vibration during the second testing session ( $n_2=10$ ). Participant recruitment was discontinued after 20 participants were identified, determined from power calculations based on previous research (11).

The local institutional review board approved all study procedures, and participants were informed of all benefits and risks prior to signing an institutional review board approved informed consent form. Participants wore their own athletic shorts, t-shirt, and athletic shoes throughout the screening and testing sessions.

## Procedures

### ***Screening session***

Prior to data collection, all participants completed a screening session. During the screening session, inclusion criteria were confirmed, dorsiflexion in the weight-bearing lunge was measured, and myofascial trigger points were identified. Myofascial trigger points were identified by placing the participant in a prone position with the knees extended on a treatment table. A single investigator (DNE) palpated the gastrocnemius and soleus of the dominant leg to identify myofascial trigger points. Myofascial trigger points had to meet a minimum of two of the following criteria to be included: 1) a palpable taut band within the muscle, 2) a hypersensitive tender spot/nodule within a taut band, 3) pain with palpation of the tender nodule,

and 4) painful limit to full range of motion (15,16,38). All measurements were recorded from the dominant leg.

### ***Testing Session***

Prior to the start of each session, participants completed a 5-minute warm-up on a stationary bike at an intensity equal to 3 out of 10 on a rating of perceived exertion scale. Following the warm-up, participants completed range of motion and pain pressure threshold measurements, received a foam rolling intervention, completed range of motion measurements a second time, completed a stretching intervention, and then completed range of motion and pain pressure threshold measurements a third time. Participants reported 7 days later for the second data collection session (Figure 1).

### ***Range of motion measurements***

The weight-bearing lunge was measured with a digital inclinometer (Saunders Group, Inc., Chaska, MN;  $ICC_{3,k} = 0.98$ ;  $SEM = 0.86$ ) while participants stood on their dominant leg, supported themselves against the wall, and rested the foot of their non-dominant leg in a comfortable position on the floor. Participants flexed the knee of their dominant leg and lunged forward as far as possible while keeping their dominant foot in line with the long axis of the leg and their heel on the ground. The primary investigator stabilized the heel on the ground and moved the foot posteriorly until the maximum range of dorsiflexion was reached (identified by the heel lifting off the ground). The digital inclinometer, placed on the anterior tibia, measured the angle of the tibia relative to vertical (4). Three measurements were recorded.

Non-weight bearing ankle dorsiflexion measurements were recorded on the dominant limb with the participant in a supine position. A standard 12-inch plastic goniometer measured ankle dorsiflexion with the knee extended ( $ICC_{3,k} = 0.97$ ;  $SEM = 0.80$ ) and flexed ( $ICC_{3,k} = 0.99$ ;  $SEM = 1.59$ ). The primary investigator recorded passive range of motion measurements at the first point of restriction in dorsiflexion with the knee straight and bent to  $90^\circ$  (3,12). Three measurements were recorded. Range of motion measurements were counterbalanced between participants.

#### *Pain pressure threshold and numerical rating scale measurements*

Myofascial trigger points in the participant's calf were identified and marked. If multiple myofascial trigger points were identified, the one that had the lowest pain pressure threshold (indicating it was most sensitive) was identified on the dominant limb and used for the pain pressure threshold measurement. A handheld digital dynamometer (Manual Muscle Tester Model 01163, Lafayette Instrument Co., Lafayette, IN) measured pain pressure threshold ( $ICC_{3,k} = 0.92$ ;  $SEM = 0.48$ ). The dynamometer with a focal tip attachment was placed over the center of the myofascial trigger point. A single investigator (DNE) applied a slowly increasing force to the area (29) until the participant identified the pain as "just noticeable," at which time the measurement was recorded. Three pain pressure threshold measurements were recorded.

The participant then rated how much pain was caused by the pain pressure threshold measurement on a numerical rating scale ranging from 0 to 10. Zero indicated no pain, 5 indicated moderate pain, and 10 indicated unbearable pain (39). Participants verbally identified their perceived pain while being shown the numerical rating scale. Only whole numbers were

recorded. The numerical rating scale was administered in the same manner after each foam rolling intervention (19).

### *Foam rolling interventions*

The VYPER™ (Hyperice, Irvine, CA) foam roller was used for all interventions. The VYPER™ is a cylinder of high-density foam, measuring 30 cm long and 15 cm in diameter. An embedded vibrating motor facilitates local muscle vibration. The vibration feature was turned onto VYPER setting 2 (32 HZ) selected for its tolerability, intensity, **force and amplitude**. **(NOTE: To achieve amplitude the VYPER uses a heavy weight that is driven by a patent pending transmission, which amplifies the vibration)**. During the foam rolling without vibration, the vibration feature was turned off. For both treatments, participants placed the foam roller under the calf of their dominant leg, applied pressure with their body weight by placing the non-dominant leg on top of the dominant leg and lifting the hips off of the ground (Figure 2). If this position was too painful to maintain, participants were instructed to place the foot of the non-dominant leg on the ground. Participants slowly rolled from the ankle to the knee for 5 seconds, and then quickly returned the foam roller to the ankle. This was repeated as many times as possible for 30 seconds. After 30 seconds, participants focused on the pre-identified trigger points. Pressure was maintained over the 3 trigger points that the participant perceived as being the most painful for 45 seconds each. If less than 3 trigger points were identified, participants placed pressure on any other hypersensitive areas in the muscle. The same foam rolling position and procedures were used for both data collection sessions.

**Figure 2 Here**

Following the foam-rolling intervention, participants rated the pain caused by the treatment on the numerical rating scale. Range of motion measurements were then taken for a second time.

### *Stretching intervention*

The stretching intervention took place immediately following the second round of range of motion measurements. Participants performed weight-bearing gastrocnemius and soleus stretching using a slant board with the knee straight and bent, respectively (22). Three sets of 30 seconds were performed for both static stretches on the dominant leg.

### Statistical Analyses

Averages were calculated for all range of motion and pain measurements. Change scores were calculated between pre-intervention and post-foam rolling as well as pre-intervention and post-stretching for each range of motion measurement. A 2x2 repeated measures ANOVA with time (pre-intervention to post-foam rolling vs. pre-intervention to post-stretching) and treatment (foam rolling with vibration vs. foam rolling without vibration) analyzed differences. Post-hoc comparisons were made with Bonferroni corrected t-tests ( $\alpha < 0.0125$ ). 95% confidence intervals were calculated and examined to determine if the change scores for foam rolling with or without vibration were significant. Statistical significance was defined as the change score's 95% confidence interval not containing zero.

Change scores were calculated for pain pressure threshold and numerical rating scale

scores between pre-intervention and post-stretching. Dependent t-tests were used to compare the change scores between the foam-rolling interventions, and 95% confidence intervals examined differences in baseline measurements for range of motion, numerical rating scale, and pain pressure threshold data to ensure no carryover effect between foam rolling interventions. Statistical significance was set *a priori* at  $\alpha < 0.05$ . Data were analyzed using SPSS 19.0 statistical software (SPSS, Inc., Chicago, IL).

## RESULTS

There were no differences between baseline measurements for range of motion, pain pressure threshold, or numerical rating scale on data collection days 1 and 2 (Tables 2 and 3), indicating there was not a carryover effect between treatments. One participant was lost to follow-up due to scheduling conflicts, resulting in analysis of 19 participants.

### **Table 2 Here**

#### Range of motion

There was no significant time by treatment interaction for the weight-bearing lunge ( $F_{1,18} = 1.10, p = 0.307$ ), ankle dorsiflexion with knee straight ( $F_{1,18} = 0.77, p = 0.392$ ), or ankle dorsiflexion with knee bent ( $F_{1,18} = 0.77, p = 0.392$ ). Thus, the amount of change in ankle dorsiflexion range of motion measures was similar following the foam rolling and static stretching interventions (Table 2).

### **Figure 3 Here**

There was a significant main effect for intervention, for the weight-bearing lunge ( $F_{1,18} = 5.75, p = 0.028$ ), ankle dorsiflexion knee straight ( $F_{1,18} = 6.54, p = 0.020$ ) and ankle dorsiflexion

knee bent ( $F_{1,18} = 12.29, p = 0.003$ ) measures. The change in ankle dorsiflexion range of motion was greater for all measures following foam rolling with vibration compared to foam rolling without vibration. The 95% confidence intervals for change scores of all ankle dorsiflexion range of motion measures did not contain zero, indicating that both foam rolling with and without vibration significantly increase ankle dorsiflexion range of motion measures, but the change is greater following foam rolling with vibration (Figure 3).

#### **Figure 4 Here**

A significant main effect for time was found for the weight-bearing lunge ( $F_{1,18} = 27.93, p < 0.001$ ), ankle dorsiflexion knee straight ( $F_{1,18} = 46.18, p < 0.001$ ) and ankle dorsiflexion knee bent ( $F_{1,18} = 42.37, p < 0.001$ ) measures. No 95% confidence interval of the change score contained zero, indicating that ankle dorsiflexion range of motion measures significantly improved following foam rolling and there were significant improvements with the addition of static stretching following foam rolling (Figure 4).

#### **Table 3 Here**

##### Pain pressure threshold and numerical rating scale

Participants demonstrated an increase in pain pressure threshold after both foam rolling with and without vibration (mean difference = 0.31 kg/cm<sup>2</sup>, 95% CI = [0.21, 0.41]). However, there was no difference in the change in pain pressure threshold between the foam rolling treatments ( $p = 0.660$ ). There was also no change in pain caused by pain pressure threshold as measured by the numerical rating scale ( $p = 0.874$ ). Participants reported no difference in pain

caused by the foam rolling treatments themselves ( $p = 0.39$ ). Pain measurement data are reported in Table 3.

## DISCUSSION

Foam rolling with and without vibration increased ankle dorsiflexion range of motion. The combination of foam rolling and vibration resulted in greater gains in all ankle dorsiflexion range of motion than foam rolling without vibration. Gains in dorsiflexion range of motion are amplified following static stretching, regardless of the type of foam rolling treatment.

Gains in range of motion following foam rolling with vibration are likely neural in origin (7). Muscle spindles surrounding myofascial trigger points are hyperactive compared to muscle spindles found in relaxed bands of muscle tissue (13). Hyperactive muscle spindles could globally result in tight musculature and restricted range of motion (1). Relaxation of the hyperactive muscle spindles may be achieved by stimulating golgi tendon organs (7) or presynaptic inhibition of Ia fibers (6). It is possible that foam rolling with vibration causes increased tension in the muscle and stimulate the golgi tendon organs which may inhibit muscle spindles (7). Alternatively, foam rolling with vibration could cause increased stimulation of type Ia afferent fibers, ultimately resulting in decreased muscle spindle activity because of prolonged stimulation (6).

Foam rolling and vibration therapies elicit physiological changes that may increase muscle elasticity and contribute to gains in range of motion (5,20,28). Vibration therapy increases muscle temperature (5,20) while myofascial release therapies increase blood flow

surrounding myofascial trigger points (28). Both increased muscle temperature and blood flow can result in increased tissue extensibility (21,33).

Foam rolling combined with static stretching resulted in greater increases in dorsiflexion range of motion than foam rolling alone. This agrees with previous work that showed static stretching results in increased range of motion when combined with foam rolling (33) or vibration therapy (31). The most surprising finding of this study was a lack of significant time by treatment interaction for range of motion measurements. This indicates there is no difference in gains in range of motion resulting from foam rolling with vibration combined with stretching compared to foam rolling without vibration combined with stretching. Vibration was not found to increase the effects of stretching, suggesting that vibration may not cause increased viscoelastic changes or that such changes are only present for a short time after treatment (27).

It is unknown if the observed gains in dorsiflexion range of motion are clinically meaningful. Previous studies examining participants with restricted dorsiflexion range of motion and aberrant movement patterns found a larger difference in range of motion between control and restricted groups (11,26), than the gains observed in the current study. Additional research is needed to determine if increased range of motion following foam rolling and stretching will aid in improving movement patterns and reducing injury risks. While it is unknown if the observed gains in range of motion will improve movement patterns, it can be theorized that the increased tissue extensibility may reduce injury risk. Lack of muscle extensibility or flexibility has been identified as a risk factor for muscle strains, so it is probable that increased tissue extensibility resulting from foam rolling with vibration could help reduce the incidence of muscle strains (40).

Foam rolling, irrespective of vibration, is effective in increasing pain pressure threshold. Increased pain pressure threshold indicates increased pain tolerance to direct compression of a trigger point, which is similar to previous findings (24). The change in reported pain during the pain pressure threshold measurement was not different between foam rolling treatments. This may be due to measurements being recorded when the participants reported pain, rather than using a standardized amount of pressure. A reduction in pain is likely clinically significant, as pain results in restrictions in range of motion (14) and contributes to aberrant movement patterns (32). Therefore, a reduction in myofascial trigger point pain could aid in improving movement patterns.

Further investigation is necessary to determine the effects of prolonged use of foam rolling with vibration, rather than just an acute application. Examination of lower-extremity kinematics, kinetics, and muscle activation would also be beneficial in determining the clinical importance of these findings. Results from this study are only generalizable to physically active young adults with myofascial trigger points and restricted dorsiflexion range of motion.

#### PRACTICAL APPLICATIONS

Overall, foam rolling combined with vibration is an effective tool for increasing range of motion and decreasing pain related to myofascial trigger points. The clinical significance of the increased range of motion caused by the foam rolling with vibration is enhanced by the similarity in reported pain for the two foam-rolling interventions. This means patients can receive a greater increase in range of motion without a resultant increase in pain. This may help with patient

compliance as well as efficiency in treatment. The foam rolling with vibration treatment is self-administered, allowing patients the flexibility to work on improving range of motion deficits where and when it is convenient.

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CAPTIONS TO FIGURES

**Figure 1: Experimental Procedures.** Testing sessions were completed 7 days apart, depicted by the dashed lines.

**Figure 2: Foam Rolling Procedure**

**Figure 3: Graph of Range of Motion Changes Comparing Foam Rolling to Foam Rolling with Vibration**

Error bars represent 95% CI

\* Significant difference between traditional and vibrating foam rolling ( $p < 0.05$ )

**Figure 4: Graph of Range of Motion Changes Comparing Foam Rolling to Foam Rolling Plus Stretch**

Error bars represent 95% CI

\* Significant difference between pre to post foam rolling and pre to post foam rolling plus stretch ( $p < 0.05$ )