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Original Research Article

# The Immediate Effect of Percussion Myofascial Release Therapy on Hamstring Flexibility and Hip flexion Range of Motion Among Active Young Adults

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### ABSTRACT

**Introduction:** The study conducted involved pre- and post-assessments, measuring lower body hamstring flexibility, utilizing alternative self-myofascial release methods to assess the effectiveness of each modality group. Modalities within the study include a percussive massage gun, foam roller, and a control group with no intervention. The purpose of this study was to see if there was a significant effect in percussive massage gun intervention in comparison to the foam roller, within the 90-second intervention time. **Methods:** Participant (N=31) adherence to the two sessions, were conducted within a forty-eight-hour window. The participant filled out a demographic questionnaire before the initial trial. The participant would then warm up on a stationary cycle, pacing 60-70 rpms for five minutes consecutively. Participant then will go through initial baseline assessments, receive one of three modalities; percussive massage gun, foam roller, and control, and perform self-intervention for 90 seconds. Post baseline assessments were collected, participants were asked if they would be present at their next session. **Results:** Repeated measures ANOVA were set to determine significance between time or modality, specifically sit and reach day two's session, specifically for percussive massage gun,  $t(10) = -4.41$ ,  $p = .001$ . Foam roller showed significance within sit and reach day two session,  $t(8) = -4.53$ ,  $p = .002$ . Though there was no interaction effect, or significance. For all other dependent variables, sit and reach day one, goniometer active day one and two, goniometer passive day one and two, there was no significance across groups or interaction effects. **Conclusions:** It was discovered that sit and reach improves hamstring flexibility post intervention, with the use of foam roller or the percussive massage gun. There was no significance among the other DV, in which it could be suggesting that more trials and extended periods of time to perform intervention and stretches would be beneficial. There was no significance to show that percussive massage gun did a greater job increasing hamstring flexibility, than foam roller, or the control group.

**KEYWORDS:** Flexibility, Goniometer, Hamstring, Myofascial Release, Sit and Reach, Young Adult.

## Introduction

Approximately 1/3 of all musculoskeletal injuries occur in individuals ages 19-44 and a large part of that population are individuals who are active in recreational sports.<sup>1</sup> However, this statistic only includes individuals who went to the ER to be treated for their injury, so the number is even higher.

The American College of Sports Medicine (ACSM) recommends that individuals stretch and engage in flexibility exercise 2-3 times a week, however daily stretching has been shown to be most effective. It is recommended that the individual should stretch the muscle to the feeling of slight discomfort or tightness and hold the stretch for at least 10-30 seconds. Adults are recommended to perform these stretches on each major muscle group.<sup>2</sup> All the participants in this study are not currently following the ACSM guidelines.

The discussion surrounding the adaptability of fascia is extensive, yet still inconclusive. Fascia is a type of connective tissue that surrounds every nerve, blood vessel, and muscle fiber in the human body and connects them to bones, muscles, and organs in large networks throughout the body.<sup>3</sup> The theory behind myofascial release states that these connective tissues support the dynamic and mechanical properties that aid in muscular movement. However, it is thought that these tissues can become altered through repeated muscle trauma or injuries.<sup>3</sup> Fascial tension accumulated through repeated microtrauma, or acute

injury can lead to the formation of adhesions in the tissue, which can cause pain and decreased functional capacity.<sup>3</sup>

A wide variety of studies have been done on increasing individuals' flexibility and range of motion through myofascial release techniques.<sup>4, 5, 6, 7, 8</sup> The objective of our study is to continue to find additional evidence of the effects of different modalities to increase flexibility. There are a variety of modalities that can be used to achieve MFR including foam rollers, lacrosse balls, Thera canes, percussive massage guns, roller sticks, etc.

The foam roller is the most popular form of self-myofascial release. Foam rolling has been shown to improve both active and passive range of motion, reduce soft tissue adhesions, reduce muscle soreness, and potentially reduce sensations of pain".<sup>5</sup> An individual can choose from a variety of densities and sizes, depending on their desired level of pressure. A multitude of studies have been conducted to determine the benefits of foam rolling, overall determining that it is a technique to allow a person to manipulate adhesions developed in their tissue. One theory is that the pressure from the foam roller condenses the tissues and then allows them to be hydrated upon relaxation. The hydrated tissues are then able to improve fascial movement as well as increase blood flow and temperature, improving range of motion.<sup>9</sup> In addition to the foam roller, a handheld roller and lacrosse ball are also useful tools for

myofascial release, although their effect is not as professionally researched. The lacrosse ball has been shown to help increase hamstring range of motion when used to roll on the plantar surface of the foot.<sup>10</sup>

Little knowledge is available related to the effectiveness of massage guns. This new modality was created to be used as a recovery and warm-up tool to help individuals decrease muscle soreness while improving their flexibility through a form of self-myofascial release. This tool became popular around 2010, and therefore there is not a lot of published research on its effectiveness on increasing ROM. There has been some evidence that using a PEM can increase hamstring ROM and therefore decrease their risk of musculoskeletal injury.<sup>11</sup> The purpose of this study is to determine the effects of the percussive massage gun on increasing hamstring flexibility and range of motion, compared to the foam roller. With our population sample being aged 18-24, there is little research done on this population's flexibility in general with only being recreationally active, or not currently a collegiate athlete.

## **Methods**

### **Participants**

Participants were required to meet several criteria before being eligible to participate in this study. Participants had to be inactive/recreationally active, and not be a part of an organized sport. Participants also had to be between the ages of 18- 24 years

old. This age population was chosen because it has proven that from 18-24 years old is the most active age range within an individual's lifetime.<sup>12</sup> The gender of the individual did not matter, nor did their baseline flexibility or range of motion measurements. Each participant could not have had a current consistent stretching or myofascial release routine. The main source of individuals that were recruited and participated in this study were students that were currently enrolled at the University of Wisconsin - Eau Claire. Participants were recruited from a variety of departments at the University to ensure diversity in this study. Departments that received communication to be involved in this study included Kinesiology majors of Rehabilitation Science and Exercise Science programs. Other departments of individuals that participated in this study included biology, business, marketing, etc. which ensured a variety of participants experienced this area of study. Recruitment strategies included sharing information through an email, or in-person introduction of the study. Individuals signed up to take part through a database, Signup Genius. Anyone that met all criteria participated, even if they were not enrolled at the University. Before joining the study, all potential participants were informed of all the eligibility requirements, the study requirements, risks, contact information, benefits, and the study procedures were explained again when the participants signed the consent form. All participants received a copy of their consent form at the end of the first session. Overall, to ensure

the best results, there were three separate groups tested which included a control group that had no intervention, use of the percussive therapy gun, or the use of a foam roller. A total of 31 participants were recruited and were randomly selected to a testing group.

### **Instrumentation**

One modality that was used was a massage gun made by the brand MaxKare. This specific device has 5 adjustable speeds and can supply vibration to 10mm (about 0.39 in) of deep muscle tissue. The speed or frequency ranges from the lowest speed of 1200 rpm to the highest speed of 3300 rpm (20 Hz-55Hz). A consistent frequency of 30 Hz was used among all participants that received the percussive therapy. This frequency was chosen because it was a middle ground between two studies that used frequencies between 6 Hz -52 Hz.<sup>3, 11</sup> The MaxKare brand of percussive gun used, had a range of frequency of 20 Hz-55 Hz. It was determined appropriate to use a frequency that was not too little of force to not achieve myofascial release, but also not too much force in which might of caused the participant to be uncomfortable. The massage gun has 6 different head attachments. For this study, the standard ball attachment was used. This attachment is used to target large and small muscle groups. Since the hamstrings were targeted, this attachment was the best fit. Based on another study,<sup>13</sup> the percussive therapy gun provided myofascial release on all 3 of the muscles in the hamstring complex when

used for 60 seconds on the participant's dominant leg, moving the head of the massage gun proximal to distal. An additional 30 seconds of percussive therapy was administered to a section of the hamstring complex that the participant found tight or sensitive, such as trigger points.<sup>14</sup> This helped achieve a more effective myofascial release. Overall, this tool allowed an increase in blood flow and muscle relaxation which was effective in providing myofascial release and increased the participant's range of motion.

Throughout the study, manual goniometer measurements were utilized to measure an individual's range of motion. Taking these measurements allowed us to compare pre-intervention and post-intervention measures to see if there were improvements in range of motion post-intervention. The validity of the goniometer is moderate, so multiple trials were completed so that our measurements would be more accurate.<sup>14</sup> A goniometer was used to conduct four measurements pre-intervention and four measurements post-intervention. The four measurements include two active hip flexion measurements and two passive hip flexion measurements. There tends to be an overestimation of hip range of motion when utilizing the manual goniometer. It was noted that there is an error margin of 2-3 degrees for each measurement.<sup>14</sup> To counter this and increase reliability as much as possible, multiple measurements for each trial were completed. The average of those measurements was recorded in the data.

Increasing the reliability makes this study to be easily replicable for future studies.

The second tool used was a standardized sit and reach assessment to measure an individual's flexibility. A standardized sit and reach box measures how far the participant can extend their fingers past their toes while keeping their dominant knee extended and non-dominant knee bent upwards at approximately a 45-degree angle. Based on current research, the sit and reach assessment is not the most reliable tool to use for measuring flexibility within the hamstrings.<sup>15</sup> To have an accurate representation of measurements, multiple trials were conducted to increase the validity. Due to the financial barrier in this study of being able to purchase more reliable measuring tools, replication, and checking that each participant was being measured correctly and that the tool was set up properly and consistently maximized the accuracy of the measurements. All researchers were qualified to take measurements during the sit and reach assessment as well. Although the reliability of the assessment is not high, having both the goniometer and the sit and reach assessments provided more evidence of hamstring flexibility and how it changed with the use of our alternate modalities.

### **Data collection**

The purpose of our study was to compare the effectiveness of two modalities, a foam roller, and a percussive therapy gun, on their

ability to increase hamstring range of motion. Individuals aged 18-24 are estimated to be the most physically active age group and would benefit from MFR more than other individuals who may not meet the recommended amount of physical activity. The percussive therapy gun is a newer modality that has been introduced to the rehabilitation field and its small, lightweight size makes it convenient for self-myofascial release in any setting.<sup>16</sup> However, since this modality is new, its effectiveness is still being tested and replicated. The percussive therapy gun typically comes with a variety of oscillating head attachments in different shapes and sizes depending on the type of tissue and surface area it is being used on. For this study, the standardized ball head was used to target the hamstring complex. The use of a foam roller is a well-established and well-researched modality that has been effectively utilized in clinics, gyms, and homes for personal myofascial release and to promote the process of soft tissue healing.<sup>17</sup> By comparing these two completely different devices, the results can be used in a recreational or therapeutic setting to help decrease the risk of musculoskeletal conditions as well as increase hamstring range of motion. The control group served as a foundation for the progression or degree of range of motion that our participants produced using the two modalities.

To begin the session, participants started with a 5-minute warmup on a stationary bike. The resistance was adjusted as

necessary to maintain a speed of 60 rev/minute for the whole 5 minutes. After completing the warmup, two researchers obtained all measurements for the two pre-intervention assessments. Next, one researcher left the room while one assigned the participant a random modality, demonstrated, and observed the performance of the modality intervention. After the intervention was administered, both researchers reunited and performed the two post-test assessments. After the first session was completed, the participant was asked if they would be willing to return for a second session. The same process, with the same modality, is repeated for the second session.

### **Measurements**

Overall, a total of 14 measurements were performed in a single session. There are three sit and reach and 4 hip flexion measurements for a total of 7 pre-intervention measurements and 7 post-intervention measurements. For the first measurement, the participants are in a supine position, on a massage table. Using a goniometer, one researcher measured the hip flexion through two active and two passive movements of the participant's dominant leg. Another researcher was present, to help stabilize the other leg of the participant to ensure their hips/glutes did not leave the table to get a more accurate measurement. All measurements were recorded and averaged (passive and active). This was performed pre-intervention and post-intervention.

The next measurement was the sit and reach. This tool is commonly utilized in public schools as an assessment in physical education classes. There were three pre-intervention measurements taken and three post-intervention measurements taken by one researcher. To correctly perform the sit and reach, the participant sat in front of the box with their dominant leg straight out in front of them, with their foot flat on the box and non-dominant leg bent upward at approximately 45-degrees, foot flat on the ground. The participant overlapped one hand over the other, making sure their fingers were parallel with one another and reached forward as far as one could, and held the measurement for 3 seconds. No shoes were required, and measurements were taken at the edge of their fingertip to avoid any bias with longer nails. All 3 measurements were recorded, and an average of the 3 measurements was calculated. It is important to mention that only one researcher took all of the measurements for both the sit and reach and goniometer assessments, and one only assisted. The researcher who assisted performed the intervention of the random modality. The one who performed the measurements left the room so they did not know which modality was assigned to avoid any type of bias that would have an effect on accurate data collection.

### **Modality**

Each participant was randomly assigned a modality. Modalities in this study included a

control group (no intervention), percussive therapy, or a foam roller. Researchers demonstrated how to use all modalities before the participant used them. A stopwatch was used to measure how much time was spent on each muscle to ensure that there were equal amounts of intervention time between all participants. Instructions that were given when using the foam roller or the massage gun were as follows. For the massage gun, participants sat/stood in a neutral position with their dominant leg rested up on a chair at approximately 90 degrees, muscles relaxed, and applied the percussive massage gun to the hamstring muscles of their dominant leg. The massage gun was set at 30Hz and once the researcher instructed the participant to start, they begin moving the gun down (from the glutes to the knee, proximal to distal) down their leg for 60 seconds, making sure to hit all 3 muscles of the hamstring complex. While participants were performing this myofascial release, the dedicated researcher instructed the participant to pay attention to trigger points, or more painful spots that they found while experiencing the percussive massage to help achieve immediate myofascial release.<sup>18</sup> Once the researcher stated that 60 seconds had passed, the participant used the massage gun for an additional 30 seconds to focus on the trigger point areas that they felt during the first 60 seconds, until the massage gun had been used for a total of 90 seconds.

For the foam roller, the modality was used on all 3 hamstring muscles at once. The

participant was in a supine position with one or both of their legs rested on the foam roller. Once the researcher started the timer, the participant moved their hamstring along the foam roller from proximal to distal, then distal to proximal to hit the medial and lateral parts of the muscle as well. The participant was instructed to put enough pressure on their hamstring that the foam rolling might feel a little bit uncomfortable, but not too much where it was painful. After 60 seconds, like the massage gun, participants used the last 30 seconds to focus on trigger points. They were instructed to hold and put pressure on that specific spot or slowly move back and forth on that spot.

The control group was also instructed to sit for a total of 90 seconds as if they were using a modality to avoid a measuring bias from the researcher that did not know which modality was assigned to the participant. Once the intervention was complete, the researcher that had left the room was instructed to return to the room and participants completed the final post-test measurements which were administered by the researcher who performed the pre-intervention measurements and did not administer the intervention.

### **Second Session**

Once the first session was over, participants were asked how they felt and if they'd be willing to continue the study and come back for a second session. The second session consisted of the same process and assigned modality. The next session was scheduled

within the next 48 hours (about 2 days). In the time between sessions, participants were informed to refrain from any stretching or myofascial release techniques (including exercises like yoga, Pilates, etc.). Participants were informed that they may remain consistent with previous workouts if they were physically active.

### Statistical Analyses

In order to test the hypothesis, a 3 x 2 (group, percussion vs. foam roll vs. control by time, pre-test vs. post-test) two-way repeated measures analysis of variance (ANOVA) was employed for each outcome variable for each of the two testing sessions. Outcome variables included passive hip flexion ROM, active hip flexion ROM, and sit-and-reach flexibility. If there was a significant interaction effect, data were split by group assignment to examine the change in outcome variable from pre-test to post-test for each group, and paired samples *t*-tests were employed as follow-up analyses. Additionally, one-way ANOVAs were employed to test the difference in each of the outcome variables across the three groups at pre-test and at post-test. IBM SPSS Statistics version 27 was used for all analyses, and the *p*-value was set at .05 to indicate significance.

### Results

Of the 31 participants who signed the consent form and filled out the initial questionnaire, one participant dropped out of the study. All participants met the eligibility to participate. The flexibility

categories for sit and reach include excellent, good, fair, and poor. 27% of participants assigned the massage gun were in the excellent group, 27% in the good category, 27% in the fair category, and 18% in the poor category. 11% percent of participants assigned to the foam roller were in the excellent group, 22% percent in the good category, 11% percent in the fair category, and 55% in the poor category. 18% percent of participants assigned to the control group were in the excellent group, 9% percent in the good category, 36% percent in the fair category, and 36% in the poor category. Active and passive goniometer measurements were also taken for each modality group. Flexibility categories for goniometer measurements included average or below average. Of participants assigned to the percussive massage gun, 73% of participants were in the average group and 27% were below average in the flexibility category for active goniometer measurements. Of participants assigned to the foam roller, 33% of participants were in the average group and 64% were below average in the flexibility category for active goniometer measurements. Participants assigned to the control group, 55% of participants were in the average group and 45% were below average in the flexibility category for active goniometer measurements. Of participants assigned to the percussive massage gun, 73% of participants were in the average group and 27% were below average in the flexibility category for passive goniometer measurements. assigned to the foam roller,



67% of participants were in the average group and 33% were below average in the flexibility category for passive goniometer measurements. Of participants assigned to the control group, 64% of participants were in the average group and 36% were below average in the flexibility category for passive goniometer measurements. The average standard deviation (SD) was taken for the weight (lbs), height (in), and age (years). SD for weight was  $143 \pm 19.1$  pounds for males and  $123.8 \pm 23.9$  pounds for females. SD for height was  $58.5 \pm 2.2$  inches for males and  $58.5 \pm 2.4$  inches for females. SD for age was  $21 \pm 0.8$  years for males and  $19 \pm 1.3$  years for females.

#### **Goniometer – Active Day 1**

Using an alpha level of .05, a two-way repeated measures ANOVA indicated there was not a significant interaction between time and modality,  $F(2,28) = 0.334$ ,  $MSE = 48.20$ ,  $p = .719$ . The main effect time was significant,  $F(1,28) = 5.37$ ,  $p = .028$ ; however, main effect for modality was not significant,  $F(2,28) = 0.76$ ,  $MSE = 101.75$ ,  $p = .477$ .

#### **Goniometer – Active Day 2**

Using an alpha level of .05, a two-way repeated measures ANOVA indicated there was not a significant interaction between time and modality,  $F(2,28) = 1.21$ ,  $MSE = 22.95$ ,  $p = .314$ . The main effect for time was not significant,  $F(1,28) = 3.59$ ,  $p = .069$ ; main effect for modality was not significant,  $F(2,28) = 1.56$ ,  $MSE = 189.58$ ,  $p = .228$ .

#### **Goniometer – Passive Day 1**

Using an alpha level of .05, a two-way repeated measures ANOVA indicated there was not a significant interaction between time and modality,  $F(2, 28) = 1.406$ ,  $MSE = 36.21$ ,  $p = .262$ . The main effect for time was significant,  $F(1, 28) = 10.89$ ,  $MSE = 279.29$ ,  $p = .003$ ; however, main effect for each individual modality was not significant,  $F(2, 28) = .654$ ,  $MSE = 156.18$ ,  $p = .528$ .

#### **Goniometer – Passive Day 2**

Using an alpha level of .05, a two-way repeated measures ANOVA indicated there was not a significant interaction between time and modality,  $F(2, 28) = 0.034$ ,  $MSE = 0.528$ ,  $p = .967$ . The main effect for time was not significant,  $F(1,28) = 0.033$ ,  $p = .858$ ; main effect for modality was not significant,  $F(2,28) = 0.261$ ,  $MSE = 65.79$ ,  $p = .772$ .

#### **Sit and Reach – Day 1**

Using an alpha level of .05, a two-way repeated measures ANOVA indicated there was not a significant interaction between time and modality,  $F(2, 28) = 2.02$ ,  $MSE = 4.003$ ,  $p = .151$ . The main effect for time was significant,  $F(1,28) = 46.12$ ,  $MSE = 91.193$ ,  $p = .000$ ; however, main effect for modality was not significant,  $F(2, 28) = .89$ ,  $MSE = 71.43$ ,  $p = .422$ .

#### **Sit and Reach – Day 2**

Simple effect follow-up analyses were conducted using paired samples t-tests with a Bonferroni-adjusted alpha of .0167. For the Percussion Therapy group, there was a significant increase in sit and reach on day 2 from pre-test to post-test,  $t(10) = -4.41$ ,  $p =$

.001. For the foam roller group, paired sample t-test indicated a significant increase in sit and reach on day 2 from pre-test to post-test,  $t(8) = -4.53, p = .002$ . For Control group, there was no significant change in Sit and Reach on Day 2 from pre-test to post-test,  $t(10) = -1.29, p = .228$ .

For each time point (Pre-test and Post-test), one-way ANOVA was conducted using an alpha of .0125 for Sit and Reach on Day 2. At both Pre-test and Post-test, the analyses indicated no difference in Sit and Reach on Day 2 across groups (Percussion Therapy vs.

Foam Roller vs. Control),  $F(2,28) = 0.69, MSE = 49.42, p = .557$  and  $F(2,28) = 1.43, MSE = 46.10, p = .256$ , respectively.

Using an alpha level of .05, a two-way repeated measures ANOVA indicated there was not a significant interaction between time and modality,  $F(2, 28) = 6.60, MSE = 1.25, p = .004$ . The main effect for time was significant,  $F(1,28) = 41.77, MSE = 1.25, p < .001$ ; however, main effect for modality was not significant,  $F(2, 28) = 0.92, MSE = 94.27, p = .409$ .

**Table 1.** Participant characteristics by sex

	Male (n=10)	Female (n=21)	Total (N=31)
Weight (lbs)	143 ± 19.1	123.8 ± 23.9	154.6 ± 28.0
Height (in)	58.5 ± 2.2	58.5 ± 2.4	66.3 ± 3.3
Age (years)	21 ± 0.8	19 ± 1.3	21.0 ± 1.2

Note. lbs= pounds; in= inches

**Table 2.** Sit & Reach Day two significance – pre and post-intervention comparison

	Pre-Intervention	Post-Intervention (n=21)	Total (N=31)
PMG (cm)	30.2 ± 7.3	32.3 ± 6.8	31.3 ± 6.9
Foam Roller (cm)	27.8 ± 5.0	30.8 ± 4.9	28.3 ± 5.0
Control (cm)	27.0 ± 8.1	27.5 ± 8.1	27.2 ± 7.9

Note. Values are presented in mean ± standard deviation for continuous variables. PMG = Percussive Massage Gun; cm= centimeters.

**Discussion**

The purpose of this study was to compare the effectiveness of several self-myofascial release modalities on hamstring flexibility and range of motion measured by sit and

reach distance and active and passive hip flexion movements. While the findings from this study did not demonstrate differences among the SMR techniques, all techniques showed acute improvement in the sit-and-reach distance by an average of 1.9 cm. A similar study also found an increase of 1.8

cm after the use of various SMR modalities.<sup>10</sup> There were no significant improvements observed in passive or active hip flexion goniometer measurements.

These findings support the hypothesis previously stated as the participants who used the percussive massage gun showed an acute increase in hamstring flexibility of their dominant limb, indicated by an increase in sit and reach distance between their pre and post-tests. This study followed the protocol used in the Konrad, et al theragun study, which also found an increase in dorsiflexion ROM.<sup>16</sup> The PEM is an SMR modality that has recently increased in popularity, created to be a recovery tool to decrease muscle soreness and increase ROM. Through the use of oscillating pressure, the PEM can allow for manipulation of the fascia and allows for adjustable frequency of repetitions.<sup>3</sup>

The results also support the previous research which states that foam rolling is an effective myofascial release technique to increase muscle flexibility and ROM.<sup>7, 10, 14, 17, 19</sup> Foam rolling has consistently been the most researched and effective method of SMR to date. One explanation for the increase in ROM is the reduction in tissue stiffness and increase in blood flow of the targeted area.<sup>5</sup> As the foam roller places pressure on the soft tissue, friction is generated which can warm the fascia, allowing the tissue to stretch and restore its extensible properties. Additionally, the intense pressure placed on the tissues may

overstimulate the receptors, causing a reduced perception of reaching the stretch endpoint, allowing for increased stretch tolerance and therefore flexibility.<sup>5</sup>

The authors theorize that performing two passive goniometer hip flexion measurements on each participant after they completed the sit and reach assessment but before use of their assigned modality, may have provided a static stretch for participants. This potential multiple treatment interference could explain the increase in sit and reach distance shown in all groups, including the control group. This effect was unintended and should be noted for future studies.

#### *Group Effect*

Utilizing a p-value of .05 or lower signifying significance, repeated measures ANOVA showed us that each group improved hamstring flexibility utilizing the sit and reach instrumentation, specifically in session two. ( $p = .001$ ) It is important to note that there was no significant interaction effect, which alludes to no modalities was specifically better than the other. For the other five dependent variables, sit and reach day one, goniometer active day one, goniometer active day two, goniometer passive day one, and goniometer day two show no significance in interaction effect or group effect.

#### *Correlation with alternate study*

Based on previous articles, it was shown that foam roller does have a significant effect on hamstring flexibility. Most studies that were

reviewed had an intervention for 30-90 seconds (about 1 and a half minutes), young adults, who performed various flexibility assessments. Regarding the percussive massage gun, there was little to no research showing significant effect with this newer modality.

### *Barriers*

While conducting the study, there was a short four-week window that was available for data collection. This created limited opportunities for participants or potential participants to sign up for two consecutive sessions, within forty-eight hours. This could have influenced transportation barriers, time adherence, as well as inability to locate specific testing buildings. In the future, this can be fixed with an extended period of testing. The study design can be altered to create a more flexible schedule, easily accessible location, and spread beyond the University student population.

### *Strength and Limitations*

Within the study, there were numerous strengths. Achieving a sample size greater than our initial goal of 30 participants, there were 32 in total with the addition of one participant being disqualified for not attending the second session. Each modality had nine or more participants, though it was uneven due to an uneven number of participants as well as the individual who was disqualified.

Additionally, this study included both male and female participants, all within the age

range of 18-23 years old. All 31 participants adhered to the criteria of maintaining a current workout as well as avoiding any stretching routine while participating. There were no reports of discomfort or soreness post assessment, or post-trial. Each participant remained healthy, with no injuries reported.

In contrast, there were minor limitations within the study. The gap in the literature regarding the effectiveness of percussive massage guns compared to other modalities in myofascial release was not supported within this study. With no interaction significance across modalities, there was no evidence to support that the percussive massage gun was more effective than the foam roller. Additionally, the sample size goal was achieved, optimizing results in the future should include increasing the sample size as well as adding additional sessions for post and pre-assessment.

Lastly, by adding aerobic or resistance training programs to this study, it expands the population sample to individuals who are physically active and participating in college athletics or any organized athletics. Aerobic and resistance training programs would consist of participation in pre-planned organized workouts, to ensure participants have warmed up their muscles correctly, and it becomes more realistic to participants' daily lifestyle. In addition, expanding the age range beyond 18-24 increases the potential sample size of participants.

### *Future Health Application*

There are high occurrences of musculoskeletal injuries in individuals between the ages of 19-44. Using modalities that increase the ROM in both males and females can additionally reduce occurrences of injuries. As found in the study, using a percussive massage gun and a foam roller is effective as a modality for myofascial release. Both the massage gun and foam roller are effective tools for myofascial release to acutely increase ROM with hip flexion. Health and rehabilitation professionals can utilize these modalities to allow individuals who are physically inactive or physically active to increase their hip range of motion to help reduce musculoskeletal injuries/conditions. Additionally, increasing hamstring flexibility and ROM has been found to help decrease low back pain,<sup>10</sup> which is a problem that can significantly impact an individual's quality of life.

### **Conclusion**

From the data collected through this study, it was determined that in males and females aged 18-24, both the foam roller and the percussive massage gun are effective in increasing hip ROM through myofascial release. Even though the data did not show that one modality was more effective than the other, incorporating either the foam roller and/or the percussive massage gun into a daily routine or a rehab setting can increase range of motion, therefore

releasing tight fascia and decreasing the risks of musculoskeletal conditions.

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