A Comparison of the Pressure Exerted on Soft Tissue by 2 Myofascial Rollers

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Context: Self–myofascial release (SMR) is a technique used to treat myofascial restrictions and restore soft-tissue extensibility. Purpose: To determine whether the pressure and contact area on the lateral thigh differ between a Multilevel rigid roller (MRR) and a Bio-Foam roller (BFR) for participants performing SMR. Participants: Ten healthy young men and women. Methods: Participants performed an SMR technique on the lateral thigh using both myofascial rollers. Thin-film pressure sensels recorded pressure and contact area during each SMR trial. Results: Mean sensel pressure exerted on the soft tissue of the lateral thigh by the MRR (51.8 ± 10.7 kPa) was significantly (P < .001) greater than that of the conventional BFR (33.4 ± 6.4 kPa). Mean contact area of the MRR (47.0 ± 16.1 cm²) was significantly (P < .005) less than that of the BFR (68.4 ± 25.3 cm²). Conclusion: The significantly higher pressure and isolated contact area with the MRR suggest a potential benefit in SMR.

Keywords: flexibility, myofascial release

Soft-tissue injuries represent a significant percentage of athletic injuries. In the 2005–2006 academic school year, approximately 87.3% of reported injuries were soft-tissue injuries. Soft-tissue dysfunction can be initiated by chronic and acute mechanisms including physical trauma, overuse, structural imbalances, or an inflammatory process. Fascia, a tough sheet of connective tissue that envelops and binds together the soft tissue of the body, is often affected. These injuries stimulate the development of inelastic, fibrous adhesions between the layers of the myofascial system that prevent normal muscle mechanics and decrease soft-tissue extensibility. Often overlooked and left untreated, these adhesions can alter surrounding joint mechanics, resulting in pain and further pathology. The treatment and rehabilitation program for these injuries must address this myofascial component to facilitate complete recovery and function.

Soft-tissue injuries have traditionally been treated using a variety of techniques. Although there is debate as to its efficacy, massage therapy continues to be one of the most common therapeutic modalities for treating soft-tissue injuries. In addition, rehabilitation specialists often use spray and stretch, ischemic compression, heat, and electric-current therapies to treat myofascial restrictions.

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Over the past decade, self–myofascial release (SMR) has become a common technique to treat myofascial restrictions and restore normal soft-tissue extensibility.\textsuperscript{12} SMR is increasingly used as a method to supplement traditional methods of treating soft-tissue injuries. During most SMR routines, patients use their body weight on a myofascial roller to exert pressure on the opposing soft tissue. By varying their body positions, patients can use the rollers to isolate specific injured areas of the body and treat restrictions in the soft tissue.

Currently, there is disagreement in literature as to the mechanism of myofascial release. Many authors contend that the application of pressure during myofascial release has an autonomic effect on the soft tissue.\textsuperscript{12,13} Conversely, many believe that myofascial release induces mechanical or histological changes in the myofascial structures.\textsuperscript{2,3,14} Most authors agree, however, that the proper technique for myofascial release involves beginning with superficial soft-tissue layers and gradually working deeper into the soft tissue.\textsuperscript{2,3,13,14} Once deeper tissues are accessed and affected, elongation of the structures is facilitated.\textsuperscript{5}

It has yet to be determined how a myofascial roller’s design might affect the user’s ability to treat restrictions in deeper layers of the fascia with SMR. It seems reasonable that roller material and design can influence the level of pressure exerted on the soft tissue and therefore might allow the patient to access deeper layers of the fascia. Fredericson\textsuperscript{15} has presented the use of a foam myofascial roller to treat myofascial adhesions. One potential limitation with a highly compressible myofascial roller is that as it deforms under the patient’s body weight, less pressure is applied to the targeted soft tissue and the roller becomes a more superficial tool. Therefore, the purpose of this study was to compare the pressure and contact area on the soft tissue of the lateral thigh and iliotibial band (ITB) while participants performed SMR with 2 myofascial rollers of different compressibility.

\section*{Methods}

\subsection*{Participants}
Ten healthy college-age individuals (age 20.8 $\pm$ 1.1 years, height 177.3 $\pm$ 10.3 cm, mass 80.7 $\pm$ 22.1 kg; 5 men, 5 women) volunteered for this study. Individuals were excluded from the study if they had experienced any lower extremity injury or undergone any lower extremity surgical procedures in the 6 months preceding the study. Before participation, a verbal explanation of the study was given and participants read and signed an informed-consent form. A university institutional review board approved this study.

\subsection*{Instrumentation}
Two myofascial rollers were compared in this study: the Bio-Foam roller (BFR; Perform Better, Inc, Cranston, RI) and the Multilevel rigid roller (MRR; Collins Sports Medicine, Raynham, MA). The BFR is composed of a uniform polystyrene foam cylinder with a 15.24-cm diameter and 30.48-cm length. The MRR is a non-uniform cylinder consisting of a hollow polyvinyl chloride inner core (wall thickness 0.64 cm) enclosed in a layer of neoprene (thickness 0.32 cm) with a 9.53-cm outer diameter and 45.72-cm length.
Pressure data were recorded by a Tekscan 5250 sensor (Tekscan, Inc, South Boston, MA) with overall dimensions of 246 mm × 246 mm and a matrix consisting of 1936 sensels, each with an area of 31.2 mm. Each sensel had a saturation pressure of 69.0 kPa. The 5250 sensor was affixed to the rollers. The 5250 sensor was selected based on the overall area, sensel area, and saturation pressure. All data were collected using I-Scan software (Tekscan) and stored to a PC. Data were exported to a Microsoft Excel (Microsoft Corp, Seattle, WA) spreadsheet and analyzed using a MATLAB (The MathWorks, Inc, Natick, MA) program modified from Drewniak et al.¹⁶

**Calibration**

Before each testing session, the 5250 sensor was conditioned and calibrated in accordance with the manufacturer’s recommendations. Sensels were conditioned 4 times at 120% of the maximum expected load. They were calibrated using the Tekscan linear 2-point calibration by applying 20% and 80% of the maximum expected load. Applied loads were estimated using the participant’s weight.

**Procedure**

Participants’ height, weight, length from greater trochanter to lateral joint line of the knee, length from umbilicus to media malleolus, and girth at midpoint of the thigh were recorded before testing. An Ober test was used to determine pretest and posttest ITB flexibility. Data were collected on both legs of each participant. The MRR and BFR were randomly allocated to each leg; rollers were used on opposite legs. Participants were instructed on how to perform the SMR technique on the region of the ITB and lateral thigh (Figure 1). They were allowed to practice the technique until they felt comfortable performing SMR. Participants were instructed to recline onto the selected myofascial roller positioned under the lateral aspect of the involved leg. While supporting the upper body with their elbow on the floor, they positioned their greater trochanter superiorly on the roller with the distal leg

![Figure 1](image_url) — Proper lateral thigh and iliotibial-band self-myofascial-release technique using the Multilevel rigid roller as described in the text.
traversing the ridge of roller. The leg was extended straight with the foot in plantar flexion. The contralateral leg was crossed over the involved leg at an approximately 90° angle and was used to propel the participant back and forth, as well as stabilize the participant. The forearm of the selected side lay flat on the ground parallel to the roller and was also used to propel and stabilize the participant. The contralateral-side arm was bent, with the hand resting on the uninvolved hip.

The participants were instructed to roll starting at their greater trochanter down their lateral thigh approximately 24 cm and return to the start position in 10 seconds. This action was performed 3 times in each trial. Three trials of data were obtained for each myofascial roller. Data were monitored by the authors visually using the I-Scan software.

Data Analysis

Data were manually filtered to only include frames during which the participant was completely on the 5250 sensor. Data were converted to ASCII and saved in Excel. A custom MATLAB program modified from a prior study\(^\text{16}\) filtered and removed sensels below a threshold value of 13.8 kPa. Data were filtered in an effort to minimize edge effects, often considered noise within the system. The program calculated mean sensel pressure by summing the filtered data and dividing by the number of active sensels for each frame of a trial. Contact area was determined for each frame by multiplying sensel area by the number of active sensels; mean contact area over the trial was determined by summing the contact areas over all frames and dividing by the number of frames. Pressure data were normalized for contact area by dividing the total pressure for each frame by the contact area for the frame. Finally, data were plotted against each subject’s physical dimensions, and linear regressions were calculated to assess any correlations between subjects’ physical dimensions and pressure.

Statistical Analyses

Variations in mean sensel pressure, mean contact area, and mean pressure per contact area between myofascial rollers were assessed using a 2-tailed paired Student \(t\) test (SigmaStat 3.1, Systat Software, Inc, Point Richmond, CA). The significance value of \(P < .05\) was set a priori.

Results

During SMR, the MRR produced significantly \((P < .001)\) more pressure on the soft tissue of the participant’s lateral thigh than a conventional BFR (Figure 2). The mean pressure exerted by the MRR was \(51.8 \pm 10.7\) kPa, whereas the mean pressure exerted by the BFR was \(33.4 \pm 6.4\) kPa (Table 1). Mean contact area was significantly \((P < .005)\) greater for the BFR (68.4 \pm 25.3 cm\(^2\)) than the MRR (47.0 \pm 16.1 cm\(^2\); Figure 3). Mean contact area using the BFR was greater than mean contact area using the MRR for all participants except 1. In that participant’s case, both rollers demonstrated similar contact areas. Normalized pressure data for contact area were significantly higher \((P < .001)\) for the MRR (165.7 kPa/cm\(^2\)) than the BFR (107.0 kPa/cm\(^2\); Figure 4). Pretest and posttest measurements
Curran, Fiore, and Crisco showed that each participant’s legs had similar physical characteristics and ITB flexibility.

As indicated in Figure 5, there was no correlation between subject body weight and pressure exerted on the lateral thigh for either roller type ($P_{MRR} = .93, R^2_{MRR} = .001; P_{BFR} = .79, R^2_{BFR} = .010$). Similarly, we found no correlation between subject leg girth and pressure exerted on the lateral thigh by either the MRR ($P = .74, R^2 = .015$) or the BFR ($P = .84, R^2 = .005$). We also determined that normalized pressure data did not correlate to body weight ($P_{MRR} = .94, R^2_{MRR} = .001; P_{BFR} = .79, R^2_{BFR} = .010$) or leg girth ($P_{MRR} = .74, R^2_{MRR} = .014; P_{BFR} = .84, R^2_{BFR} = .005$) for either the MRR or BFR. Finally, we found that there was a correlation between contact area and both body weight ($P_{MRR} < .005, R^2_{MRR} = .662; P_{BFR} < .05, R^2_{BFR} = .557$) and leg girth ($P_{MRR} < .001, R^2_{MRR} = .807; P_{BFR} < .05, R^2_{BFR} = .465$).

**Discussion**

SMR has been introduced in the literature as a method to treat restrictions in the fascia resulting from soft-tissue injury. Although several researchers have discussed the potential applicability of the treatment, there are limited clinical data demonstrating the efficacy or mechanism of this technique. The purpose of this study was not to investigate roller efficacy for SMR but to examine 2 commonly used apparatuses for SMR. We hypothesized that a more rigid roller design would exert more pressure over a smaller area on the soft tissue of the lateral thigh during performance of an SMR technique than the conventional roller design. Although the data presented here might appear to be intuitive, this study is of clinical significance because of the popularity of SMR rollers. In addition, these data might be applicable as reference for future studies examining the efficacy or mechanism of SMR. Direct comparison of our findings with other studies is limited because there are no known previous studies.
Table 1  Mean Sensel Pressure, Contact Area, and Pressure per Contact Area of the 2 Rollers for Each Participant

<table>
<thead>
<tr>
<th>Subject</th>
<th>Men</th>
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<tr>
<td>Multilevel rigid roller</td>
<td>68.8</td>
<td>62.5</td>
<td>52.1</td>
<td>41.0</td>
<td>48.1</td>
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<td>43.1</td>
<td>67.1</td>
<td>43.1</td>
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<tr>
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<td>26.1</td>
<td>34.2</td>
<td></td>
<td>33.6</td>
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<td>22.0</td>
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<tr>
<td>Multilevel rigid roller</td>
<td>60.9</td>
<td>33.9</td>
<td>46.2</td>
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Examining 2 myofascial rollers, we found that an MRR applied significantly more pressure on the soft tissue than a BFR during an SMR technique. Although no studies have addressed the therapeutic benefits of increased pressure for inducing SMR, several researchers have examined the benefits of increased pressure during myofascial release and massage therapies. Many authors²,³,¹³,¹⁷,¹⁸ believe that deep, sustained therapies during the subacute phase of inflammation might increase muscle extensibility and tissue strength through the stimulation of the autonomic nervous system and by relaxing myofascial structures deep in the soft tissue. We contend that similar to these therapies, higher pressure values exerted...
Pressure Exerted by Myofascial Rollers

by the MRR might allow deeper penetration into the soft tissue than with the BFR. Although this research was not designed to examine the mechanism of myofascial release during SMR, prior studies indicate that deeper penetration might aid in the overall healing process of damaged tissue and increase muscle extensibility if introduced at the appropriate time in the process.

In this study we showed that roller design significantly affected the contact area between the roller and the soft tissue. We found that the contact area between the lateral thigh and the myofascial roller was significantly less for the MRR than for the BFR. By monitoring each participant’s SMR technique, we were able to ensure that both rollers exerted similar force on the lateral thigh. The design of the MRR enabled participants to apply the same load as with the BFR over an isolated, less deformable contact area and exert increased levels of pressure on the lateral thigh. We found that it was important to normalize pressure for contact area to account for size differences between roller types. After normalization, we found that pressure per contact area was significantly (P < .001) higher for the MRR than for the BFR. This indicates that the MRR in contact with the lateral thigh maintains its rigid shape and does not deform under an applied load as the BFR does. This is important because it enables a subject to isolate a specific region of soft tissue. Figure 6 illustrates an example of a more localized distribution of

Figure 5 — Mean pressure versus body weight for each subject. These data demonstrate that pressure exerted is not a function of subject body weight but rather a function of the subject’s self-myofascial-release technique. Linear regressions were calculated for all subjects for each roller type. Abbreviations: MRR, Multilevel rigid roller; BFR, Bio-Foam roller.
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pressure on the lateral thigh by the MRR than by the BFR for 1 trial. In this example, the maximum pressure exerted by the MRR over the length of the ITB was greater than 158.6 kPa, whereas the maximum pressure using the BFR was 110.3 kPa. Examining the MRR data, we saw concentric pressure rings focusing around the targeted treatment area of the ITB. This figure further demonstrates the ability of the MRR to apply the subject’s body weight over a more isolated area of soft tissue.

We determined that pressure exerted on the lateral thigh was not a function of subject body weight or leg girth. We find this of clinical significance because it indicates that a patient’s technique, rather than physical dimensions, might have more of an impact on the level of pressure exerted on the underlying tissue. This is important because it indicates that subjects can vary body positioning to access and treat adhesions deeper in the soft tissue.

Several studies have evaluated the use of the Tekscan system to measure contact pressure and contact area for biomedical applications. 19,20 Although more accurate than other pressure-measurement systems, Tekscan is believed to show a degree of inaccuracy. One study described a method for filtering data that reduced error in contact area to less than 1%.16 We used a similar filtering algorithm to minimize edge effects. Applying this filtering algorithm, we believe that we were able to obtain data accurate to within 1%.

This study had several limitations. It is important to note that our participants modeled an SMR technique over 3 revolutions and did not perform SMR. Data were clearly elucidated by the modeled SMR motion and did not require extended trials. Additional trials, however, might have illustrated more detailed trends. In addition, data in this trial were obtained from a small sample size and did not account for gender differences. Although data were found to be significant in all analyses, the small sample size could poorly represent the true patient population. Furthermore, although data were obtained from both sexes, a comparison between genders did not yield significant differences. Finally, the clinical effectiveness of the myofascial rollers was not examined in this study. The goal of this study was to examine the potential therapeutic characteristics of the myofascial rollers. Given the results of this study, future studies will be needed to compare the effectiveness of the rollers with conventional methods of treatment. Currently, there is disagreement in literature as to the mechanism of myofascial release and the levels of force.

Figure 6 — Maximum pressure exerted on the lateral thigh by each roller over one 30-second trial. (a) Multilevel rigid roller (MRR). (b) Bio-Foam roller (BFR).
that trigger it. It can be implied from the literature, however, that deeper therapies, such as might be obtained using the MRR, might yield a higher therapeutic benefit.\textsuperscript{2,11,13} In addition, the athletic training staff at our institution have found the rigid rollers to be useful when treating subacute soft-tissue injuries in athletes. Nonetheless, there has not been a formal study to determine their efficacy.

**Conclusion**

SMR is a common therapy used to increase soft-tissue extensibility and decrease muscle soreness. This study shows that the MRR exerts more pressure on the soft tissue than the BFR during SMR. Although its mechanism is not exactly known, we believe that increased pressure might result in myofascial release and treatment of adhesions deep in the soft tissue. Further research must be conducted to explore the mechanism of myofascial release and to evaluate the effectiveness of the SMR technique using various myofascial rollers.

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**References**