Note: This article will be published in a forthcoming issue of the *Journal of Sport Rehabilitation*. The article appears here in its accepted, peer-reviewed form, as it was provided by the submitting author. It has not been copyedited, proofed, or formatted by the publisher.

Section: Original Research Report

Article Title: Self-Myofascial Release of the Superficial Back Line Improves Sit-and-Reach Distance

Authors: Whitney Williams and Noelle M. Selkow

Affiliations: School of Kinesiology and Recreation, Illinois State University, Normal, IL.

Running Head: Self-myofascial release of the SBL

Journal: *Journal of Sport Rehabilitation*

Acceptance Date: February 6, 2019

DOI: https://doi.org/10.1123/jsr.2018-0306

SELF MYOFASCIAL RELEASE OF THE HAMSTRING IMPROVES SIT-AND-REACH DISTANCE

Whitney Williams
Illinois State University
School of Kinesiology and Recreation
Campus Box 5120
Normal, IL, 61761
williamswhit20@gmail.com

Noelle M. Selkow, PhD, ATC (Corresponding Author)
Illinois State University
School of Kinesiology and Recreation
Campus Box 5120
Normal, IL, 61761
nselkow@ilstu.edu

"Self-Myofascial Release of the Superficial Back Line Improves Sit-and-Reach Distance" by Williams W, Selkow NM
Journal of Sport Rehabilitation

Abstract

Context: Decreased hamstring flexibility can lead to a plethora of musculoskeletal injuries, including low back pain, hamstring strains, and patellofemoral pain. Lack of flexibility may be the result of myofascial adhesions. The fascia connected to the hamstrings is part of the superficial back line that runs from the cranium to the plantar aspect of the foot. Any disruption along this chain may limit flexibility of the hamstring. **Objective**: The aim of this study was to investigate if self-myofascial release (SMR) of the plantar surface of the foot in addition to the hamstring group was more effective at improving flexibility of the hamstrings when compared to either intervention alone. **Design**: Crossover Study. **Setting**: Athletic Training Facility. Patients (or Other Participants): Fifteen collegiate students (5 Males and 10 Females Age: 20.9±1.4 years; Height: 173.1±10.3cm; Mass: 80.0±24.9Kg) with no history of low back pain or injury within the past six months, no history of leg pain or injury within the past six months, no current signs or symptoms of cervical or lumbar radicular pain, no current complaint of numbness or tingling in the lower extremity, and no history of surgery on the lower extremity or legs. **Intervention(s)**: Each participant received each intervention separated by at least 96 hours in a randomized order: hamstring foam rolling, lacrosse ball on plantar surface of foot, and combination of both. **Main Outcome Measures**: The sit-and-reach test evaluated hamstring flexibility of each participant before and immediately after each intervention. **Results**: There were no significant differences found among the SMR techniques on sit-and-reach distance ($F\ 2, 41)=2.7$, $p = .079$, partial eta squared = .12. However, at least 20% of participants in each intervention improved sit-and-reach distance by 2.5cm. **Conclusions**: Self-myofascial release may improve sit-and-reach distance, but one technique of SMR does not seem to be superior to another.

Flexibility is important in both the prevention and the rehabilitation of musculoskeletal injuries.[1] Range of motion (ROM) is a measurement of flexibility determined by joint structure, congruency, capsuloligamentous structures, and muscles. Reduced joint ROM may result from a plethora of factors, including physical activity level, fascial adhesions, and muscle tightness.[2,3] One cause of muscle tightness that may result in decreased flexibility can be from an increase in active or passive tension within the structure. Although active tension shortens the muscle through spasm or contraction, passive tension is caused by postural adaptation or scarring.[1] As a consequence, ROM abnormalities may create muscle imbalances.[4] This can lead to the disruption of force couples around joints. A force couple is defined as equal and parallel forces that act in opposing directions to create rotation,[5] so when imbalances occur, alterations in mechanical alignment and load affect the kinetic chain. For example, muscle tightness of the hamstrings pulls the ipsilateral innominate bone of the pelvis posteriorly, shortening the abdominal muscles. In return, the erector spinae and hip flexors become lengthened and weak, often leading to low back pain.[6]

In addition to alterations in force couples, the fascial network connecting muscles together can also be compromised with adhesions, leading to "knots" in the connective tissue altering ROM throughout the kinetic chain. Fascia is connective tissue that surrounds every nerve, blood vessel and muscle fiber in the human body. It connects bones, muscles and organs in large networks throughout the body,[7] commonly referred to as "anatomy trains".[8] Anatomical dissections have confirmed the continuity of the fascial system in the upper and lower limbs.[9,10] Due to this association, tension at a particular part of the fascia may have adverse effects resulting in a decrease in flexibility.[8,10] The "anatomy train" suggested to be mostly related to injuries of the hamstrings is the superficial back line (SBL).[8] The SBL contains the plantar fascia and short toe

flexors (lumbricals, flexor accessories and flexor digitorum brevis), the Achilles and the triceps surae (gastrocnemius and soleus), the hamstrings (semimembranosus, semitendinosus, and biceps femoris), sacrotuberous ligament, the fascia of the sacrolumbar area, erector spinae, and finally the epicranial fascia which extends and attaches to the supra orbital ridge on the anterior surface of the cranium.[8] In the Anatomy Trains Text, Myers[8] provided an example of how rolling the plantar aspect of the foot with a tennis or golf ball improved ROM or "flexibility" of the hamstrings. This demonstrated that myofascial release applied to one area of the SBL can affect another area of the "train". Additional studies have found improved flexibility of the hamstrings with the use of self-myofascial release (SMR) to parts of the body away from the hamstrings.[11,12]

SMR is a technique to allow a person to manipulate adhesions on their own utilizing a foam roller or dense ball. The foam roller is a solid foam cylinder available in different variations of hardness and size. A mechanism for why foam rolling may improve ROM is that it stimulates hydration of tissues.[7] While rolling, soft tissue is squeezed like a sponge then becomes soaked through with fluid when relaxed. This improves motion between the different layers of fascia and increases blood flow and temperature.[7] It is hypothesized that foam rolling releases fascial adhesions to improve ROM.[13] In addition, foam rolling can be used as additional warm-up[14] and self-massage[15].

The sit-and-reach test is widely used to estimate flexibility through the lumbopelvic region and hamstrings. According to the American College of Sport Medicine, a change of one inch (~2.5 cm) would increase the percentile of flexibility a young adult (both male and female) would fall into.[16]

Therefore, the aim of this study was to investigate if SMR of the plantar surface of the foot in addition to the hamstring group was more effective at improving flexibility of the hamstrings

when compared to either intervention alone. We hypothesized that the combination of SMR to the feet and hamstrings would yield the greatest improvement in flexibility as measured by the sit-and-reach test.

METHODS

Design

This was a single-blinded cross-over study with randomization of intervention order. The independent variables were intervention (SMR to the hamstrings, SMR to the feet, and SMR to both the hamstrings and feet) and time (pre and post intervention). The dependent variable was sit-and-reach distance (cm). The investigator measuring sit-and-reach distance was blinded to the intervention.

Patients or Participants

Fifteen collegiate students (5 Males and 10 Females Age: 20.9 ± 1.4 years; Height: 173.1 ± 10.3 cm; Mass: 80.0 ± 24.9 Kg) volunteered for this study. Participants were excluded from the study if they were older than 30 to limit associated age changes to flexibility, no history of low back pain or injury within the past six months, no history of leg pain or injury within the past six months, no current signs or symptoms of cervical or lumbar radicular pain, no current complaint of numbness or tingling in the lower extremity, and no history of surgery on the lower extremity or legs. The Institutional Review Board (IRB) approved this study and all participants signed informed consent.

Instrumentation

A sit-and-reach test was used to determine the difference in flexibility reported as mean ± SD. Baseline and post intervention flexibility was assessed using a sit-and-reach box (Cranlea, Birmingham UK). The outcome measure is a valid measurement for hamstring flexibility,[17] and

correlations have been found between the sit-and-reach test and lumbar spine flexibility.[18] It was selected for use in the current study due to the unique ability to incorporate lumbar spine and flexibility of the hamstrings simultaneously while tensioning the superficial back line.[19]

Procedures

The participants were randomly assigned the order in which they would perform each intervention using a computerized random number generator (random.org). Each intervention was completed on a separate day with 96 hours between sessions with a pretest and posttest evaluation for each session. With limited research on the acute effects of SMR, we chose our wash-out period to be 96 hours from clinical experience based on when patients would no longer maintain ROM gains from SMR.

Each participant was asked to not go through any warm up prior to testing. All sit-and-reach testing was performed by one clinician. Participants were educated on how to perform the sit-and-reach using three warm up attempts. All participants sat with the heels/soles of their feet flat against the box, with knees fully extended, reaching forward as far as possible without breaking form and fingertips at the correct position on the metal slider. Participants were instructed to reach forward as far as possible, with their fingertips pushing the measuring gauge, and hold the maximal reach for two seconds.[20] Three measurements were recorded and the average was calculated.

Interventions

The three interventions included: SMR on the hamstrings using a foam roller, SMR on the plantar surface of the foot using a lacrosse ball, and a combination of the SMR on the hamstrings and plantar surface of the foot. All interventions were administered by one clinician. Participants were taught SMR of the hamstrings and the plantar surface of the foot, using a predetermined script

which was sufficient for the participant to complete the intervention competently and reduced bias.[21]

For the SMR of the hamstrings using a foam roller, participants were instructed to use a foam roller (Perform Better Elite molded Foam Roller, 3' x 6", Black) to roll on the posterior aspect of their thigh while supine for two minutes on both legs. The length of the hamstring was rolled at 60 bpm with a metronome.[22] Participants were instructed to apply as much pressure as they could, pushing into discomfort but not pain, as greater pressures have shown to have better benefits on flexibility.[23]

For the SMR of the plantar surface of the foot, participants were instructed to roll a lacrosse ball on the sole of each foot from behind the metatarsal heads to the heel concentrating on the medial arch for two minutes[12] to the beat of a metronome set to 90 bpm. The researchers wanted consistency among participants and chose this cadence based on experimentation in our lab associated with patient comfort, as it had not been documented in the literature. It is a faster cadence compared to the hamstrings due to the smaller length of the plantar fascia. Participants were instructed to apply as much pressure as they could, pushing into discomfort but not pain, as greater pressures have shown to have better benefits on flexibility.[23]

For the combination intervention, participants were instructed as they were for each of the individual treatments. The combination treatment was two minutes of SMR on the hamstrings and two minutes of SMR of each plantar surfaces of the foot with the same cadence settings. Rolling of the feet occurred first, with randomization of which foot started. There was a one minute rest before the hamstrings were rolled.

Statistical Analysis

SPSS Statistical software SPSS (IBM SPSS Statistics for Windows, version 25.0; IBM Corp, Armonk, NY) was used to analyze all data. A 3 x 2 repeated measures ANOVA was conducted to compare the effectiveness of SMR on the sit-and-reach test reported in mean ± SD. The independent variables were the SMR technique (foot, hamstrings, and both) and time (pre-intervention and post-intervention) and the dependent variable was distance (cm) on the sit-and-reach test. Alpha was set *a priori* at $\alpha \leq 0.05$. Total sample size was calculated for 25 participants based on the results presented by Grieve at al.[12]

RESULTS

Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, and homogeneity of variances. There were no significant differences found among the SMR techniques on sit-and-reach distance (F 2, 41) = 2.7, p = .079, partial eta squared = .12 Table 1. The order in which the interventions were applied also did not have a significant influence on the results (p = .079). The average improvement in sit-and-reach distance for all interventions combined was 1.8 ± 1.4cm.

Improvement of 2.5cm or more on the sit-and-reach test, appears to be slightly better for the hamstrings, as 5/15 participants (30%) showed the greatest improvement. SMR of the foot only showed improvement in 3/15 participants (20%) and a combination of hamstring and foot SMR showed improvement in 4/15 participants (26.7%). The participants that showed improvement in one intervention did not always show improvement in the other interventions. Individual before/after changes for each intervention are presented in Figures 1-3.

DISCUSSION

The purpose of this study was to analyze the effect of different types of self-myofascial release on changes in sit-and-reach distance. While the findings from this study did not find differences among the SMR techniques, all techniques did show improvement in sit-and-reach distance by an average of approximately 1.8 cm. As clinicians, we felt that an improvement of 2.5 cm from one session of SMR was clinically meaningful and beneficial to the patient. This correlates to an improvement of 1 inch and would move a person into a higher percentile for the sit and reach test.[16]

The improvement in hamstring flexibility with the foam roller on the hamstrings is supportive of recent research on SMR techniques using the foam roller on the hamstring specifically. Foam rolling is reported to improve mobility, reduce scar tissue and adhesions, and decrease muscle tone in overactive muscles.[24] These factors help improve ROM throughout the muscle when applied directly to it. Although, it is important to note that lumbar spine mobility may have also been improved due to the relationship of the hamstrings to the SBL and the sit-and-reach test measuring lumbopelvic and flexibility of the hamstrings.

SMR is exerting mechanical pressure and is theorized to decrease adhesions between tissue layers, improve muscular compliance and decrease muscle stiffness of the muscle fibers when SMR is applied directly to the muscle belly.[13,25] The physiology behind SMR can be attributed to the autonomic and central nervous systems. Within the autonomic nervous system the interstitial type III and IV receptors are stimulated and lower overall sympathetic tone, increase gamma motor neuron activity and promote relaxation of intra-fascial smooth muscle cells.[26] It is also believed that the autonomic nervous system promotes vasodilation and local fluid dynamics which increases soft-tissue compliance, allowing for greater ROM.[26-28] Combined effects have been associated

with improved muscle function and flexibility and may have a potential association with trigger point release.[28-30]

In reference to the SBL, there is support that tension within one area of the "line" can affect function in another area. For example, tightness within the gastrocnemius/Achilles tendon is associated with heel pain and plantar fasciitis.[31] As clinicians, it is important to address rehabilitation from a whole body perspective, instead of the specific area of pain and/or injury, particularly chronic and overuse injuries. It also appears force transmitted along fascial lines can affect strength gains and ROM.[31]

The lack of hamstring flexibility and ROM is a risk factor for low back pain. People with short hamstring muscles tend to compensate with increased lumbar flexion during bending forward, sitting down, or reaching toward the toes.[32] Salder et al.[33] reported that restriction in lateral flexion and hamstring ROM, as well as limited lumbar lordosis were associated with an increased risk of developing LBP. SMR is an easy and convenient way to increase flexibility of the SBL and potentially decrease risk of injury. With the feasibility of performing SMR techniques in a variety of settings (clinic, home, etc), SMR can be incorporated into long-term rehabilitation plans for flexibility by utilizing this technique at the beginning of a rehabilitation session, followed by stretching and strengthening that utilizes the increased ROM.

LIMITATIONS

There are a number of limitations to bear in mind when interpreting the results of the present study. Limitations of this study included the amount of time and pressure that were applied to each area. Each participant was instructed to apply pressure until discomfort, but not pain. This resulted in each participant placing a different amount of pressure through the foam roller and the lacrosse ball. The time between each session was 96 hours (4 days) and this may have led to an

accumulation effect of the treatments used. The population was also small and relatively homogenous limiting generalizability to other ages, as well as participants were healthy and not necessarily lacking flexibility.

CONCLUSION

Self-myofascial release may improve sit-and-reach distance, but one technique of SMR does not seem to be superior to another. SMR is patient driven and can decrease the time a clinician spends on individual myofascial release treatments.

ACKNOWLEDGEMENTS

The authors would like to thank Jonathan Roman, MS, ATC for his help with data collection to maintain blinding of treatment effects.

REFERENCES

1. Shadmehr A, Hadian MR, Naiemi SS, Jalaie S. Hamstring flexibility in young women following passive stretch and muscle energy technique. *J Back Musculoskelet Rehabil.* 2009;22(3):143-148.

2. Beijsterveldt AMC, Port IGL, Vereijken AJ, Backx FJG. Risk Factors for Hamstring Injuries in Male Soccer Players: A Systematic Review of Prospective Studies. *Scandinavian Journal of Medicine & Science in Sports.* 2013;23(3):253-262.

3. Freckleton G, Pizzari T. Risk factors for hamstring muscle strain injury in sport: a systematic review and meta-analysis. *British Journal of Sports Medicine.* 2013;47(6):1-9.

4. Page P. Current concepts in muscle stretching for exercise and rehabilitation. *Int J Sports Phys Ther.* 2012;7(1):109-119.

5. Luttgens K, Wells KF: Kinesiology: Scientific Basis of Human Motion (7th Ed). Philadelphia: Saunders College, 1982

6. Gajdosik RL, Hatcher CK, Whitsell S. Influence of short hamstring muscles on the pelvis and lumbar spine in standing and during the toe-touch test. Clin Biomech (Bristol, Avon) 1992 7:38–42.

7. Schleip R, Müller DG. Training principles for fascial connective tissues: scientific foundation and suggested practical applications. *J Bodyw Mov Ther.* 2013;17(1):103-115.

8. Myers T. *Anatomy Trains: Myofascial Meridians for Manual and Movement Therapists.* United States of America: Churchill Livingstone Elsevier; 2014.

9. Stecco C, Gagey O, Belloni A, et al. Anatomy of the deep fascia of the upper limb. Second part: study of innervation. *Morphologie.* 2007;91(292):38-43.

10. Stecco C, Porzionato A, Lancerotto L, et al. Histological study of the deep fasciae of the limbs. *J Bodyw Mov Ther.* 2008;12(3):225-230.

11. Cho SH, Kim SH, Park DJ. The comparison of the immediate effects of application of the suboccipital muscle inhibition and self-myofascial release techniques in the suboccipital region on short hamstring. *J Phys Ther Sci.* 2015;27(1):195-197.

12. Grieve R et al. The immediate effect of bilateral self myofascial release on the plantar surface of the feet on hamstring and lumbar spine flexibility: A pilot randomised controlled trial. *J Bodyw Mov Ther.*2015;19(3):544-552.

13. Schleip R. Fascial plasticity – a new neurobiological explanation. *J Bodyw Mov Ther*. 2003;7(1):11-19 and 7(2):104-116.

14. Sullivan KM, Sivley DBJ, Button DC et al. The immediate effects of self-myofascial release on female footballers. *Sports Exerc Dynamics*. 2013;38(10):12-17

15. Chaudhry H, Schleip R, Ji Z et al. Three-dimensional mathematical model for deformation of human fasciae in manual therapy. *J Am Osteopath Assoc.* 2008;108:379-390.

16. Golding LA, Myers CR, Sinning WE, eds. Y's Way to Physical Fitness. 3rd ed. Champaign, IL: HUman Kinetics, 1989.

17. Baltaci G, Un N, Tunay V, Besler A, Gerçeker S. Comparison of three different sit and reach tests for measurement of hamstring flexibility in female university students. *Br J Sports Med.* 2003;37(1):59-61.

18. Grenier SG, Russell C, McGill SM. Relationships between lumbar flexibility, sit-and-reach test, and a previous history of low back discomfort in industrial workers. *Can J Appl Physiol.* 2003;28(2):165-177.

19. Mayorga-Vega D, Merino-Marban R, Viciana J. Criterion-Related Validity of Sit-and-Reach Tests for Estimating Hamstring and Lumbar Extensibility: a Meta-Analysis. *J Sports Sci Med.* 2014;13(1):1-14.

20. Lemmink KA, Kemper HC, de Greef MH, Rispens P, Stevens M. The validity of the sit-and-reach test and the modified sit-and-reach test in middle-aged to older men and women. *Res Q Exerc Sport.* 2003;74(3):331-336.

21. MacDonald G, Penney M, Mullaley M, et al. 2013. An acute Bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. J. Strength Cond. Res. 27 (3), 812e821.

22. Wilke J, Niemeyer P, Niederer D, Schleip R, Banzer W. Influence of Foam Rolling Velocity on Knee Range of Motion and Tissue Stiffness: A Randomized, Controlled Crossover Trial. *J Sport Rehabil.* 2018 Jun 28: 1-17 doi: 10.1123/jsr.2018-0041.

23. Curran PF, Fiore RD, Crisco JJ. A comparison of the pressure exerted on soft tissue by 2 myofascial rollers. *J Sport Rehabil.* 2008;17(4):432-442.

24. Stecco C, Schleip R. A fascia and the fascial system. *J Bodyw Mov Ther.* 2016;20(1):139-140.

25. Kalichman L, Ben David C. Effect of self-myofascial release on myofascial pain, muscle flexibility, and strength: A narrative review. *J Bodyw Mov Ther.* 2017;21(2):446-451.

26. Wiktorsson-Möller M, Oberg B, Ekstrand J, Gillquist J. Effects of warming up, massage, and stretching on range of motion and muscle strength in the lower extremity. *Am J Sports Med.* 1983;11(4):249-252.

27. Paolini J. Review of myofascial release as an effective massage therapy technique. *Athl Ther Today.* 2009(15):30-34.

28. Barnes MF. The basic science of myofascial release: morphological change in connective tissue. *J Bodyw Move Ther.* 1997;1(4):231-238.

29. Abes KM. The Impact of Faom Rolling on Exploive Strength and Excitability of the Motor Neuron Pool. In. The University of Texas at Austin2013.

30. Schleip R, Jäger H, Klingler W. What is 'fascia'? A review of different nomenclatures. *J Bodyw Mov Ther.* 2012;16(4):496-502.

31. Krause F, Wilke J, Vogt L, Banzer W Intermuscular force transmission along myofascial chains: a systematic review. *J Anat.* 2016;228(6):910-918.

32. Sahrmann S, Azevedo DC, Dillen LV. Diagnosis and treatment of movement system impairment syndromes. *Braz J Phys Ther.* 2017.

33. Sadler SG, Spink MJ, Ho A, De Jonge XJ, Chuter VH. Restriction in lateral bending range of motion, lumbar lordosis, and hamstring flexibility predicts the development of low back pain: a systematic review of prospective cohort studies. *BMC Musculoskelet Disord.* 2017;18(1):179.

Figure 1.

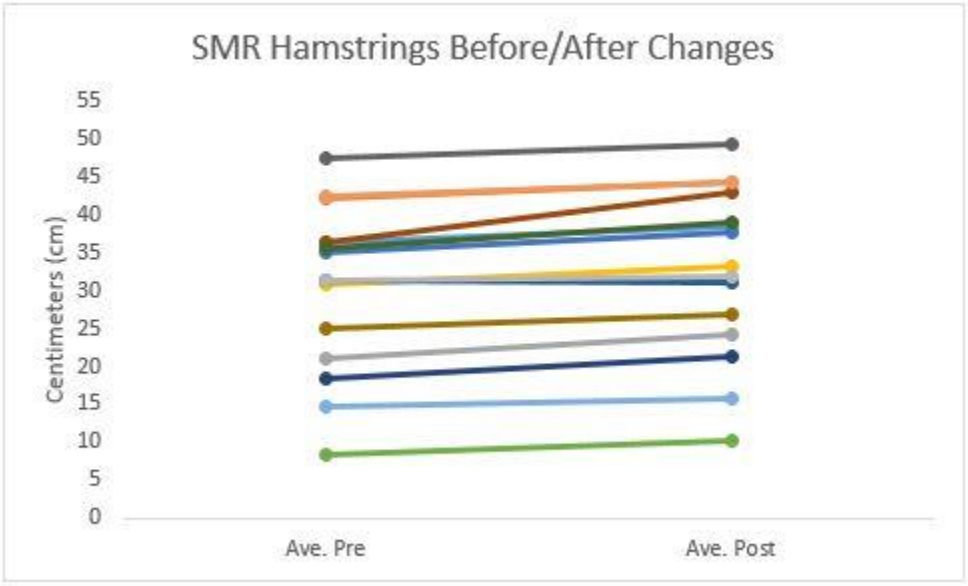

Figure 2.

Figure 3.

Table 1: Pre/Post measurements of the sit and reach.

SMR Technique	Pre-Intervention distance (cm)	Post-Intervention distance (cm)	Pre/Post Change Distance (cm)
Foot	31.06 ± 9.91	32.19 ± 10.24	1.13 ± 1.09
Hamstrings	30.49 ± 11.03	32.76 ± 11.34	2.27 ± 1.60
Both	29.19 ± 12.60	31.10 ± 13.15	1.91 ± 1.54