International Journal of
EXERCISE SCIENCE

Original Research

The Acute Effects in Postural Sway as a Result of Self-Myofascial Release on the Lower Extremities in Collegiate Female Athletes

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ABSTRACT

International Journal of Exercise Science 17(1): 274-284, 2024. Myofascial release is a popular therapy technique used to manipulate connective muscle tissue to become more pliable. The maintenance of body posture relies on mechanoreceptors located in connective tissue, thus manipulation of connective tissue should affect postural control. The effects of this phenomenon have not been well studied, leaving room for this investigation. PURPOSE: To observe if postural sway scores changed before and after foam rolling proximal (quadriceps and hamstrings) in comparison to distal (calves) muscles. METHODS: Thirty-six, college-aged female athletes (age 20.39 ± 0.25 years, mass 68.70 ± 1.97 kg, height 170.18 ± 1.56 cm.) performed approximately two and one-half minutes of moderate intensity foam rolling to their calves (n = 19, Group A) or to their hamstrings and quadricep muscle (n = 17, Group B). Center of Pressure (CoP) and Limit of Stability (LoS) testing was assessed both pre- and post-foam rolling using a computerized posturography balance plate. CoP sway was measured under both eyes open (EO) and eye closed (EC) Conditions on both stable and unstable surfaces. LoS was measured in the Anterior, Posterior, Left, and Right Directions. Effects of foam rolling on CoP and LoS were assessed using a repeated-measures MANOVA (α = 0.05). RESULTS: Eyes Open Stable Surface had the lowest postural sway (p = 0.001). However, CoP did not differ for any condition either between Groups ($p \geq 0.6$) or from pre- to post-foam rolling (p = 0.3). LoS significantly differed between Directions such that LoS was greater in the frontal plane than in the sagittal plane (p = 0.011). There was also a significant Time X Group X Direction interaction effect (p = 0.001) such that LoS for Group A decreased after foam rolling (mean change = -1.621 cm) but increased for Group B after foam rolling (mean change = + 0.878 cm). No differences were found for any other Direction ($p \geq 0.1$). CONCLUSION: This study demonstrated CoP and LoS improvements between the two groups based on acute effects of foam rolling intervention. Further research is suggested to determine if long-term gains are observed within or between groups.

KEY WORDS: Balance, limit of stability, center of pressure, self-myofascial release

INTRODUCTION

Manual therapy techniques are popular treatments used among physical therapists, occupational therapists, chiropractors, and physicians alike. Previous report has indicated that eighty percent of sports and orthopedic physical therapy professionals use a foam roller in their practice (1, 2, 4, 5, 6, 9). Among other manual therapy techniques (3, 5, 6, 9, 14, 15), foam rolling has been recognized to provide enhancements in joint mobilization, as well as aiding in the treatment of myofascial adhesions (1, 14, 15, 17, 18, 27). Contrary to approaches that require more skillful application and professional assistance, this technique can be completely self-induced (29). The foam rolling tool that has become so popular today is still a relatively new piece of equipment providing that some of the benefits of foam rolling may still be unknown. Improved muscular performance and flexibility as well as decreased muscle soreness and perception of pain has been attributed to the mechanical, neurological, physiological, and psychophysiological parameters of foam rolling (4 ,6, 14, 17, 18, 27, 28). It is necessary to continue research to document the occurrence of these immediate effects of foam rolling therapy.

Immediate physiological changes from this self-applied myofascial therapy have demonstrated significant increases in pressure pain threshold following treatment (4, 14, 26, 27, 28). Athletic performance and decreased instance of delayed onset muscle soreness (DOMS) primarily dominates the research field of foam rolling. Much of the research that exists for foam rolling focuses on the changes occurring at the knee and hip joint, failing to provide a more centered approach on the lower extremity (e.g., inclusion of ankle joint range of motion) and well as joint stability in relation to balance of an individual. Additionally, the knee joint provides for a limiting factor in balance and postural control of the body, specifically associating the presence of knee pain to double the risk of fall and instability (11, 13, 14, 16, 24). Improvements in postural control can therefore be used to gauge the effectiveness of foam rolling therapy on joint range of motion and stability. Postural control is measured in static and dynamic conditions owing to the different demands of each state. Static postural control can be measured via center of pressure (CoP) scores, defined as the area where mass is concentrated in standing the non-moving position. Dynamic postural control can be measured via a person's ability to move their center of mass outside their base of support, termed limits of stability (LoS) (23).

Most manipulative therapy interventions such as foam rolling have shown positive effects on postural control via muscle spindles and cutaneous receptors (6, 7, 10, 11, 15, 20, 21, 25). However, protocols for foam rolling vary widely (4), and it is unclear whether foam rolling the lower leg (21) or the thigh (14, 20) is more advantageous for improving athletes' performance in postural control and its associated factors (e.g. joint range of motion, joint stability). Given jumping/sprinting sports demand the lower extremity for performance, understanding the impact of foam rolling to the calves versus thigh regions on postural control may provide more robust outcomes to guide training and performance assessments. The comparison between foam rolling of the calves and foam rolling of the hamstrings and quadriceps is of greater interest due to the lack of past literature. Therefore, the purpose of this study was to compare CoP and LoS scores before and after a bout of self-myofascial release targeting the calf versus the hamstrings/quads of the thigh.

METHODS

Participants

Participant recruitment took place at a Midwestern University in the United States. The sponsoring Institutional Review Board for the institution deemed a full acceptance for this study to be conducted (CSM #2124). Prior to any data collection, the primary investigator reviewed the rights of the participants and secured signed informed consent forms and health questionnaire from subjects. Inclusion criteria included current students at the university, 19+ years of age, currently participating on the athletic teams through the university, and had no current issues in balance and stability of the ankle joint which could limit the findings of the study such as ankle sprains or diagnoses of excessive joint laxity within the previous month. Participants were asked to disclose any pre-existing ankle or knee injuries which could potentially be a limiting factor in their performance of the balance testing protocol. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (19). Participants were recruited through a voluntary convenience sample and divided into 2 unequal groups. There were no significant differences found between groups in age, mass, height, or body mass index (BMI): Group A (n = 19, 20.39 ± 0.25 years, 67.35 ± 1.57 kg, 168.48 ± 1.56 cm, and 24.26 ± 0.57 BMI); Group B (n = 17, 20.39 ± 0.43 years, 69.50 ± 1.26 kg, 173.18 ± 1.38 cm, and 23.76 ± 0.33 BMI). Foam rolling protocols were randomly assigned to each group, resulting in foam rolling of the calves assigned to Group A, and foam rolling of the hamstrings/quadriceps to Group B. Based on a priori power analysis, the desired sample size for this study was 30 when power was set to .9 and $p < 0.05$.

Protocol

This pretest-posttest study design tested two protocol conditions: Group A foam rolled the hamstrings/quadriceps, and Group B foam rolled the calves. All subjects were required to complete 8 balance tests using a Bertec® Computerized Dynamic Posturography Force Plate (Bertec Corporation, Columbus, OH). Participants stood barefoot on the force plate with their medial malleolus parallel to the horizontal line of the force plate and lateral calcaneus of each foot aligned to the appropriate midline to complete testing as intended (23, 25). Proper etiquette for the testing protocol was established and demonstrated first by the researchers before any participants were able to attempt the testing. Protocol for the balance testing required the participants to remain barefoot for all tests to ensure changes within the testing parameters were conducted accurately. The 8 tests conducted were: normal stability eyes open (EOSS), normal stability eyes closed (ECSS), perturbed surface stability with eyes open (EOPS), perturbed surface stability with eyes closed (ECPS), limit of stability (LoS) leaning anteriorly in the frontal plane (LoSA), limit of stability leaning backwards in the posterior plane (LoSP), limit of stability leaning to the left in the sagittal plane (LoSL) and limit of stability leaning to the right in the sagittal plane (LoSR). Center of pressure (CoP) scores (from EOSS, ECSS, EOPS, and ECPS) measured any movement produced through assessment of postural sway of the participants when standing still (20). LoS scores measured dynamic postural sway of the participants (20). Perturbed testing included use of a foam surface placed on top of the force place. EOSS, ECSS, EOPS, and ECPS tests were performed for a duration of 10 seconds for each individual test. The four LoS tests required the participants to lean forward, backwards, to the left, and to the right as far as possible without losing their balance, performing the movement through the sagittal and frontal (coronal) planes of the body. If balance was lost, participants were given another chance to repeat the test without losing their balance.

Once the initial balance testing was completed, participants were then divided into one of two groups. Group A emphasized the ankle joint with foam rolling applied to the muscles of the calves only. Group B targeted the knee joint by applying the foam roller to the hamstring muscle group as well as the quadricep muscle group. A Rocktape® Rock N Roll foam roller was provided for all participants in the study proceeding the initial balance testing. Each group followed the same intensity and duration for the prescribed foam rolling therapy session. A Visual Analog Scale (VAS) was used to standardize the intensity of the foam roller, aiming for an intensity level of a 7 out of 10 on the 10 mm scale provided (9). After establishing the intensity level goal, participants were then instructed to maintain this intensity for the entire duration of the session. A demonstrational video was played for the participants to follow along during the session. This video was incorporated to display the proper foam rolling technique, to emphasize the desired intensity level, and establish the tempo being used for the treatment. The video used a metronome to guide the participants actively, using five 'ticks' of the metronome to indicate a five second tempo for foam rolling of the selected muscle grouping. Group A performed the foam rolling therapy on the calves at a standardized velocity using a metronome rolling forwards and backwards at 30 second intervals, spending two and a half minutes on each calf providing a total duration of five minutes for the session. Group B performed three, 30 second intervals foam rolling the hamstrings, and two 30 second intervals foam rolling of the quads. Participants spent a total of two and a half minutes on each leg, giving a total duration of five minutes of foam rolling with a 10-second break included between each 30-second interval until the session was completed. Following the 5-minute session, participants then were instructed to immediately perform post-testing of the same 8 balance tests recorded previously, using the same protocol instructed during the pre-testing assessment.

Statistical Analysis

A repeated-measures multivariate analysis of variance (MANOVA) was conducted to detect the effects of the intervention on the continuous dependent variables of the study. Changes between the two measurements of balance testing were compared for each condition: EOSS, ECSS, EOPS, ECPS for time (pre & post) and the condition of the intervention (ankle vs knee). LoSL, LoSR, LoSA, & LoSP compared direction improvements and time (pre & post). If differences were detected, Bonferroni-corrected *t*-tests were used to detect pairwise comparisons. All statistical treatments were performed with IBM SPSS (ver. 27) with a significance level (alpha) set at 0.05.

RESULTS

Average CoP outcomes for all Conditions and Groups are displayed in Table 1. There was no significance based on time ($p = 0.625$; $\eta^2 = 0.007$) which indicated that CoP did not change from Pre to Post regardless of Group. However, there was a significant effect (Table 2) for Condition

($p < 0.001$; $\eta^2 = 0.516$). Bonferroni-corrected *t*-tests comparing the Conditions showed that EOSS had the smallest CoP scores when compared to the other Conditions (all $p < 0.01$; mean differences = 0.083, 0.067, & 0.267 for ECSS, EOPS, & ECPS, respectively); similarly, both ECSS and EOPS also had significantly smaller CoP scores compared to ECPS ($p < 0.01$; mean differences = 0.184 & 0.20, respectively) but did not significantly differ from each other ($p > 0.9$; mean difference = 0.016). There were no differences between the Groups ($p > 0.6$; $\eta^2 = 0.008$), and no significant interaction effects were detected ($p > 0.3$; $\eta^2 < 0.04$).

Table 1. Group A vs. Group B Center of Pressure (CoP) Average Outcomes

Group + Condition	Pre-Foam Rolling (inches)	Post-Foam Rolling (inches)
Group B EOSS	0.221 ± 0.024	0.271 ± 0.028
Group B ECSS	0.349 ± 0.036	0.339 ± 0.021
Group B EOPS	0.308 ± 0.033	0.322 ± 0.027
Group B ECPS	0.506 ± 0.045	0.466 ± 0.079
Group A EOSS	0.250 ± 0.026	0.262 ± 0.030
Group A ECSS	0.386 ± 0.038	0.261 ± 0.022
Group A EOPS	0.326 ± 0.034	0.315 ± 0.028
Group A ECPS	0.538 ± 0.047	0.561 ± 0.084

*Data presented as mean±SEM; Significance symbols: * significance < ECPS, † significance < EOPS, § significance < ECSS, ‡ significance < ECPS.*

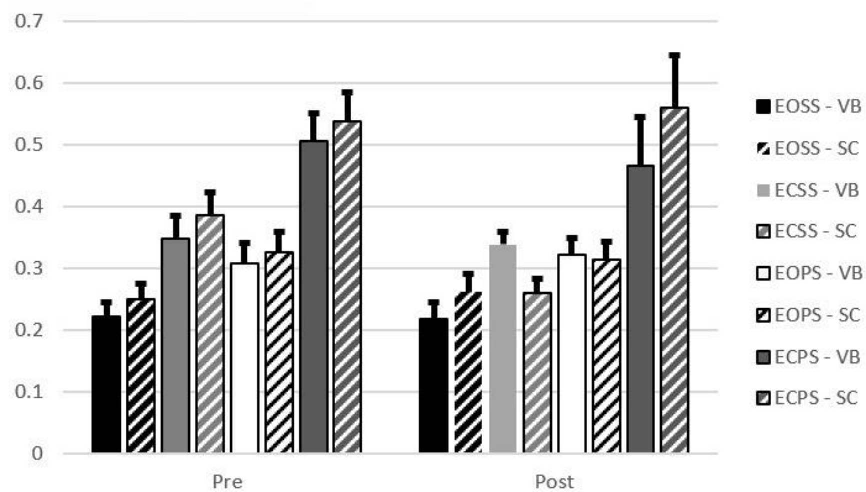

Figure 1. Pre-Post CoP Means

Table 2. Statistical Outcomes – Center of Pressure

Effect	Significance (p)	Effect Size (η^2)	Observed Power
Time	0.625	0.007	0.077
*Condition	< 0.001*	0.516	1
Group	0.606	0.008	0.08
Time x Group	0.516	0.013	0.098
Time x Condition	0.331	0.031	0.214
Condition x Group	0.427	0.025	0.193
Time x Condition x Group	0.411	0.024	0.175

(*) significant at $p \leq 0.05$

The average LoS outcomes are listed in Table 3. The main effect for Time (Table 4) did not have a significant outcome (p = 0.269; η^2 = 0.036). This indicated that changes from Pre to Post did not occur for LoS regardless of the intervention. Bonferroni-corrected t-tests showed a significant main effect for Direction in that LoS was significantly greater for the Left Direction when compared to Anterior & Posterior Directions for Group B (p < 0.05; mean differences = 2.670 & 3.854, respectively). Group A displayed significantly greater LoS for the Left Direction when compared to the Posterior Direction (mean difference = 3.578; p < 0.001), but not for the Anterior Direction (mean difference = 1.118; p > 0.7). The differences indicated that there was significant change in LoS from pre-foam rolling to post-foam rolling based upon group. LoS for Group A decreased after foam rolling (mean change = -1.621) and increased for Group B after foam rolling (mean change = +0.878).

Table 3. Group A vs. Group B Limit of Stability (LoS) Average Outcomes

Group + Condition	Pre-Foam Rolling	Post-Foam Rolling
	Postural Sway (inches)	
Group B LoSA	7.854 ± 0.501	8.732 ± 0.499
Group B LoSP	7.19 ± 0.428	7.028 ± 0.351
Group B LoSL	10.616 ± 0.762	11.31 ± 0.644
Group B LoSR	10.53 ± 0.834	10.165 ± 0.641
Group A LoSA	10.203 ± 0.53	8.582 ± 0.527
Group A LoSP	6.452 ± 0.452	7.414 ± 0.371
Group A LoSL	9.769 ± 0.806	11.254 ± 0.681
Group A LoSR	11.75 ± 0.882	11.37 ± 0.678

*Data presented as mean±SEM; Significance symbols: * significance < LoSR, † significance < LoSL, § significance < LoSA, ‡ significance < LoSP.*

Table 4. Statistical Outcomes – Limit of Stability

Effect	Significance (p)	Effect Size (η^2)	Observed Power
Time	0.269	0.036	0.194
Direction	< 0.001	0.511	1
Group	0.452	0.017	0.115
Time x Group	0.655	0.006	0.072
Time x Direction	0.088	0.067	0.502
Direction x Group	0.139	0.054	0.448
Time x Direction x Group	0.032	0.089	0.671

DISCUSSION

The purpose of this investigation was to observe and record the determined effects of self-myofascial release through foam rolling on Center of Pressure and Limit of Stability scores. The results of this study showed that static postural sway measured in the EOSS balance condition demonstrated the least amount of deviation in center of pressure, whereas the ECPS condition had the greatest deviation in center of pressure, found in pre- and posttest conditions and between groups. This was expected as generally, balancing ability of the body tends to decrease as somatosensory information relayed to the brain is inhibited or manipulated (12, 23). The ECSS and EOPS did not differ within or among both groups. This study also showed that limit of stability in the sagittal plane (Anterior and Posterior) was lower than in the frontal plane (Left and Right). It was also found that foam rolling of the calves with Group A resulted in a significant decrease in limit of stability in the Anterior direction alone when compared to foam rolling the thigh in Group B. While CoP is static in nature and LoS tends to be more dynamic in nature, the findings for each must be discussed separately to make different inferences and conclusions.

Anterior		Mean Δ LoS (cm)	*F*	Between-group Significance (*p*)	Effect Size (d)
	Volleyball	0.878±0.462	10.037	0.003	0.228
	Soccer	-1.621±0.655			
Posterior					
	Volleyball	-0.162±0.319	2.237	0.144	0.062
	Soccer	0.962±0.711			
Left					
	Volleyball	0.694±0.361	0.084	0.366	0.024
	Soccer	1.485±0.820			
Right					
	Volleyball	-0.365±0.425	less than 0.001	0.988	less than 0.001
	Soccer	-0.380±0.901			

Figure 2. Group B vs. Group A Change in Limit of Stability (pre to post)

Average outcomes within Group B exhibited a decrease from pre to post only under the ECPS condition (pre = 0.506 ± 0.045, post = 0.466 ± 0.079). We did not observe a decrease in postural sway for the other 4 CoP conditions in the Group B. According to our results, CoP scores decreased the most pre to post for ECSS for Group A (pre = 0.386 ± 0.038, post = 0.261 ± 0.022). We expected to see a decrease in postural sway of the body after undergoing a bout of foam rolling but we observed little to no change from pre to post balance scores. Because there was no significant time x interaction effect present for CoP, we gathered that postural sway of the body was not directly affected by foam rolling manipulation regardless of group. CoP is static in nature, in that body mass acceleration is attempted to be controlled as much as possible by the body in a double-legged stance (3, 20, 21, 22, 23). With past research, foam rolling has generally shown improvement in joint position sense however, this has generally been measured from an assessment via Y-balance testing (7, 21). Again, this area of interest is new to the research community and therefore there is not a significant amount of past research that has been conducted. For this study, however, postural sway of the body remained consistent pre- to post- indicating that foam rolling had little to no impact on center of pressure for EOSS, ECSS, EOPS, ECPS conditions.

Average outcomes for LoS found a significant main effect for direction for both groups (Table 4). Group A had significantly greater scores for the LoSL direction compared to the LoSA direction. Group B had significantly greater scores for the LoSL direction in comparison to both the LoSA and LoSP directions. Because these differences occurred, we could infer that these significant changes from pre- to post foam rolling scores occurred based upon the foam rolling intervention. However, due to group allocation by sport and lack of control group, it cannot be confirmed if foam rolling calves was more or less beneficial than hamstrings/quads in producing this effect.

Studies which support our findings are very limited because this area of research is quite new, but within this area, a positive correlation between improved postural control and self-myofascial release has been observed (7, 8, 12, 19). While we did not observe a decrease in LoS for Group B, we must unpack why we may have seen this result occur primarily for Group A. Our hypothesis was formulated with the idea that changes in postural sway of the body could occur due to one of two causes: morphological and neurological changes in muscle tissue (1, 3, 12). The ability for foam rolling to decrease delayed onset muscle soreness and improved range of motion has been supported and therefore establishes a connection between the changes in muscle tissue and the therapy applied (14). And while we know this connection exists, it is unclear whether these changes occur due to morphological changes in musculature or if the changes occur due to a neurological aspect. When pressure is applied and manipulated on connective tissue, the morphological change that occurs in the muscle may allow for it to become more pliable (2). The existence of this phenomenon could have led cause to why these scores improved in a short period of time. Restoration of the muscle length within fascia releases the pressure off nerves and blood vessels of the body (2), however morphological induced changes have been recently debated in the literature (28). This relationship between pressure manipulation and myofascial release is that together the goal is to restore mobility and alignment to the joints the therapy is applied to (2). While the aim of the study was not on recovery and restoration of athletes, the acute effects that occurred could benefit athletic performance based off the changes in balance scores we observed. However, we must also consider the impact of neurological changes that can occur from foam rolling. Spinal reflex excitability is inhibited by deep pressure which in turn affects the way that pressure sensitive receptors in muscle react to stimuli (29). Young et al. observed that an increase in roller massage decreases spinal excitability suggesting that the change occurred due to a decrease in facilitation or an increase in inhibition (29). This is not the only study to observe a relationship between various massage techniques and decreased spinal excitability and several have also shown a decrease (3). Improvements in range of motion and a decrease in the pressure-pain threshold is the outcome of this neurological change (29), and therefore this may also be the reason why we observed the change in LoS resulting in an improved score. It is unclear whether neurological or morphological implications played a role in the changes in balance outcomes, or if it may be a combination of the two. Given that the body of research surrounding foam rolling has generally shown that musculature is affected by this type of massage, more research needs to be conducted to further investigate the primary cause for why this change occurs.

In conclusion, this study demonstrated CoP and LoS improvements between the two groups based on acute effects of foam rolling intervention. The findings of the study may be helpful in several aspects of sports performance. From our CoP results, we understand that there was not a significant change in static balance after foam rolling was applied. From our LoS results, foam rolling of the calves provided the greatest benefit in dynamic balance aspects. Sporting events which require balance control towards lateral reaching movements may benefit from short interval foam rolling of the calves to improve overall dynamic balance. This study is not absent of limitations that should be addressed. The use of the Visual Analog Scale is only an exemplar for perceived level of intensity during the foam rolling session. Feelings of perceived pain and overall intensity level may differ across participant population. Guidelines for the specific foam rolling technique were provided through instructional demonstration as well as verbal cueing supplied by researchers of the study; however, it is not certain that all participants followed the guidelines as directed. Isolation of muscle groups should also be considered as a limitation, as participants were only allowed to foam roll either the calves or the hamstrings and quads dependent on their group allocation. As groups were allocated by sport type, in this case the sport groups were soccer and volleyball, additional factors such as sport demands may also influence testing results. Future studies should consider foam rolling of the entirety of the major lower extremity muscles without isolation, allocating lower leg versus thigh form rolling protocols between subjects within the same sport to determine differences between groups, adding in a control group to improve the ability to rule out test familiarity contributing to findings, and testing subjects who compete in different sports.

ACKNOWLEDGEMENTS

The authors would like to recognize Charles Smith, PhD, for his assistance with the data tables.

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