

## Evaluating Acute Changes in Joint Range-of-Motion using Self-Myofascial Release, Postural Alignment Exercises, and Static Stretches

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### ABSTRACT

*International Journal of Exercise Science* 6(4): 310-319, 2013. This study was designed to compare the acute effect of self-myofascial release (SMR), postural alignment exercises, and static stretching on joint range-of-motion. Our sample included 27 participants (n = 14 males and n = 13 females) who had below average joint range-of-motion (specifically a sit-and-reach score of 13.5 inches [34.3 cm] or less). All were university students 18-27 years randomly assigned to complete two 30-40-minute data collection sessions with each testing session consisting of three sit-and-reach measurements (which involved lumbar spinal flexion, hip flexion, knee extension, and ankle dorsiflexion) interspersed with two treatments. Each treatment included foam-rolling, postural alignment exercises, or static stretching. Participants were assigned to complete session 1 and session 2 on two separate days, 24 hours to 48 hours apart. The data were analyzed so carryover effects could be estimated and showed that no single acute treatment significantly increased posterior mean sit-and-reach scores. However, significant gains (95% posterior probability limits) were realized with both postural alignment exercises and static stretching when used in combination with foam-rolling. For example, the posterior means equaled 1.71 inches (4.34 cm) when postural alignment exercises were followed by foam-rolling; 1.76 inches (4.47 cm) when foam-rolling was followed by static stretching; 1.49 inches (3.78 cm) when static stretching was followed by foam-rolling; and 1.18 inches (2.99 cm) when foam-rolling was followed by postural alignment exercises. Our results demonstrate that an acute treatment of foam-rolling significantly increased joint range-of-motion in participants with below average joint range-of-motion when combined with either postural alignment exercises or static stretching.

KEY WORDS: Functional training, flexibility, movement assessment, sit-and-reach test

### INTRODUCTION

Increases in joint range-of-motion have been correlated with improvement in performance, especially in athletes whose

events require a full range-of-motion, and are also associated with pain relief (11). Much of this pain appears to be associated with dysfunction within the musculoskeletal system due to tight (overactive) or weak (underactive) muscles

which may lead to skeletal misalignments and associated microtrauma and pain. Self-myofascial release (SMR), postural alignment exercises, and static stretching are three common techniques aimed at improving joint range-of-motion. The purpose of this study was to investigate the acute effect of these techniques on improving sit-and-reach scores.

For many years myofascial release commonly has been used among physical therapists, massage therapists, osteopathic clinicians, and allopathic clinicians to elicit skeletal muscle inhibition and accompanying relaxation to improve joint range-of-motion (12). Recently, a self-administered version of myofascial release (SMR) has been popularized using a foam roller that also serves as an inhibitory technique which decreases overactive myofascial tissue (4). Applying pressure to triggerpoints (the overactive part of the tissue) appears to cause the Golgi tendon organ (GTO) complex to elicit an inhibitory effect on the muscle, allowing it to become less tense and more pliable, leading to an increase in joint range-of-motion (4). However, little research has been conducted to document the practical effectiveness of SMR.

Postural alignment exercises are similarly designed to increase joint range-of-motion. These exercises typically involve a prolonged stretch or active movement of the targeted muscles in order to improve joint range-of-motion but are specifically designed to improve body alignment by improving the length and tension of the muscles (7). As with SMR, the beneficial effects of these exercises on improving joint range-of-motion or body alignment have

not been documented in the scientific literature.

Static stretching, on the other hand, is commonly used throughout the fitness and athletic world and is well documented (2, 10, 11, 13). Similar to foam-rolling, static stretching appears to cause the GTO to elicit an inhibitory effect on the muscle, improving joint range-of-motion (4, 5). Typically, static stretches are held for 10–120 seconds in order to enhance joint range-of-motion (4, 5).

## METHODS

### *Participants*

All participants were university students (mean  $\pm$  SD = 22.7  $\pm$  2.4 years), recruited via classroom announcements. Before data collection, we elected to include only those individuals who had a sit-and-reach score of 13.5 inches (34.3 cm) or less. The rationale for using this cut-point was to evaluate participants who currently exhibited approximately average or below average sit-and-reach scores (1). During data collection we evaluated a total of 39 participants; of these 27 (males = 14; females = 13) met the required prescreening sit-and-reach score of 13.5 inches (34.3 cm) or less (Table 1). All participants completed an informed consent document and all research procedures were approved by the University's Institutional Review Board.

Table 1.

### **Participant's sit-and-reach averages**

<b>Mean sit-and-reach score (pretest only)</b>	<b>Mean <math>\pm</math> SD (inches)</b>
Total screened (n=39)	11.1 $\pm$ 4.4 (28.2 $\pm$ 11.2 cm)
Experimental sample (n=27)	9.4 $\pm$ 3.0 (23.0 $\pm$ 7.6 cm)
Sample omitted from study (n=12)	14.9 $\pm$ 4.7 (37 $\pm$ 11.9 cm)

*Protocol*

All participants in the experimental sample (n = 27) completed two indoor testing sessions (gymnasium setting) with a comfortable ambient temperature of approximately 23-degrees Celsius. Three trained test administrators (2 undergraduate students and 1 graduate student) collected all sit-and-reach data and supervised all treatment activities. Participants completed three sit-and-reach tests and two treatments during each testing session (Table 2). Each treatment activity was self-administered by the participant under the direct supervision of the trained administrator/instructor (with a participant-to-instructor ratio of about 1 to 10). No formal warm-up or preparatory exercises were performed before the initial sit-and-reach test (at the beginning of session 1 or 2). Participants completed session 1 and session 2 in a random order on two separate days, 24 hours to 48 hours apart. A computerized compound random number generator (6) was employed to randomly assign participants their treatment sequence. We did not measure the body mass or body height of the participants since data collection was conducted during scheduled physical activity classes with limited time constraints.

TABLE 2 Example of Testing/Treatment Order	
Session 1	Session 2
Sit-and-reach test	Sit-and-reach test
Foam-roll treatment	Postural exercise OR
Sit-and-reach test	static stretch treatment
Postural exercise OR	Sit-and-reach test
static stretch treatment	Foam-roll treatment
Sit-and-reach test	Sit-and-reach test

The sit-and-reach test consisted of using a sit-and-reach box (Mayes Brothers Tool Manufacturing Company, Madisonville

TN; see Figure 1) with the participant sitting on the floor with legs extended and the soles of the feet against the sit-and-reach box at the 10-inch (25.4-cm) mark (16). For each test trial, participants were instructed to slowly reach forward with both hands as far as possible (refraining from fast, jerky movements), and to hold the maximal reach position for 1–2 seconds.



Figure 1. Sit-and-Reach.

Participants were advised to slowly exhale during each maximal reach and to keep the knees extended as much as possible. A test administrator positioned his or her hand just above the participant’s knees during each trial as a reminder to keep the knees fully extended. Participants were also reminded to keep the palms facing downward (with the fingers of each hand side by side or overlapped, with neither hand leading ahead of the other) and in contact with the sit-and-reach box. During each trial, participants were asked to close their eyes while the score was recorded so as not to bias the level of effort on subsequent sit-and-reach tests. A total of three test trials were performed during the sit-and-reach test, with the highest score of the three trials recorded as the final score. Three separate sit-and-reach tests were completed during a given session (initial,

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post-treatment 1, and post-treatment 2; see Table 2).



Figure 2a. Foam rolling – low back.



Figure 2b. Foam rolling – calf.

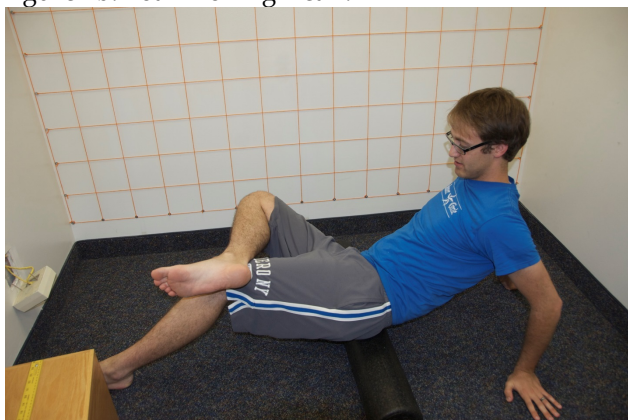


Figure 2c. Foam rolling - buttocks/piriformis.

The foam-roll treatment consisted of using a cylindrical foam roller (6" circumference by 36" long; model: AXIS; OPTP, Minneapolis, MN) made of densely packed foam (5). Participants foam-rolled various muscle groups (4) that could potentially



Figure 2d. Foam rolling – hamstrings.



Figure 2e. Foam rolling – calves.



Figure 3a. Postural alignment exercise – cobra on elbow.

affect the sit-and-reach test: low back (erector spinae), upper back, buttocks (gluteus maximus and piriformis), posterior thigh (hamstrings), and calf (gastrocnemius and soleus). Participants spent a total of 10 minutes foam-rolling these muscle groups

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Figure 3b. Postural alignment exercise – upper spinal floor twist.



Figure 3c. Postural alignment exercise – static extension position.



Figure 3d. Postural alignment exercise – cobra.

using their own body weight to provide pressure (see Figures 2a-e). The postural alignment exercises (7) were repeatedly performed for 10 minutes (timed by the exercise leader) and included the following: cobra on elbows, upper spinal floor twist, static extension position, cobra, sitting floor twist, pelvic tilts, and cats and dogs (see Figures 3a-g). The static stretches (4) were

also repeated for 10 minutes and included the following: hurdler's stretch, butt/hamstring stretch, supine hamstring stretch, child's pose, downward facing dog, gastrocnemius stretch, soleus stretch, and calf stretch, (see Figures 4a-h).



Figure 3e. Postural alignment exercise – sitting floor twist.



Figure 3f. Postural alignment exercise – pelvic tilts.



Figure 3g. Postural alignment exercise – cats and dogs.

### *Statistical Analysis*

A randomized crossover study was employed to compare and contrast acute changes in joint range-of-motion using SMR, postural alignment exercises, and static stretching. The data were analyzed using a model that appropriately accounted for variability both within and between

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participants. The model included both treatment and crossover effects. The independent variables were the treatments that were used and the order in which they were performed. The dependent variable was joint range-of-motion as measured by the sit-and-reach test. Data were analyzed using a Bayesian paradigm so posterior probabilities could be calculated.



Figure 4. Static stretch. a. Hurdler's stretch. b. Butt/hamstring. c. Supine hamstring stretch. d. Child's pose. e. Downward facing dog. f. Gastrocnemius. g. Soleus. h. Calf.

Our experimental design accounted for the two treatments applied randomly across the two testing sessions. The response

variable was taken to be the difference between a posttreatment sit-and-reach test score and the pretreatment sit-and-reach test score, giving us two responses for each participant on each treatment day. A positive response indicated that ability to stretch had increased.

The foam-roll treatment was randomly paired with either the postural alignment exercises or the static stretches on the first test day with the order reversed on the second test day (Table 2). In total, the foam-roll treatment was applied 54 times, the postural alignment exercises 23 times, and the static stretches 31 times. The postural alignment exercises and static-stretch treatments were never applied on the same day to any participant.

The model we formulated had a term for the gender of the participant, treatment, previous treatment, day, participant, and administrator. Day, participant, and administrator were placed in the model to appropriately account for these sources of variability. Preliminary analyses showed that neither gender nor day needed to be included in the model.

Our data were assumed to be normally distributed with the mean for the  $i^{\text{th}}$  observation,  $\mu_i$  modeled as:  $\mu_i = \beta_{\text{treatment}} + \beta_{\text{previous}} + \beta_{\text{administrator}} + \beta_{\text{participant}} + \sigma^2$  where  $\beta_{\text{treatment}}$  indicates the effect of one of the three treatments: foam-rolling, postural alignment exercises, or static stretching.  $\beta_{\text{previous}}$  indicates the effect of the previous treatment and so has four levels: each of the three treatments plus no treatment preceding the first measurement.  $B_{\text{administrator}}$  is a random teacher effect and  $\beta_{\text{participant}}$  is a random participant effect and each was modeled as a hierarchical term.

Such a formulation is well suited to using a Bayesian approach. In the Bayesian framework, the model consists of the scaled product of the likelihood of the data given the parameters and prior probability densities for each of the parameters (3, 8). The prior distributions were as follows:

$$\begin{aligned} \beta_{treatment} &\sim \text{Normal}(0, \text{var} = 10) \\ \beta_{previous} &\sim \text{Normal}(0, \text{var} = 10) \\ \beta_{administrator} &\sim \text{Normal}(0, \text{var} = \sigma^2_{teacher}) \\ \sigma^2 &\sim \text{Inverse Gamma}(1.1, \text{rate} = .5) \\ \sigma^2_{participant} &\sim \text{Inverse Gamma}(1.1, \text{rate} = .5) \\ \sigma^2_{administrator} &\sim \text{Inverse Gamma}(1.1, \text{rate} = .5) \end{aligned}$$

We used the JAGS program called from the statistical program R (14) using the r2jags package to generate the samples from the posterior distributions using Markov Chain Monte Carlo (MCMC) (9, 15). Checks for convergence of the posterior chains and further analyses of combinations of parameters were also completed in R. The posterior distributions are based on a sample of 10,000 after a burn-in of 15,000 iterations. Raftery-Lewis and Geweke convergence diagnostics indicated that the chains had converged.

**RESULTS**

All participants (n = 27) successfully completed the two testing sessions with no injuries, muscle strains, or ill effects. Based on the statistical analysis, each of the coefficients for the single treatments had 95% posterior intervals that included zero. That is, none of the treatments by themselves yielded statistically significant posterior intervals that did not include

zero. Posterior means, standard errors, and 95% posterior intervals for all parameters are given in Table 3.

**TABLE 3**  
Posterior distribution means, standard errors, and 95% posterior probability limits for the model parameters (n = 27)

Parameter	Posterior Mean (inches)	Standard Error	.025 Quantile	.975 Quantile
Treatment preceded by <sup>a</sup> Foam	0.59	1.21	-1.79	2.97
Treatment preceded by <sup>b</sup> Postural	0.90	1.23	-1.50	3.31
Treatment preceded by <sup>c</sup> Static	0.68	1.23	-1.74	3.11
Treatment Foam	0.81	1.21	-1.55	3.19
Treatment Postural	0.58	1.22	-1.79	2.96
Treatment Static	1.17	1.21	-1.21	3.55
$\sigma^2$	0.59	0.10	0.43	0.81
$\sigma^2_{teacher}$	0.40	0.40	0.10	1.33
$\sigma^2_{participant}$	0.44	0.18	0.19	0.87

<sup>a</sup>Foam = foam-rolling (self-myofascial release); <sup>b</sup>Postural = postural alignment exercise; <sup>c</sup>Static = static stretching

It is instructive to examine not only the individual treatment parameters, but also the combinations of parameters within a given treatment day. For example, we were interested not only in the effect of static stretching on the response, but also what happens when static stretching either preceded or followed foam-rolling. This was done quite easily in this formulation since the posterior distribution for static stretching followed by foam-rolling was determined by adding the values of these parameters at each draw of the Markov Chain. Summaries for these situations can be found in Table 4. From these data we can see that significant 95% posterior interval gains (that did not include zero) were made with both static stretching and postural alignment exercises when used in combination with foam-rolling. For example, the posterior means (with 95% posterior probability limits noted) equaled 1.71 inches (1.05 inches to 2.45 inches) when postural alignment exercises were followed by foam-rolling; 1.76 inches (0.73 inches to 1.90 inches) when foam-rolling was followed by static stretching; 1.49 inches (0.43 inches to 1.90 inches) when static stretching was followed by foam-rolling; and 1.18 inches (0.97 inches to 2.46 inches) when foam-rolling was followed by postural alignment exercises.

**DISCUSSION**

This study appears to be the first to document the effects of foam-rolling and postural alignment exercises on joint range-of-motion. The data indicated that foam-rolling, when combined with postural alignment exercises or static stretches, increased sit-and-reach scores. In previous studies, an increased joint range-of-motion correlated with an improvement in athletic

performance, and also was associated with pain relief (11), potentially increasing an individual’s quality of life.

**TABLE 4**  
**Posterior distribution means, standard errors, and 95% posterior probability limits for combinations of the model parameters (n = 27)**

Parameter Combinations	Posterior Mean (inches)	Standard Error	.025 Quantile	.975 Quantile
<sup>a</sup> Foam followed by <sup>c</sup> Static	1.76	0.35	1.05	2.45
Static followed by Foam	1.49	0.38	0.73	2.24
Foam followed by <sup>b</sup> Postural	1.18	0.37	0.43	1.90
Postural followed by Foam	1.71	0.38	0.97	2.46

<sup>a</sup>Foam = foam-rolling (self-myofascial release);  
<sup>b</sup>Postural = postural alignment exercise; <sup>c</sup>Static = static stretching

As stated in the methods, we elected to include only those individuals who had a sit-and-reach score of 13.5 inches (34.3 cm) or less. Based on the Canadian Physical Activity, Fitness & Lifestyle Approach, a score of 13 inches for males or 14.2 inches for females is average (1). Our intent was to include participants that we felt were most likely to respond favorably to the treatment. By so doing, we recognize that



making broad generalizations about the results is problematic. However, the results do show that foam-rolling combined with postural alignment exercises and static stretching are beneficial for individuals with less than average joint range-of-motion and who might experience the greatest improvement.

This study evaluated the acute response of foam-rolling, postural alignment exercises, and static stretching to joint range-of-motion as opposed to a chronic, long-term response. As such, we only looked at the short-term effects of the treatments on the participant. A longer study period may have exhibited greater improvements in sit-and-reach scores for each individual treatment. However, the results of this study are beneficial to lay the groundwork for future study and comparison. An important future contribution would be to look at the chronic, long-term response of these treatments across an extended time frame.

Currently, the National Academy of Sports Medicine (NASM) recommends foam-rolling and some type of stretching (static, active isolated, or dynamic stretching) be performed before each exercise session as part of a warm-up (5). During this 5-10-minute warm-up, NASM recommends that foam-rolling precede the stretching activity. The results of this study support the NASM recommendation of foam-rolling and static stretching in combination as opposed to doing just one or the other independently.

Although this study provides meaningful data and results, it is not without limitation. For example, an obvious limitation was the lack of a control group to account for possible improvements in scores simply

due to repeated sit-and-reach testing across a given test session (and other possible confounding variables). A second concern was that the sample size was relatively small and included only college students with less than average joint range-of-motion. A larger sample, across various ages and fitness levels, would have improved the generalizability of the study. A third concern was the nature of the sit-and-reach test. Although this test has been used for research purposes in the past and is used commonly in fitness and wellness centers, it is dependent on the participant's level of motivation and may be less accurate than other joint range-of-motion measures. We elected to employ the sit-and-reach test because of its simplicity and time-efficiency; however, using a more accurate measurement tool may have generated differing test results. A fourth concern was that body mass and height were not measured due to a lack of time. Finally, the treatments employed in this study were self-administered under the direct supervision of a trained instructor/administrator (with a participant-to-instructor ratio of about 1 to 10), but the treatment still may not have been done as correctly or as thoroughly as possible.

There are a number of potential follow-up studies that could be completed as a result of this research. For example, researchers could repeat this study with a control group, more diverse sample, lower participant-to-instructor ratios, longer treatment times (20-30 minutes per treatment), a different measurement tool, inclusion of body mass and height data (measured or self-reported), and an evaluation of different joints. Additionally, studies could be conducted focusing on the

chronic effects of these treatments to further document their effectiveness on improving joint range-of-motion, athletic performance, and injury prevention.

In conclusion, this study showed that college-age students with below average flexibility experienced statistically significant acute improvements in sit-and-reach scores when they included foam-rolling in combination with either static stretching or postural alignment exercises. Future investigation is warranted to document the chronic effect of these practical treatments.

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