

## Original Research

# The Effects of Soft Tissue Flossing on Hamstring Range of Motion and Lower Extremity Power

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### Background

Flossing includes wrapping a specialized latex band around a muscle group providing compression, partially occluding blood flow, followed by performing exercises. This is hypothesized to improve flexibility by dissipating myofascial adhesions; however, research is lacking.

### Objective

To determine the effect of the application of a floss band to the thigh on hamstring flexibility and lower extremity power.

### Design

Crossover Study

### Setting

Exercise Physiology Laboratory.

### Participants

Twenty-one recreationally active individuals (8 male, 13 female; age = 22.62±2.99 years; height = 171.52±9.08 cm; mass = 73.57±11.37 kg).

### Methods

Three counterbalanced interventions were studied during body weight squats, lunges, and hamstring curls (without resistance): floss, sham, and control. The floss treatment included wrapping the Rogue Wide Voodoo Floss Band™ from the proximal knee to the gluteal fold at a pressure of 140 to 200 mmHg. The sham treatment included wrapping the same band in the same location with less pressure (10 to 40 mmHg) while the control treatment did not include floss band application. Hip flexion range of motion, via the straight leg raise, and power (single-leg vertical jump) were compared from pre-test to post-test using a 3x2 repeated measures ANOVA.

### Results

There was a significant interaction between time and session for hamstring flexibility ( $F_{(2,40)}=17.54$ ,  $p<0.001$ ,  $\eta^2=0.47$ ). Post hoc tests showed significant differences between pre- (86.14±8.06 degrees) and post-test (90.81±7.69 degrees) for the floss session ( $p<0.001$ , Mean Difference=4.67,  $CI_{95}=3.35-5.98$ ) and between pre- (87.67±7.51 degrees) and post-test (89.86±7.88 degrees) for the sham session ( $p=0.001$ , Mean Difference=2.19,  $CI_{95}=0.98-3.40$ ). There were no significant interactions for jump power ( $F_{(2,40)}=1.82$ ,  $P=0.18$ ,  $\eta^2=0.08$ ,  $1-\beta=0.36$ ).

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## Conclusions

Flossing treatment increased hamstring flexibility more than the sham session without affecting lower body power. Flossing could be beneficial when treatment or performance preparation goals are increased flexibility without decreased power. Future studies should continue to examine the clinical effectiveness of flossing on an injured population.

## INTRODUCTION

Tissue flossing using floss bands, or “Voodoo bands™,” is becoming increasingly popular throughout the world of athletics and strength and conditioning.<sup>1</sup> The application of a floss band includes wrapping a large specialized latex rubber band around a joint or muscle group to provide compression, partially occluding blood flow, and then performing a range of motion exercise for a short period of time, approximately one to three minutes.<sup>1</sup> This form of therapy is hypothesized to improve flexibility by dissipating myofascial adhesions across the muscle belly;<sup>2</sup> however, few research studies have been conducted to support this proposed benefit.

Currently, there have only been three studies examining the effectiveness of flossing.<sup>1,3,4</sup> Flossing across the talocrural joint has been shown to improve peak muscular dorsiflexion torque, both dorsiflexion and plantarflexion range of motion (ROM), and power during ankle movements.<sup>1,3</sup> The hypothesized benefit of increased ROM by applying a floss band across the talocrural joint has been evaluated previously,<sup>1,3</sup> but a study investigating the efficacy of flossing solely soft tissue, such as the hamstrings, has yet to be completed. Adequate flexibility are essential to the performance of athletes and are commonly a target for improvement as athletes with hypomobility are at a higher risk for injury in sport.<sup>5</sup>

Many traditional warm-up methods such as proprioceptive neuromuscular facilitation (PNF), static stretching, and deep tissue foam rolling (DTFR) have been shown to improve range of motion.<sup>6-8</sup> However, these techniques have also been shown to have some negative effects such as decreased power immediately after stretching.<sup>6-8</sup> A second limitation to a method such as static stretching is that there is an extended amount of time required to see ROM benefits from baseline.<sup>6</sup> Flossing is hypothesized to immediately increase ROM while potentially leaving power unaltered. The effects of flossing have been researched across joints in multiple studies but is yet to be studied across the belly of targeted muscles.<sup>1,3,4</sup> Therefore, the purpose of this study was to determine the effect of the application of a floss band to the thigh on hamstring flexibility and lower extremity power.

## METHODS

A 3x2 repeated measures crossover study design included two within factors, intervention (floss, sham, control) and time (pre-test, post-test). Participants completed three different sessions occurring approximately two to four days apart where they received one of the three interventions in a counterbalanced order. For the purposes of this study, ROM was defined as movement coming from a joint while flexibility involves optimization of a muscle or muscle

group.

## PARTICIPANTS

A convenience sample of 21 recreationally active university students (8 male, 13 female; age = 22.62±2.99 years; height = 171.52±9.08 cm; mass = 73.57±11.37 kg) were recruited to participate in this study after obtaining approval by the University of Lynchburg IRB. Recreationally active was defined as exercising for at least 30 minutes per day, three times per week at moderate intensity.<sup>9</sup> Exclusion criteria included a history of chronic hamstring strains, recent surgery to the lower extremity that would alter his or her ability to complete the study, pregnancy, and age under 18 years.

## PROCEDURES

Emails were sent to prospective participants seeking to recruit volunteers. Those who responded scheduled a meeting with the lead author to sign an informed consent form and provide demographic information. A counterbalanced approach was used when assigning participants to an intervention order in an effort to reduce any potential learning effects. Once treatment order was determined, the participants warmed-up on a stationary bike (Monark Ergomedic 828E, Vansbro Sweden) for five minutes with no resistance and a constant cadence of 50-60 RPM.<sup>10</sup> The warm-up was the same prior to each session. After warm-up, three trials of hip flexion ROM,<sup>10</sup> via the straight-leg raise, were measured on the dominant leg with a digital inclinometer on a smartphone app (iHandy level, reliability=0.97, validity=0.99, SEM=1.35°).<sup>11</sup> The dominant leg was determined by asking the participants which leg would be used to kick a ball. The researcher observed participants for proper positioning, keeping the knee extended, contralateral thigh remaining against the table, neutral pelvic position, and no external rotation of the contralateral hip ([Figure 1](#)). If participants performed any of these deviations, corrections were cued by the researcher and measurement was reassessed. The best of the three trials was recorded for analysis.<sup>10,12</sup>

The participants completed three trials of a single-leg vertical jump with countermovement and an arm swing using his/her dominant leg on the Just Jump mat (Probotics Inc, Huntsville, AL, reliability=0.96, validity=0.97).<sup>10,13</sup> The best of the three trials was recorded for analysis.<sup>10</sup> Each intervention group performed pre-testing the same way and each session took less than 20 minutes.

*Intervention.* The floss treatment involved applying a 4" elastic band to the dominant upper leg ([Figure 2](#)). The thigh was wrapped, starting at the superior pole of the patella overlapping by 50% and moving proximally up the thigh, ending at the gluteal fold.<sup>2</sup> The desired pressure of this wrap was between 140 and 200 mmHg<sup>2</sup> as measured by a

sub-bandage pressure sensor (Tekscan, South Boston, MA, reliability=0.97, validity=0.98) placed over the belly of the rectus femoris (Figure 3).<sup>14</sup>

The sham treatment involved the exact same 4" elastic band with very light pressure. The floss band was applied the same way as the floss treatment while reducing the pressure so that the band was just tight enough to not fall off. Pressure was measured between 10 and 40 mmHg of pressure on the thigh. The control treatment involved no application of a band and the participants only warmed-up on the stationary bike, performed the pre-test, performed active movements as described below without a band, and then completed post-test measurements.

**Exercise Protocol.** The participants were instructed to perform one set of 10 bodyweight squats so the quadriceps were parallel to the floor, 10 lunges on each leg, and 20 standing hamstring curls with no resistance. The researcher demonstrated the proper technique first in order to show the participants how to correctly perform the exercises. The protocol took approximately two minutes to complete and was designed to target the muscles tested in the straight leg raise through complex multi-joint dynamic movements. After participants completed all of the exercises, the wrap was removed and the participants were instructed to walk for one minute. The ROM and power measurements were repeated in the same manner as during the pre-test. The cool-down consisted of five minutes on the stationary bike at the same speed and resistance as the warm-up. There were two to four days between each of the three research sessions.

#### STATISTICAL ANALYSIS

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, version 25.0) using two separate 3x2 repeated measures ANOVAs to compare the effects of intervention (floss, sham, control) and time (pre-test, post-test), one for each of the two dependent variables (ROM and power). Post-hoc analysis was performed with Bonferroni correction when main effects were found to be significant. We set the alpha level at 0.05 *a priori*.

#### RESULTS

For flexibility, the interaction between time and session was significant ( $F_{2,40}=17.54$ ,  $p<0.001$ ,  $\eta^2=0.47$ ; Table 1). Figure 4 illustrates the means for each group at pre-test and post-test. Post hoc tests for flexibility showed significant differences between pre- (86.14±8.06 degrees) and post-test (90.81±7.69 degrees) for the floss session ( $p<0.001$ , Mean Difference=4.67 degrees,  $CI_{95}=3.35-5.98$ ). In addition, post hoc tests revealed significant differences between pre- (87.67±7.51 degrees) and post-test (89.86±7.88 degrees) for the sham session ( $p=0.001$ , Mean Difference=2.19 degrees,  $CI_{95}=0.98-3.40$ ). For jump power, the interaction between time and session was not statistically significant ( $F_{2,40}=1.82$ ,  $p=0.18$ ,  $\eta^2=0.08$ ,  $1-\beta=0.36$ ; Table 2).



Figure 1: Straight leg raise range of motion test



Figure 2: Application of Floss Band

#### DISCUSSION

This study was the first to investigate the application of floss bands to the muscles of the thigh and measure subsequent flexibility improvements and single-leg vertical jump performance. The main clinical finding was that flossing improved flexibility by an average of 4.68 degrees without hindering power in the lower extremity. Based on the validity and reliability research by Vohralik et al.,<sup>11</sup> the criterion validity of the inclinometer tool was based upon a device with ±0.5° margin of error and was found to have a SEM of 1.35°, indicating that the differences found in the current study were also clinically significant. The researchers hypothesize that tissue flossing caused dissipation of myofascial adhesions along the hamstrings without affecting actual tissue length or negatively affecting the priming of Golgi tendon organs (GTOs) and muscle spindles.<sup>2</sup> There have been multiple research studies using several different techniques proposed to improve flexibility in the hamstrings, such as static and PNF stretching.<sup>6,7</sup> Physiologically for these stretching techniques, hamstring flexibility improvement is accomplished by stimulating GTOs

**Table 1: Range of Motion (ROM) Measurements in Degrees**

	Pre-test	Post-test	Mean Difference (95% CI)
Floss	86.14±8.06°	90.81±7.69°	4.67° (3.35, 5.98)*
Sham	87.67±7.51°	89.86±7.88°	2.19° (0.98, 3.40)*
Control	87.95±10.75°	88.14±9.93°	0.19° (-0.63, 1.01)

\* p<0.05 for intervention compared to control; CI = confidence interval

**Table 2: Power Measurements in Watts**

	Pre-test	Post-test	Mean Difference (95% CI)
Floss	3078.73±767.97 W	3120.58±823.16 W	41.85 W (-5.66, 89.35)
Sham	3130.86±817.71 W	3116.91±865.23 W	-13.95 W (-76.56, 48.66)
Control	3101.49±817.64 W	3117.64±810.74 W	16.15 W (-26.51, 58.81)

CI = confidence interval

and muscle spindles to allow the muscle fibers to lengthen.<sup>2</sup>

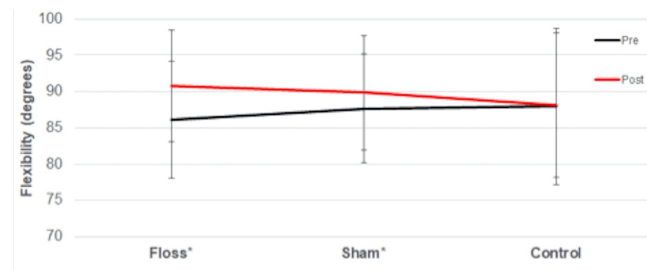
The difference between static and PNF stretching techniques and flossing is that flossing is proposed to break up tissue adhesions that limit flexibility, which may cause some irritation of the underlying tissue allowing maintenance of flexibility over time.<sup>2</sup> Traditional stretching techniques target the length or extensibility of the muscle, but this lengthening mechanism has been shown to decrease strength, power output, and muscle activation by affecting the GTOs and muscle spindles.<sup>15</sup> Research has also shown that 30 minutes of static stretching must be performed twice per week for at least five weeks to improve baseline flexibility.<sup>16</sup> In this study, flexibility was increased immediately while power remained unaffected. These findings may have significant value in a variety of settings that may include injury prevention, rehabilitation, and increased athletic performance due to maintaining ROM of the hamstrings.

Another common mechanism for increasing flexibility is deep tissue foam rolling (DTFR). DTFR has been reported to improve hamstring flexibility similarly to a PNF stretching routine.<sup>8</sup> The hypothesis behind the benefits of DTFR includes the stimulation of GTOs.<sup>8</sup> This stimulation is believed to decrease athletic performance by negatively affecting the priming of the GTOs.<sup>8</sup> When GTOs in the muscle are rolled over, they become less sensitive resulting in a decrease in the amount of power the muscle is able to produce. DTFR should be used with caution prior to physical activity as this may decrease performance by reducing power.<sup>8</sup>

Even though this study is the first to the authors' knowledge to examine the effects of flossing over muscle bellies, other researchers have examined the effects of tissue flossing on joints, specifically the ankle and the shoulder.<sup>1,3,4</sup> These studies have all found clinically relevant improvement in ROM of the ankle and shoulder after the application of a floss band. Researchers have claimed that occlusion and reintroduction of blood flow helps to improve ROM.<sup>2</sup> Clinically, this theory supports the use of floss bands not only



**Figure 3: TekScan Pressure Sensor**



**Figure 4: Group Means for Flexibility Across Testing Session**

\* p<0.05 for intervention compared to control

across a joint but also over the muscle bellies for increased

ROM as these same claims may be supported when flossing the muscle.

This study was not without limitations. The population was composed solely of healthy, college-aged individuals. With positive outcomes in a healthy population, future studies should continue to examine the clinical effectiveness of flossing on an injured population. While flossing has been shown to be effective with healthy individuals, these benefits may be compounded when being used for recovery and rehabilitation from injury. Another limitation was that there was low statistical power for the analysis of vertical jump which increases the odds of a Type II error. Increasing the sample size may produce different results for the effects of tissue flossing on lower extremity power. Further research should be conducted to determine what band pressure provides optimal benefits. Future research should also aim to determine a timeline for flexibility improvements after flossing. Determining the effects of flossing on more functional exercises could aid in identifying potential improvement carryover to sport specific activities. Lastly, the variability in days between the trials (2-4) could also be a limitation and should be examined in future studies.

## CONCLUSION

While there are many mechanisms to increase flexibility, these results support that flossing may not only immediately improve flexibility, but achieve this without hindering power. Therefore, flossing may be an appropriate treatment when ROM needs to be increased without altering power output. With positive outcomes in a healthy population, future studies should continue to examine the clinical effectiveness of flossing on an injured population.

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## CONFLICTS OF INTEREST

Authors report no Conflicts of Interest.

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