Original Research

Effect of deep stripping massage alone or with eccentric resistance on hamstring length and strength

Jeffrey Forman, PhD, NCTMB\textsuperscript{a,}*\textsuperscript{,} Lisbeth Geertsen, MS, CMT\textsuperscript{a}, Michael E. Rogers, PhD\textsuperscript{b}

\textsuperscript{a}De Anza College, Jeffrey Forman/Massage Therapy Program, 21250 Stevens Creek Boulevard, Cupertino, CA 95014, USA
\textsuperscript{b}Wichita State University, Department of Human Performance Studies, Wichita KS, USA

Received 6 December 2012; received in revised form 22 March 2013; accepted 8 April 2013

Keywords: Deep stripping massage strokes; Hamstring flexibility; Hamstring strength; Eccentric resistance

Summary

Background: Many studies have evaluated the effects of different interventions on hamstring length. However, little research has been conducted on the effects of deep stripping massage strokes (DSMS) alone, or combined with eccentric resistance, on hamstring length and strength.

Purpose: To determine: 1) if DSMS have an effect on hamstring length and strength and 2) if the effects on hamstring length and strength are any different when DSMS are combined with eccentric exercise.

Methods: 89 Community College students and community members between the ages of 18 and 62 volunteered for the study. Of these, 64 demonstrated tight hamstrings on either one or both sides as defined by supine, passive terminal knee extension of $\leq 75^\circ$ and participated in the study. Strength was assessed by pressing the posterior calcaneus into a strain gauge for approximately 5 s while seated with the knee flexed to $90^\circ$. On their tighter side, participants were administered longitudinal DSMS during 15, 10-s bouts of eccentric resistance with an elastic resistance band. On their other hamstring, participants were administered 15, 10-s longitudinal DSMS while lying passive. All massage strokes were performed at a depth of 7 out of 10 on a verbal pressure scale index. Afterwards, the hamstring flexibility and strength tests were repeated.

Results: Both DSMS with eccentric resistance (10.7%) and DSMS alone (6.3%) resulted in improved ($p < 0.01$) hamstring flexibility. The improvement following DSMS with eccentric resistance was greater ($p < 0.05$) than following DSMS alone. Strength was not significantly affected by either treatment.

* Corresponding author.
E-mail address: formanjeffrey@fhda.edu (J. Forman).

Please cite this article in press as: Forman, J., et al., Effect of deep stripping massage alone or with eccentric resistance on hamstring length and strength, Journal of Bodywork & Movement Therapies (2013), \textit{http://dx.doi.org/10.1016/j.jbmt.2013.04.005}
Introduction

Poor flexibility can negatively impact normal biomechanical balance and function, which can result in impaired mobility, pain and reduced sports performance. For example, limited range of motion in the hamstring muscle group has been associated with postural deviations, low back problems, impaired athletic performance and greater risk of injury (Crosman et al., 1984). Athletes participating in sports that require sprinting and acceleration commonly experience hamstring injuries. These injuries force many to miss practice and games and if not adequately treated the chance for re-injury is high (Brughelli et al., 2009).

Many studies have been performed measuring the effectiveness of different techniques at improving hamstring length and strength. Techniques such as static stretching, exercise, heat, massage, proprioceptive neuromuscular facilitation (PNF) and eccentric training have previously been shown to improve hamstring flexibility, and although some studies found PNF superior to other stretching techniques, most comparative analyses were inconclusive as to which techniques work best (Decoster et al., 2005; Spernoga et al., 2001; Funk et al., 2001, 2003; George et al., 2006).

The utilization of classic massage techniques such as gliding (effleurage), kneading (petrissage), and friction in studies by Barlow et al. (2004) and Hopper et al. (2005a,b) showed non-significant results in terms of improving flexibility of hamstrings. However, Hopper et al. (2005a,b) employed a technique called Dynamic Soft Tissue Mobilisation (DSTM) in addition to the aforementioned classic massage techniques, which showed a significant increase in hamstring length compared to both the control and the group that received traditional Swedish massage. In the soft tissue mobilization group the therapist positioned the client prone and employed deep longitudinal strokes over the entire hamstring group to isolate adhesions and/or hypertonic tissue. When these areas of myo-fascial restriction were uncovered the client was turned supine and focused deep longitudinal stripping strokes were then applied over these areas of restriction. The knee was first passively extended, then actively extended and finally eccentrically contracted against the therapists’ resistance during the stripping strokes. George et al. (2006) successfully utilized the Active Release Technique™ to increase hamstring flexibility. For the intervention participants were placed on their side with the hip extended and compressive forces were applied to the dorsal sacral ligaments while the hip was actively flexed. Participants were then placed in the prone position where the muscle bellies were treated. The knee joint was approximated, shortening the hamstrings, and compressive force was applied and maintained to areas of restriction in the bellies of the muscles while the subject actively contracted their antagonistic muscles, lengthening their hamstrings. The origins of the hamstrings were then treated using the same principles of joint approximation and compressive force into the tissue while the antagonist was contracted. Results showed that hamstring flexibility on average increased by 8.3 cm.

The results of the Nelson and Bandy (2004) study indicated that even though both static stretching and eccentric training improved flexibility there was no significant difference between the two methods. Regardless, Nelson & Bandy stipulated that a reduction in injuries may be achieved by implementing an eccentric training program that takes a muscle through a full range of motion as this provides a more functional option for flexibility training. Ferreira (2007) reported that their comparison between static stretching and eccentric training resulted in the same non-significant gains in hamstring flexibility. In agreement with Nelson & Bandy they opined that eccentric training was a better strategy to use for training because, in addition to increasing flexibility, it increases strength and can help protect against injuries.

Brughelli et al. (2009) argued that, since muscle has an optimum length for producing peak tension, hamstring injuries can be reduced if this optimum length is increased via training. They concluded that eccentric exercise is the only form of training that has consistently been shown to increase the optimum length of tension development and emphasized the importance of using functional movements with eccentric muscle contraction to rehabilitate hamstring muscle injuries. Aquino et al. (2010) studied individuals with tight hamstrings and compared the effect of strengthening the hamstrings in a lengthened position versus stretching. They reported no significant change in flexibility for the stretching and strength training groups, but the strengthening in the lengthened position group did demonstrate changed peak torque angles in the direction of knee extension. The authors suggested that strength training in the elongated position most likely induces structural adaptations in shortened muscles, which may help prevent musculoskeletal injuries.

Finally, in a pilot study by Forman et al. (2011) the effects of a warm-up versus deep stripping massage strokes DSMS combined with eccentric resistance on hamstring length were examined. Participants were taken through a pretest terminal hamstring length goniometer measurement, which was followed by a five-minute warm-up on an exercise cycle with zero resistance. After the warm-up, another hamstring length measurement was recorded. Then a series of fifteen ten-second bouts of hamstring eccentric resistance exercises were combined with DSMS before a final goniometer measurement of hamstring length was completed. They found that both warm-up and combining eccentric resistance with deep stripping massage increase hamstring length significantly, however the

Conclusions: These results suggest that DSMS increases hamstring length in less than 3 min but has no affect on strength. Furthermore, combining DSMS with eccentric resistance produces more hamstring flexibility gains than DSMS alone and does not affect strength. © 2013 Published by Elsevier Ltd.
combination of eccentric exercise with DSMS was three times more effective than the five-minute warm-up.

Our analysis of research has focused on techniques that have demonstrated the potential to increase muscle length and strength. Other researchers have suggested that eccentric training is an effective tool for increasing muscle length and strength and recommended it for preventing injuries (Nelson and Bandy, 2004; Ferreira, 2007). A great deal of research on eccentric training has been conducted, however certain avenues have not yet been investigated. There is a paucity of research on the effects of DSMS and minimal investigation has been conducted on the effects of combining DSMS with eccentric resistance. Therefore, this study seeks to fill the void in the existing research by investigating the effects that DSMS alone and combining DSMS with eccentric resistance have on hamstring length and strength.

Methods

Subjects

Participants between the ages 18–62 years (N = 89) were recruited through advertisements in the school newspaper, by informing all coaches of the sports teams, and by convenience. Of these, 64 participants (Age: 31.4 ± 12.1; 29.7% women; 70.3% men) qualified with either one or both hamstrings tight (85.9% right-side dominant; 14.1% left-side dominant) to match the criteria and with no history of knee, thigh, hip or lower back problems for 1 year before the study.

The Institutional Review Board of Wichita State University reviewed and approved the project according to the Federal Policy for the Protection of Human Subjects. All participants received written and oral instructions for the study and each gave their written informed consent prior to participation.

Community College adult students between the ages of 18 and 62 participated in this study. Individuals were allowed to participate if they had tight hamstrings, as demonstrated by a 15° or more knee extension deficit measured supine with the hip flexed to 90° and the ankle relaxed and no history of knee, thigh, hip or lower back problems for 1 year before the study. Bilateral hamstring pretest measurements were taken to record pre-intervention hamstring lengths and strength. Subjects were positioned supine on a massage table and hips were secured with a padded belt placed over both anterior superior iliac spines to eliminate pelvic rotation before hamstring measurements were taken. Hamstring flexibility measurements were recorded with a Hoggan Health Industries (West Jordan, UT) microFET3 digital muscle tester/inclinometer set to inclinometer. Before every measurement the machine was calibrated to zero using a pre-leveled surface. The subject was placed into 90° of hip flexion and while maintaining the 90° of hip flexion they were passively moved into their terminal hamstring length by a researcher extending the knee. When the researcher felt end-feel and the subject verbally agreed that terminal length was achieved another member of the research team placed the microFET3 on the anterior tibia four fingers inferior to the anterior fold of the ankle and recorded the measurement.

After the length of each hamstring was recorded, the microFET3 was set to muscle testing on the high threshold setting to measure and record the strength of each hamstring. To measure hamstring strength the participant was seated on the edge of a desk with the knee of the leg being measured flexed to approximately 90°. The microFET3 was attached to the side of the desk with Velcro, posterior and slightly superior to the center of the subjects’ calcaneus. After the participant was instructed to fold their arms across their abdomen members of the research stabilized both shoulders and the contralateral leg. The participant was then instructed to maximally contract their hamstring pushing against the machine with their calcaneus for approximately five seconds. For consistency, a metronome was used while the subject was instructed to “contract, 2, 3, 4 and stop”. After the pretests were completed the interventions were administered to all participants.

Interventions

Advanced massage therapy students of De Anza College performed the massage strokes and procedures for both interventions. These soon-to-graduate students received advanced training to become part of the research team. Every team member was familiar and confident with the different tasks required for each intervention. One massage therapist would complete both deep stripping massage interventions on each participant. However, between subjects the massage therapists would switch roles so that fatigue of the therapist would not affect results.

For Intervention A, the participants were positioned prone on a massage table and a researcher placed a Velcro extremity strap that had a green Thera-Band elastic resistance band (Hygenic, Akron, OH) attached to it around the participant’s ankle (Fig. 1).

The leg chosen for deep stripping combined with eccentric contraction was the leg with the tighter hamstring. If equally tight, the dominant leg was chosen. The free end of the resistance band was attached to the underside of the massage table and adjusted so that there was no slack in it to provide eccentric resistance throughout the full range of motion during the intervention. A few drops of Prossage oil were then gently spread on the participants’ skin. A metronome set to one beat per second was turned on to help maintain consistent timing. The participant was then passively moved into knee flexion beyond 90°, so that they experienced zero concentric resistance. After releasing the ankle the participant was instructed to engage their hamstring muscles countering the resistance of the resistance band so that it took a full 10-s count for the leg to be fully extended. As the participant slowly lowered their leg under resistance, a massage therapist concurrently performed a series of deep longitudinal stripping massage strokes (7 out of 10 on the verbal pressure scale) up the participants’ hamstring muscles from the insertion points to the ischial tuberosity (Fig. 2).

The massage therapists would discuss the verbal pressure scale with the participant before the interventions began. During the procedures the therapist would ask the
participant for feedback on the pressure and adjust the amount of force applied during the strokes to what the participant considered to be a seven. Everyone has a different level of force tolerance and the intention was to apply firm strokes without unnecessary pain. This subjective feedback from the participants allowed the massage therapists to work at an appropriate level of force for each individual. These deep-stripping strokes were first applied to the lateral aspect of the hamstrings, then the center and finally the medial aspect. A total of fifteen deep stripping massage strokes were applied to each hamstring group. The longitudinal stripping massage strokes were applied with the flats of the knuckles of one hand as the therapist reinforced their wrist by grasping it with their other hand. The therapist held a green Hand Exerciser (Hygenic, Akron, OH) ball as a shock absorber in the hand performing the strokes (Fig. 3). Intervention B was administered immediately following the completion of intervention A.

For intervention B, which was performed on the less tight hamstring (and if equally tight the non-dominant leg), fifteen deep longitudinal stripping massage strokes were applied in exactly the same manner. However, the participant was passive and did not perform any eccentric contractions during the treatment.

Immediately after the massage strokes for intervention B were completed the participant’s hamstring length and the strength of both legs were measured with the aforementioned pretest protocols.

Statistical analysis

Data analysis was completed using the statistical software program SPSS for Windows V.18.0 (SPSS Inc., Chicago, IL). Data were screened for outliers, and assumptions of normality and homoscedasticity. To reduce the potential influence of outliers on the statistical analysis, box-and-whiskers plots were used to identify outliers, which were subsequently eliminated prior to analysis. Each variable was examined for normality using the Kolmogorov–Smirnov test. Assumptions of homogeneity of variance and sphericity were evaluated. Baseline group mean comparisons were performed using a one-way ANOVA. Repeated measures ANOVA procedures were conducted using the raw values to evaluate the effects of the interventions. Percent change scores were also calculated from the difference in scores. A probability value of less than 0.05 was considered statistically significant.

Results

The qualifying participants \( (n = 64) \) completed both interventions. Groups were divided into DSMS with eccentric resistance and DSMS alone. Groups were similar at baseline
for both flexibility and strength measures. For DSMS with eccentric resistance there was a 10.7% improvement \((p < 0.01)\) in flexibility following intervention. For the group receiving only DSMS, there was a 6.3% improvement \((p < 0.01)\) in flexibility. A comparison between groups found that the improvement in flexibility following the combination of stripping strokes and eccentric resistance was significantly greater \((p < 0.01)\) than following stripping strokes alone (Table 1).

There was a non-significant 1.1% increase \((p > 0.05)\) in strength following the combination of stripping strokes and eccentric resistance. There was also a non-significant 1.8% decrease \((p > 0.05)\) in strength with massage only (Table 2) Table 3.

### Discussion

This study attempted to determine the effects of DSMS combined with eccentric resistance (intervention A) versus DSMS alone (intervention B). We were able to reject the null hypothesis regarding flexibility as we saw a significant difference in flexibility comparing the results from intervention A and B. Although both interventions were effective at increasing flexibility significantly, the leg that was submitted to DSMS combined with eccentric resistance showed significantly greater gains than the leg where only DSMS were applied. The superiority of combining DSMS with eccentric exercise was also seen in a previous pilot study conducted by Forman et al. (2011).

The reasoning behind the greater gains in flexibility when adding eccentric resistance to DSMS may be found in the rapid training effect, which has been explored in a few studies on eccentric exercises by Lynn and Morgan (1994) and Lynn et al. (1998). The training effect refers to improvement in functional ability and strength due to changes in the muscular, cardiovascular, and neurological systems, and in their study of rats Lynn and Morgan (1994, 1998) found that the number of connected sarcomeres in the vastus intermedius muscle fiber increased during decline running. This is possibly the same phenomenon Simons et al. (1999) are referring to when suggesting that lengthening contractions may equalize sarcomere length. In terms of strength there were no significant increases following any of the interventions. Wiktorsson-Moller et al. (1983) noted the same lack of effect of massage on strength. If rapid training effect causes adaptations in the muscular and neuromuscular systems, and thus has an effect on flexibility it cannot explain why similar adaptations in strength did not take place in the current study. However, a study by Raastad and Hallen (2000) found that muscles exposed to eccentric training with maximal contraction were 12–14% weaker 5–20 min after exercise. Raastad and Hallen speculated whether the causes of fatigue were from the central nervous system in the form of reduced motor drive or from the peripheral nervous system and thus within the muscle. They concluded that since reduced neural activation seem to recover within five minutes, the prolonged fatigue had to come from within the muscle itself possibly due to reduced \(\text{Ca}^{2+}\) release from the sarcoplasmic reticulum caused by changes in the excitation-contraction coupling.

In the current study, the participants had less than five minutes to recover from intervention to post test, and thus their hamstrings could still be fatigued from the eccentric loading and massage combination. Given adequate time to recover the potential for significant strength gains would possibly increase.

Although the current study showed significantly better results combining DSMS with eccentric resistance than by utilizing only DSMS, the technique will need to be researched further in order to fully determine its benefits relative to other techniques aimed at improving flexibility, e.g., ART and PNF. Additionally, further study is needed to determine how long flexibility is enhanced following DSMS combined with eccentric resistance. This is a shortcoming of most research on soft tissue techniques, and thus there is limited scientific evidence as to whether improvements are transitory or have a lasting effect. Finally, training studies utilizing these techniques are warranted to determine the effects of repeating these measures on flexibility and strength over time. This will be of importance to

### Table 1 Means & standard deviations for flexibility measures (degrees).

<table>
<thead>
<tr>
<th></th>
<th>(N)</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre flexibility: stripping + eccentric</td>
<td>64</td>
<td>64.4</td>
<td>8.2</td>
<td>33</td>
<td>42</td>
<td>75</td>
</tr>
<tr>
<td>Post flexibility: stripping + eccentric</td>
<td>64</td>
<td>71.3</td>
<td>9.3</td>
<td>40</td>
<td>48</td>
<td>88</td>
</tr>
<tr>
<td>Pre flexibility: stripping alone</td>
<td>64</td>
<td>69.5</td>
<td>8.6</td>
<td>44</td>
<td>45</td>
<td>89</td>
</tr>
<tr>
<td>Post flexibility: stripping alone</td>
<td>64</td>
<td>73.9</td>
<td>9.0</td>
<td>38</td>
<td>49</td>
<td>87</td>
</tr>
</tbody>
</table>

* Within group comparison: \(p \leq 0.01\); † Between group comparison: \(p \leq 0.01\).

### Table 2 Means and Standard Deviations for Strength Measures (kg).

<table>
<thead>
<tr>
<th></th>
<th>(N)</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre strength: stripping + eccentric</td>
<td>64</td>
<td>6.5</td>
<td>3.3</td>
<td>15.1</td>
<td>1.6</td>
<td>16.7</td>
</tr>
<tr>
<td>Post strength – stripping + eccentric</td>
<td>64</td>
<td>6.6</td>
<td>3.8</td>
<td>14.8</td>
<td>2.1</td>
<td>16.8</td>
</tr>
<tr>
<td>Pre strength – stripping alone</td>
<td>64</td>
<td>6.7</td>
<td>3.4</td>
<td>13.2</td>
<td>1.4</td>
<td>14.6</td>
</tr>
<tr>
<td>Post strength – stripping alone</td>
<td>64</td>
<td>6.6</td>
<td>3.9</td>
<td>15.9</td>
<td>1.6</td>
<td>17.5</td>
</tr>
</tbody>
</table>
practitioners who utilize various mobilization techniques on a daily basis to improve flexibility, as determining the optimal number of repeats for long-term effects will help their clients obtain and maintain flexibility.

Conclusions

Many techniques to improve flexibility have previously been explored and more continue to be studied to determine the most efficient and effective method. The results of this study indicate that utilizing DSMS with eccentric resistance improves flexibility to a greater extent than DSMS alone. Obtaining and maintaining normal joint range of motion is an important factor in injury prevention, and provided treatment protocols are developed for upper and lower extremities as well as the spine, this technique may prove beneficial and effective in the work of athletic trainers, massage therapists, and physical therapists when the aim is restoring flexibility to restricted joints.

References


