Immediate Effects of Hamstring Muscle Stretching on Pressure Pain Sensitivity and Active Mouth Opening in Healthy Subjects

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Abstract

Objective: This study analyzed the immediate effect of hamstring muscle stretching on pressure pain sensitivity over the masseter and the upper trapezius muscles and maximum active mouth opening in healthy subjects.

Methods: One hundred twenty volunteers, 70 males and 50 females, between the ages of 22 and 47, were randomly divided into 3 groups: group 1 (control group) that did not receive any intervention, group 2 where a unilateral hamstring muscle stretching was applied, and group 3 where a bilateral stretching was applied. Pressure pain thresholds (PPTs) were bilaterally assessed over the masseter and upper trapezius muscles pre- and 5 minutes posttreatment by an assessor blinded to group assignment. Maximum mouth opening was also assessed pre- and 5 minutes posttreatment. Mixed-model analyses of variance (ANOVAs) were used to examine the effects of the intervention. The primary analysis was the group × time interaction.

Results: The ANOVA revealed significant group × time interaction for changes in PPTs over the upper trapezius (F = 4.5; P = .01) and masseter (F = 6.3; P = .002) muscles. Pre-post effect sizes were moderate (0.5 > d > 0.7) for both stretching groups and negative ($d < -0.2$) for the control group. A significant group × time interaction (F = 8.15; P < .001) for maximum mouth opening was also found; both experimental groups showed greater improvement when compared to the control group (P < .001). Pre-post effect sizes were large (d > 0.7) for both stretching groups and negative ($d < -0.2$) for the control group.

Conclusions: The application of a stretching of the hamstring musculature produced an immediate increase in PPTs over both masseter and upper trapezius muscles in healthy subjects. (J Manipulative Physiol Ther 2010;33:42-47)

Key Indexing Terms: *Pain Threshold; Neck Muscles; Masseter Muscle; Muscle Stretching Exercise*

The temporomandibular joint has been linked to several alterations in different parts of the body, particularly the cervical spine[1,2] and sacroiliac joint.[3] Several authors have hypothesized that posture training may be a positive impact on the masticatory muscles because a proper posture can play a relevant role in the relationship between the temporomandibular joint and the rest of the body.[4-6]

Within postural control, both the suboccipital and hamstring musculature may be involved. It has been recently found that the application of a manual intervention over the suboccipital muscles induced an increase in hamstring flexibility.[7] The continuity of the neural system theoretically links the dura mater, which anatomically is inserted into the suboccipital muscles (particularly the rectus capitis posterior minor muscle)[8] and the hamstring musculature. These hypotheses suggest an anatomical relationship between the hamstring muscles and the cervical, which may also have other potential relationships, for example, biomechanical, therapeutics, and others.

In 1955, Morton[9] hypothesized a possible relationship between the musculature of the lower extremity and mouth opening. Nevertheless, this observation has not been deeply studied. Fernández-de-las-Peñas et al[10] found an increase in active mouth opening and a decrease in trigger point sensitivity over the masseter muscle after the application of a

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postisometric relaxation technique of the hamstring musculature ipsilateral to the masseter muscle trigger point. Authors explained their findings due to a possible functional relationship between hamstring and masticatory muscles through the concept of muscle chains.

Nevertheless, it is plausible that hamstring muscle stretching may have a more general effect, as other therapeutic interventions, activating the descending inhibitory control pathways.[11] Previous studies have investigated the hypoalgesic effect of joint mobilization targeted at the cervical spine,[12,13] or the elbow region[14] in patients with lateral epicondylalgia, or in patients with mechanical neck pain.[15] To initially elucidate the physiologic mechanisms associated with stretching interventions, it is essential to determine the response in asymptomatic individuals who do not have any sensitization process mechanisms.[16] In fact, we have recently used healthy subjects for investigating hypoalgesic effects of spinal manipulation of the middle[17] or lower[18] cervical spine.

To the best of the authors' knowledge, no previous study has investigated bilateral changes in pressure pain sensitivity over the masseter and upper trapezius muscles after the application of a stretching intervention of a distant-related muscle. The aim of the current study was to analyze the immediate effect of the stretching of the hamstring muscles on pressure pain sensitivity over the masseter and upper trapezius muscles and maximum active mouth opening in healthy pain-free subjects.

Methods

Subjects

One hundred twenty pain-free volunteers, 70 males and 50 females, with ages from 22 to 47 years (mean age, 32 ± 7 years), were included. Participants were excluded if they exhibited history of neck trauma (whiplash), neck symptoms, history of fracture in any part of the body, history of neck or low back pain, herniated disk or lumbar protrusion, symptoms in the lower extremity, diagnosis of fibromyalgia,[19] any muscle tendon injury of the hamstring muscles, or regular use of analgesic or antiinflammatory drugs. Ethical approval for the study was granted by the Ethical Committee of the Escuela de Osteopatía de Madrid (Spain) (CCT-NANT-1755). All participants signed the informed consent before they were included in the study, and all procedures were conducted according to the Declaration of Helsinki.

Sample Size Determination

The sample size and power calculations were performed with a Spanish software (Ene 2.0, e-biometría, GSK, Madrid, Spain). The calculations were based on detecting differences of 7.9 mm at postdata, assuming an SD of 13 mm in maximum active mouth opening, a 2-tailed test, an α level of .05, and a desired power of 80%. These assumptions generated a sample size of 40 subjects per group.

Fig 1. *Pressure pain threshold assessment (trapezius muscle and masseter muscle).*

Pressure Pain Threshold Assessment

Pressure pain threshold (PPT) is defined as the amount of pressure where a sense of pressure first changes to pain.[20] A mechanical pressure algometer (Pain Diagnosis and Treatment Inc, New York, NY) was used. This device consists of a round rubber disk (1 cm^2) attached to a pressure (force) gauge. The gauge displays values in kilograms. Because the surface of the rubber tip is 1 cm^2, the readings are expressed in kilogram per square centimeter. The range of the algometer is 0 to 10 kg and records in 0.1-kg divisions. The mean of 3 trials (intraexaminer reliability) was calculated and used for the main analysis. A 30-second resting period was allowed between each trial. The reliability of pressure algometry has been found to be high (intraclass correlation coefficient = 0.91 [95% confidence interval, 0.82-0.97]).[21] Pressure pain threshold was bilaterally assessed over the masseter and the upper trapezius muscles (Fig 1) pre- and 5 minutes posttreatment by an assessor blinded to group assignment.

Maximum Active Mouth Opening

Active mouth opening was assessed with subjects in supine. Participants were asked to "open the mouth as wide as possible without causing pain." At the end position of maximum active mouth opening, the distance between upper-lower central incisors was measured in millimeters. The intratester reliability has been found to be high (intraclass coefficient = 0.9-0.98).[22] The mean of 3 trials was calculated and used for the main analysis. Active mouth opening was assessed pre- and 5 minutes posttreatment by an assessor blinded to group assignment.

Stretching of the Hamstring Muscles

There are several protocols related to the time of the application of hamstring muscle stretching: 10 seconds,[23] 15 seconds,[24] 30 seconds,[25] or 60 seconds.[26] Nevertheless, it seems that 40 seconds appears to be a proper time for the application of the stretching.[27-29] Therefore, both experi-

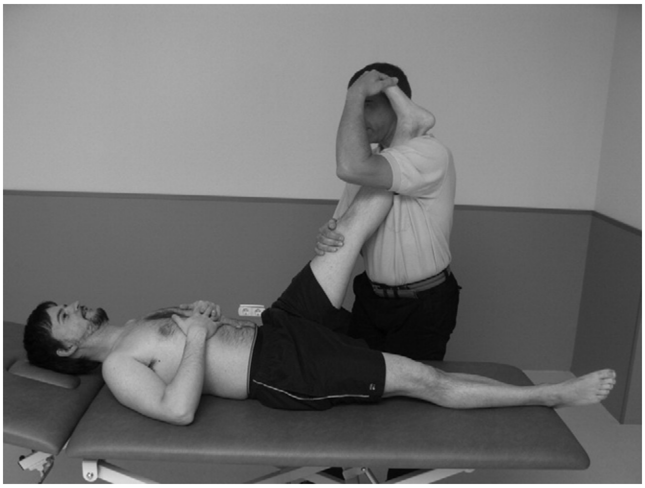

Fig 2. *Stretching of the hamstring muscles.*

mental groups received a stretching of the hamstring muscles as follows. Participants were in supine. The therapist passively positioned the hamstring muscle of the participant in the barrier (hip in flexion and knee in extension) without discomfort to the point where resistance to movement was first noted. In addition, dorsiflexion of the ankle was applied (Fig 2). That position was maintained for 40 seconds. The therapist ensured that participants would not make any compensation that might modify the stretching position.

Randomization

Participants were randomly divided, using a simple random distribution, into 3 groups: group 1 was a control group that did not receive any intervention during 40 seconds, group 2 where a unilateral stretching of the hamstring muscles of the dominant leg was applied, and group 3 where a bilaterally stretching of both hamstring muscles was conducted.

Statistical Analysis

Statistical analysis was conducted with the SPSS 14.5 package (SPSS, Chicago, IL). Mean, SD, or 95% confidence intervals of the values are presented. The Kolmogorov-Smirnov test showed a normal distribution of quantitative data ($P > .05$). Baseline features were compared between the study groups using an analysis of variance (ANOVA) for continuous data and χ^2 test of independence for categorical data. A 2 × 2 × 3 mixed model ANOVA with time (pre-post intervention) and side (dominant or nondominant; ipsilateral or contralateral to the unilateral stretching) as the within-subjects variables and group (control, unilateral, or bilateral stretching) as between subjects variable was used to examine the effects of interventions on PPTs. A 2 × 3 mixed model ANOVA with time (pre-post) as the within subject variable and group (control, single stretching, or bilateral stretching) as between subjects variable was used to examine the effects of interventions on mouth opening. The hypothesis of interest was the group × time interaction at an a priori α level equal to .05. The Bonferroni test was used for post hoc analysis. Within-group effect size was calculated using Cohen d coefficient (*d*).[30] An effect size greater than 0.8 was considered large, around 0.5 was moderate, and less than 0.2 was small.

Table 1. *Pre, post, and change scores in PPTs (kPa) over the masseter and upper trapezius muscles and active mouth opening after each intervention*

	Unilateral stretching	Bilateral stretching	Placebo group
PPT (kg/cm²) in the dominant/ipsilateral masseter muscle			
Preintervention	2.5 ± 0.7	2.7 ± 1.1	2.9 ± 1.1
Postintervention	2.7 ± 0.7	3.0 ± 1.3	2.8 ± 1.1
Pre-post differences	0.2 ± 0.5 (0.1/0.4)	0.3 ± 1.1 (0.1/0.7)	−0.1 ± 0.5 (−0.2/0.1)
PPT (kg/cm²) in the nondominant/contralateral masseter muscle			
Preintervention	2.5 ± 0.6	2.6 ± 0.9	2.8 ± 1.0
Postintervention	2.6 ± 0.7	2.7 ± 1.1	2.7 ± 0.9
Pre-post differences	0.1 ± 0.3 (0.0/0.2)	0.1 ± 0.8 (0.0/0.4)	−0.1 ± 0.3 (−0.2/0.0)
PPT (kg/cm²) in the dominant/ipsilateral upper trapezius muscle			
Preintervention	4.0 ± 1.5	4.7 ± 2.2	4.6 ± 1.7
Postintervention	4.6 ± 1.7	5.3 ± 2.9	4.8 ± 1.9
Pre-post differences	0.6 ± 0.9 (0.2/0.8)	0.6 ± 1.3 (0.2/1.2)	−0.2 ± 0.9 (−0.5/0.1)
PPT (kg/cm²) in the nondominant/contralateral upper trapezius muscle			
Preintervention	4.1 ± 1.6	4.7 ± 2.3	4.8 ± 1.9
Postintervention	5.0 ± 2.0	5.4 ± 2.7	5.1 ± 2.2
Pre-post differences	0.9 ± 1.1 (0.5/1.2)	0.7 ± 1.2 (0.4/1.1)	−0.3 ± 0.8 (−0.6/0.1)
Active mouth opening (mm)			
Preintervention	41.7 ± 8.9	42.7 ± 7.5	44.3 ± 8.8
Postintervention	42.5 ± 8.3	44.1 ± 7.3	43.9 ± 9.1
Pre-post differences	0.8 ± 1.3 (0.5/1.5)	1.4 ± 1.8 (0.9/2.0)	−0.4 ± 1.8 (−1.0/0.2)

Scores are expressed as mean ± SD for pre- and postintervention data and as mean ± SD (95% confidence interval) for pre-post differences.

Results

Forty subjects, 23 men and 17 women (mean age, 33 ± 7 years), were assigned to the control group; another 40 participants, 24 men and 16 women (mean age, 29 ± 6 years), were in the unilateral stretching group; and finally, the remaining 40 subjects, 23 men and 17 women (mean age, 32 ± 7 years), formed the bilateral stretching group. No significant differences between groups were found for sex ($P = .8$), age ($P = .4$), mouth opening ($P = .4$), and PPTs over either upper trapezius or masseter muscle ($P = .2$), so it could be assumed that they were comparable at the start of the study (Table 1).

Pressure Pain Threshold Levels

The 2 × 2 × 3 mixed model ANOVA revealed significant effect for time ($F = 61.1$; $P < .001$) and a significant group × time interaction ($F = 4.5$; $P = .01$) for changes in PPT over the upper trapezius muscle. No significant interaction between group × time × side ($F = 0.4$; $P = .6$) was found. Post hoc found significant differences between the control group and both experimental groups ($P < .01$) but not between experimental groups ($P = .7$). Pre-post effect sizes were moderate ($0.5 > d > 0.7$) for both stretching groups but negative ($d < -0.2$) for the control group. Table 1 summarizes pre-post values of PPT levels in the 3 groups.

The mixed model ANOVA also found a significant effect for time ($F = 6.6$; $P = .01$) and a group × time interaction ($F = 6.3$; $P = .002$) for changes in PPT over the masseter muscle. Post hoc analyses found differences between the control group and both experimental groups ($P < .05$) but not between the experimental groups ($P = .8$). Pre-post effect sizes were moderate-small ($0.4 > d > 0.2$) for both stretching groups and negative ($d < -0.2$) for the control group. Table 1 summarizes pre-post values of PPT levels in the 3 groups.

Active Mouth Opening

The 2 × 3 mixed model ANOVA found significant effect for time ($F = 10.4$; $P = .002$) and a significant group × time interaction ($F = 8.15$; $P < .001$) for active mouth opening. Post hoc revealed significant differences between the control group and both experimental groups ($P < .001$) but not between experimental groups ($P = .6$). Pre-post effect sizes were large ($d > 0.7$) for both stretching groups and negative ($d < -0.2$) for the control group. Table 1 shows pre-post values of active mouth opening in each group.

Discussion

The results of the current study found that stretching of the hamstring muscles, either unilateral or bilateral, exerts an immediate hypoalgesic effect, that is, an increase in PPT levels, over the masseter and the upper trapezius muscles in a cohort of healthy subjects. Effect sizes for both stretching groups were moderate for the increase in PPT over the upper trapezius muscle and small-moderate for PPTs over the masseter muscle. In addition, an increase in maximum active mouth opening, with large effect sizes, was also found after the stretching of the hamstring musculature.

It has been previously suggested that stretching of the hamstring musculature may reduce the number of leg overuse injuries after exercise,[31] although further high-quality studies are needed.[32] Furthermore, stretching of the hamstring muscles may be also capable of increasing the straight-leg raise range of motion.[33] Some theories explaining the therapeutically effects of muscle stretching may be the alteration of the viscoelastic properties of muscles.[29,34]

A relationship between the hamstring musculature and the cervical region has been previously suggested. In fact, the application of a muscle inhibition intervention over the suboccipital muscles induced an increase in hamstring muscle flexibility and PPT over the hamstring muscles.[7] Another study found that a contraction-relaxation of the suboccipital muscles was able to generate an increase in hip flexion, although the results are debatable.[35] Even cervical manipulation techniques have provided changes in the hamstring muscles, supporting the notion of a cranial-caudal influence.[36]

The results of this study provide some evidence that muscle stretching may exert a mechanical hypoalgesic effect, at least, in healthy subjects in distant areas, such as the upper trapezius and masseter muscles. We found that the increase in PPT was greater over the upper trapezius (15%-22%) when compared to the masseter muscle (10%). Because postintervention data were taken 5 minutes after the muscle stretching, it is possible that the hamstring muscle stretching has different effects over pain sensitivity of muscles innervated by spinal nerves as compared to those effects over muscles innervated by cranial nerves. Future studies should investigate this. Current findings are similar to those previously found in patients with trigger points in the masseter muscle.[10] Nevertheless, in our previous study, we only investigated unilateral changes on pressure pain sensitivity. In the present study, we found bilateral changes in PPT levels with a unilateral stretching, supporting the activation of central structures, because a unilateral intervention produced a bilateral response.

Our findings also agree with previous studies investigating hypoalgesic effects of joint mobilization or manipulation interventions.[12,14,15,17,18,37] We found increases in PPT between 12% and 22% over the upper trapezius muscle but only 10% for PPT over the masseter muscle. Previous studies have reported that joint mobilizations of the cervical spine produced an immediate increase of 25% in PPT levels over the elbow in patients with lateral epicondylalgia[37] and over the symptomatic cervical level in patients with idiopathic neck pain.[15] We had also previously found that manipulative interventions targeted to the cervical spine produced a bilateral immediate increase of PPT between 20.1% and 35.5% in healthy subjects.[17,18] Other authors found increases of PPT levels between 10% and 20% after the application of mobilization-with-movement interventions to the elbow.[12,14] These findings suggest that muscle stretching may have similar effects, at least, on pressure pain sensitivity than mobilization and/or manipulation interventions.

We also found an increase of 1.4 mm in active mouth opening after the bilateral stretching and 0.8 mm after the unilateral stretching. These increases are inferior to those previously found after the treatment of the masseter muscle with localized interventions[38] or after the application of a cervical thrust manipulation.[39] Nevertheless, we should take into account that with a hamstring muscle stretching, clinicians cannot treat restrictions in active mouth opening. The increase in active mouth opening found in the current study may be related to indirect relaxation of the masseter muscle obtained after the stretching intervention or to a more general effect of the stretching. Future studies should investigate the neurophysiologic mechanisms of muscle stretching on pressure pain sensitivity and active range of motion of distant regions.

Limitations

Our study has several limitations. It should be recognized that we only assessed immediate hypoalgesic effects of stretching of the hamstring muscles on pressure pain sensitivity and active mouth opening. Immediate changes occurred after the muscle stretching provides impetus for future research in this area. Futures studies should investigate the long-term impact of this intervention on PPT. Another limitation is we used an asymptomatic sample. Hence, we do not know if the same effects would be similar in patients with acute pain or in a state of central sensitization. Thirdly, we cannot rule out a placebo effect because the control group did not receive any type of intervention.

Conclusions

The application of a stretching of the hamstring muscles produces an immediate increase in PPT over the masseter and upper trapezius muscles in healthy subjects. Effect sizes for both stretching groups were moderate for PPTs over the upper trapezius and small-moderate for PPT levels over the masseter muscle. Furthermore, an increase in active mouth opening, with large effect size, was also found after the stretching of the hamstring musculature. It may be that muscle stretching may also activate descending inhibitory pathways; although further studies are required.

Practical Applications

- The application of a stretching of the hamstring muscles produces an immediate increase in PPT levels over the masseter and upper trapezius muscles in healthy subjects.
- The application of a hamstring muscle stretching also produced an increase in active mouth opening, with large effect sizes as compared to placebo.
- It may be that hamstring muscle stretching may activate descending inhibitory pathways.

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No funding sources or conflicts of interest were reported for this study.

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