A Comparison of the Immediate and Lasting Effects Between Passive Stretch and Muscle Energy Technique on Hamstring Muscle Extensibility

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ABSTRACT

Introduction: Muscle energy technique (MET) and passive stretching are two manual techniques commonly used by manual therapists to increase the extensibility of muscles. This study examined the effect of both techniques to produce lasting increased hamstring muscle extensibility.

Methods: 162 asymptomatic volunteers were measured for active knee extension (AKE) and randomly allocated to either a passive stretch, MET or control (no treatment) group. All participants were re-measured for AKE immediately after intervention, ten minutes after, and one hour after by an examiner who was blinded to the treatment allocation.

Results: Within-group pre-post changes were calculated using a one-way ANOVA. The MET produced a significant (MET: p=0.027, stretch: p=0.608 at one hour post) and greater mean change than the passive stretching group. The MET also produced a greater pre-post effect size (MET: *d*=0.95, stretch: *d*=0.56, control: *d*=0.18 at one hour post) than the passive stretching or control groups. Between-group differences were analysed using SPANOVA, and revealed that mean changes for both MET and passive stretching groups were significantly different to the control group at all stages (MET: p=0.000, stretch: p=0.015 at one hour post), but were not significantly different from each other.

Conclusion: MET appeared to be more effective than passive stretching for increasing hamstring extensibility immediately post-treatment and still at 1 hour later.

Keywords: isometric, stretch, muscle energy, hamstring, osteopathy

INTRODUCTION

Passive stretching and isometric contract-relax stretching (muscle energy technique, "MET") are commonly used in manual therapy professions, such as osteopathy and physiotherapy, to improve joint and muscle extensibility in patients. Static stretching consists of a sustained elongation of the desired muscle group, commonly with a duration of 10 to 30 seconds.[1] MET is an osteopathic treatment procedure that involves the voluntary contraction of patient muscle in a precisely controlled direction, at varying levels of intensity, against a distinctly executed counterforce applied by the operator.[2] Greenman [2] stated that MET can be used to lengthen a shortened, contracted, or spastic muscle; to strengthen a physiologically weakened muscle or group of muscles; and to mobilize an articulation with restricted mobility.

Passive static stretch and MET have been demonstrated to be effective in increasing joint range of motion (ROM) and muscular extensibility, [3,4,5,6] but it is unclear whether passive stretch or MET produce greater or more lasting change. Furthermore, the mechanism of increased extensibility is controversial, with some authors citing visco-elastic changes while other researchers support a change in stretch tolerance only.

Researchers who have investigated the effect of stretching techniques on hamstring muscle extensibility have commonly measured extensibility with either active knee extension (AKE) [1,7] or torque-controlled passive knee extension (PKE).[10,11,13] AKE has been demonstrated to be reliable and accurate, when using either a fluid-filled goniometer attached to the upper leg,[1] or using a hand-held goniometer.[7] AKE has the advantage of being relatively simple to use, particularly in the clinical setting, and is a good measure of physiological ROM. Torque-controlled PKE additionally measures the torque required to extend the muscle, and can provide an indication of the mechanism behind change (change in muscle property or in increase in tolerance to stretching). Hence, an increase in AKE indicates a greater range of available motion, but the mechanism of change cannot be determined.

Passive hamstring muscle stretching has been demonstrated to produce a temporary increase in hamstring extensibility. Bandy *et al.*[8] recruited 57 volunteers with limited hamstring muscle extensibility and demonstrated that stretching for 5 days per week over 6 weeks was more effective for increasing muscle extensibility (as determined by increased AKE), but there was no difference between stretching one or three times per day, or using either a 30 or 60-second duration of stretching. The authors concluded that a 30-second duration was an effective amount of time for hamstring muscle stretching.

Willy *et al.*[9] investigated hamstring muscle extensibility in 16 inactive college students following a stretching programme, and again after resumption of stretching. The authors evaluated the effect of 6 weeks of static hamstring stretching (two 30-second stretches per day, 5 days per week), followed by 4 weeks of cessation from stretching, and than 6 weeks with resumption of stretching. Hamstring extensibility was measured with AKE. Stretching produced increased AKE but there was no retention of increased AKE four weeks following the stretching protocol, and a subsequent stretching period did not enhance the gain of knee ROM over the initial stretching period.

Most studies that have investigated the effect of hamstring stretching using PKE have failed to demonstrate significant changes when the some pre and post torque was used.[3,10,11] Magnusson *et al.*[11] investigated the effect of a 3-week stretching regimen using torque-controlled PKE. No significant differences in stiffness, energy and peak torque were seen as a result of the training, although PKE increased when stretched to the point of pain. Magnusson *et al.*[11] concluded that the increased range of motion achieved from a stretching programme was a consequence of increased stretch tolerance rather than a change in the mechanical or viscoelastic properties of the muscle.

Gajdosik[3] reported similar findings following three weeks of daily static stretching of short hamstrings using a passive straight leg raise (SLR). The author reported that daily static stretching of short hamstring muscles significantly increased the muscle's length with a concomitant increase to withstand a greater passive torque (stretch tolerance).

Several studies have shown the effectiveness of isometric stretch techniques (such as MET, contract-relax and PNF) in increasing hamstring flexibility.[5,6,12,13] Lustig *et al.*[6] examined the effects of two PNF (stretch relax (SR) and contract relax (CR)) stretching procedures on extensibility and muscular strength, using non-torque controlled PKE. The SR and CR groups showed mean increases in hip flexibility (6.2% and 6.8% respectively), which were significantly ($p= 0.05$) different from the control group. The results of this study suggested that PNF stretching procedures may be effective for increasing extensibility and developing muscular strength yet the mechanism underlying the change was not investigated.

Ballantyne *et al.*[13] found that a single application of MET produced an immediate increase in torque controlled PKE. However there was no evidence of visco-elastic change, because the increased PKE was accompanied by an increase in torque, suggesting that increased extensibility was due to an increase in tolerance to stretch.

Only a few studies have compared the effectiveness of passive stretching and isometric stretching techniques.[4,11,12] Gribble *et al.*[4] explored the effects of static and hold-relax stretching on hamstring extensibility using a SLR method. The authors determined that both static and hold-relax techniques significantly improved hamstring extensibility but were equally effective. Magnusson *et al.*[11] examined EMG activity, passive torque, and stretch perception during static stretch and contract-relax stretch using torque controlled PKE. Magnusson *et al.*[11] found that contract-relax and static stretch did not differ in passive torque or EMG response, but contract-relax increased extensibility significantly more. The authors concluded that the viscoelastic and EMG response was unaffected by the isometric contractions, but it was possible that contract-relax stretching altered stretch perception more than passive stretching.

MET and static stretching have been demonstrated to improve flexibility and joint ROM, particularly when measured by AKE, although the mechanism and duration of effect remains controversial. In many clinical situations, patients may be seen by practitioners once or twice a week, or even less commonly in non-acute situations. It is therefore important to examine whether passive stretching or MET produce either a greater or longer lasting effect on physiological range of motion. The objective of this study is to investigate whether the application of a single session of MET is more effective, and has a longer lasting effect, than a single session of static stretching on the extensibility of the hamstring muscles measured by AKE over 4 different time interval (pre-treatment, immediately, 10 minutes after and 1 hour after treatment application) using digital camera imaging.

METHODOLOGY

Subjects

Asymptomatic participants (N=162, age range 18-48) were recruited from the student and staff population at Victoria University, Melbourne, Australia. Data on the effect size produced by MET on AKE was not available, but on the assumption of a medium effect. The number of participants needed in each group with equal sample sizes to achieve 80% power for SPANOVA testing at the .05 significance level was 52 per group.[14] The study was approved by Victoria University Human Research Ethics Committee and all participants signed a consent form.

Active Knee Extension (AKE)

This study followed the same AKE measuring procedure as used by Worrell *et al.*[1] and Gadjosik *et al.*,[7] who have demonstrated high reliability of the procedure. However, whereas Worrell *et al.*[1] used a universal fluid-filled goniometer placed on the head of the fibula, and Gadjosik *et al.*[7] used a hand-held goniometer in line with the greater trochanter and lateral malleolus, the present study used digital photography and computer analysis. Analysis of photographic images has previously been used to accurately measure joint range of movement in other joints, such as the ankle joint.[15,16] All measurements of hamstring muscle length were reported as degrees from full knee extension.

Participants were required to undress down to their underwear for the attachment of anatomical markers (greater trochanter, fibula head and lateral malleolus). The testing leg was fixed on a fixation bar, and the hip was locked at 90° of flexion. The volunteer was requested to bring their knee actively into a straight condition or full extension to the point of discomfort (Figure 1). The leg was held in this position for several seconds, and the image recorded by a digital camera placed perpendicular to the plane of motion, and AKE angles were later calculated using Swinger® software. AKE was performed 3 times and the average was later calculated and used for analysis.

Procedures

Participants were pre-tested for AKE, then randomly assigned by lottery draw (54 tickets for each group) to MET (n=54), passive stretch (n=54). Participants were directed into another room, where a second examiner (a qualified and registered Osteopath) performed treatment on the right leg as indicated by the random selection. The left legs of the first 54 participants from both groups acted as a control. The participants returned to the original testing room, and post-test AKE measurement was recorded. AKE was measured 10 minutes after treatment and again one hour later.

Passive stretch

Participants were lying supine and asked to relax the leg while the researcher extended their knee to the point of first onset of pain. The stretch was held for 40 seconds where the force of stretch was increased as subject tolerance changed or the muscle was felt to "give" during the stretch (Figure 2).

Muscle Energy Technique

Participants were lying supine and asked to relax the leg while the researcher extended their knee to the point of first onset of pain. The participant was asked to lightly push their leg against the researcher's unyielding counter-force, for 5 seconds, then relaxed for 10 seconds while the stretch was maintained. The process was repeated three times for each participant (Figure 2).[2]

Statistical analysis

Differences over time within each group were analysed using a one-way ANOVA and mean change differences between groups were analysed by SPANOVA using SPSS version 11.0; significant levels were set at 0.05.. Effect sizes (pre-post) were calculated using Cohen's *d*.

RESULTS

Analysis of the pre-test values of all groups (Homogeneous subsets, Tukey HSD) revealed there were no significance differences in means between groups before the participants received intervention (p=0.138, p=0.865). Table 1 shows greater mean differences for MET treatment immediately, 10 minutes and 1 hour after treatment than the other two interventions. There were lasting significant pre-post changes in the MET group immediately, 10 minutes and 1 hour after treatment, but not the passive stretch or control group, as analysed with a one-way ANOVA (Table 1).

Analysis of the mean changes with SPANOVA revealed significant differences in both static stretch and MET group immediate (imm), ten minutes (@10) and one hour (@1hr) compared to the control group (Table 2).

Table 3 shows the pre-post effect sizes for each group at each stage. Effect sizes (Cohen's *d*) can be interpreted as small (*d*= 0.2), medium (*d*= 0.5), and large (*d*= 0.8).[14] The pre-post effect size calculations showed that the control group produced small effect sizes (*d*=0.03 – 0.22), static stretch produced medium effect sizes (*d*=0.57 – 0.72) whereas the MET group consistently demonstrated large effect sizes (*d*= 0.94 – 0.99).

DISCUSSION

This study demonstrated that MET of the hamstring muscle produced significantly increased extensibility compared to the pre-test value (as measured by AKE), and the mean changes were significantly different from the non-treated control group. Pre-post analysis using a one-way ANOVA demonstrated that MET produced a significant change at all stages (p=0.027-0.039), but passive stretching did not. The two treatments were not significantly different from each other when analysed using SPANOVA, although the MET group mean differences and statistical significance were greater than the control at each stage (MET: 6.021 – 6.298°, p=0.000; passive stretch: 3.100 – 3.031°, p=0.015 – 0.043). The effect size calculations showed that static stretch had a smaller effect size (d=0.57 – 0.72) whereas the MET group consistently demonstrated large effect sizes (d= 0.94 – 0.99). Although there were no statistically significant differences between the two treatment groups, this data suggests that MET was more effective than passive stretching.

This study used AKE to measure hamstring extensibility. AKE has been demonstrated to be reliable,[1] but it does not indicate the mechanism behind the increased range, which may result from a change in muscle tissue property (viscoelastic change) or a change in tolerance to stretch. Torque-controlled PKE can determine tissue property change because it measures the force needed to elongate the muscle. Several studies have suggested little tissue property change, and that increased ROM was more due to the increased stretch tolerance,[10,11] and this may be the case with the current study.

The area of interest in this study was the comparison of the two techniques. Passive stretching was not performed light-heartedly; the muscle was stretched to pain tolerance, held for 40 seconds with increasing force as the muscle was felt to yield. This represented a genuine effort to apply both techniques as effectively as they might be used in practice, and so it is of interest that the MET produced greater results.

AKE requires the subject to actively stretch the muscle to pain tolerance, and may potentially be influenced by motivation. All subjects knew if their leg had been treated or untreated, and may have tried harder after treatment. In the opinion of the authors this was not likely the case, and this is supported by the small variation in the 3 post-treatment means over time in all groups (less than 1°). A potential design flaw was that the left leg was used as a control, which left the measurer unblinded to the control. The measurer was blinded to the status of the right leg (MET or stretch). In reality this would have no bearing on the results, because the measurer was unable to influence the measurement (a digital photo was taken and the angles calculated later on computer in a blinded manner).

However, it later appeared that the camera was not entirely perpendicular to the plane of motion, and this could produce an error in the measurements. The camera position would likely result in under-estimation of AKE angles, but this would not have greatly influenced calculation of mean change because the camera position was not moved during a single day of data collection, and so was consistent from pre to post photographs. During the analysis of the digital images, an amount of camera movement was noticed, presumably due to manually pressing the record button on the camera. This may have resulted in some inaccuracy of the measurements. In future careful camera placement and remote controlled recording are recommended.

In future studies, mechanisms that underlie both treatment techniques can be explored to determine the contribution of stretch tolerance or actual physiological lengthening of the muscle. The effect of repeated treatment application over a longer time frame needs to be explored. A sham treatment could be used if using AKE to minimize participant's motivation and bias. Researchers should investigate the effect of these techniques on participants with shortened or symptomatic hamstring muscles, as it is possible they may respond more than non-symptomatic participants.

Conclusion:

The study demonstrated a significant increase in AKE with MET. MET produced a larger effect size and a greater mean change than passive stretching. This study suggests that MET may be more effective than passive stretching for elongating the hamstring muscle.

Summary of Important Points

- This study examined and compared the effect of muscle energy technique (isometric contract-relax) and passive stretching to produce lasting increased hamstring muscle extensibility

- Both passive stretch and MET produced significantly greater range of motion than the control group at all stages post treatment, but were not significantly different from each other.
- The MET produced a greater mean change, a significant p value (MET: $p=0.027$, stretch: $p=0.608$ at one hour post) and greater effect than the passive stretching group.
- MET appeared to be more effective than passive stretching in increasing hamstring extensibility immediately post-treatment and still at 1 hour later.

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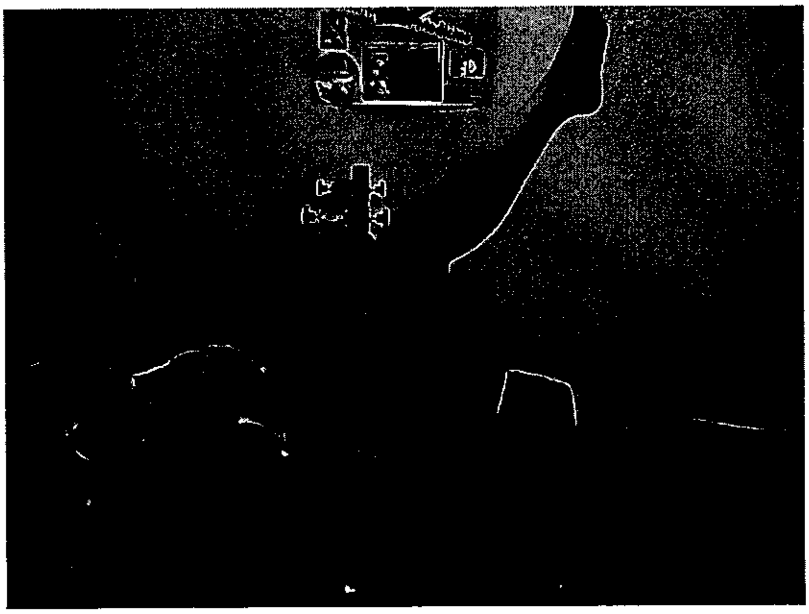

Figure 1: Active knee extension

Figure 2: Hamstring MET and stretching

Group		Mean change (SD)	p value
Stretch pre	Stretch Immediate	3.11 (4.34)	0.590
	Stretch post10min	2.50 (4.39)	0.740
	Stretch post 1 hr	3.06 (5.49)	0.608
MET pre	MET Immediate	5.98 (6.35)	0.039 *
	MET post 10 mins	6.30 (6.39)	0.031 *
	MET post 1 hour	6.33 (6.70)	0.027 *
Control pre	Control immediate	0.15 (4.60)	1.000
	Control post 10	0.94 (4.23)	0.995
	Control post 1 hr	1.15 (6.38)	0.992

Table 1: Within-group differences (pre-post) analysis with one-way ANOVA

*significant at $p<0.05$

	AKE (A)	AKE (B)	Mean difference (A-B)	P value
Immediate	Control	Stretch	-7.578	0.043 *
		MET	-11.731	0.000 *
	Stretch	MET	-4.154	0.176
10 minutes post treatment	Control	Stretch	-6.202	0.021 *
		MET	-11.139	0.000 *
	Stretch	MET	-4.9377	0.085
One hour post treatment	Control	Stretch	-6.587	0.015 *
		MET	-11.087	0.000 *
	Stretch	MET	-4.500	0.134

Table 2: Mean change (pre-post) analysis with SPANOVA: differences between groups

Note: * significant at p<0.05

Timing	Treatment group	Effect size (Cohen's *d*)
IMM	Control	0.03
	Static stretch	0.72
	MET	0.94
@10	Control	0.22
	Static stretch	0.57
	MET	0.99
@1hr	Control	0.18
	Static stretch	0.56
	MET	0.95

Table 4: Within group (pre-post) effect sizes (Cohen's *d*)