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ABSTRACT

Purpose: To investigate the effectiveness of muscle energy technique in increasing passive knee extension and to explore the mechanism behind any observed change.

Procedure: 40 asymptomatic subjects were randomly allocated to control or experimental groups. Subjects lay supine with their thigh fixed at 90° flexion, and the hamstring muscle stretched to the onset of discomfort by passive knee extension. Knee range of motion was recorded with digital photography and passive torque recorded with a hand-held dynamometer. The experimental group received muscle energy technique to the hamstring muscle, after which the resistance to stretch and the range of motion were again measured. The knee was extended to the original passive torque and the angle at the knee recorded. If the onset of discomfort was not produced at this angle, the knee was further extended and the new angle was recorded.

Results: A significant increase in range of motion was observed at the knee ($p < 0.019$) following a single application of MET to the experimental group. No change was observed in the control group. When an identical torque was applied to the hamstring both before and after the MET, no significant difference in range of motion of the knee was found in the experimental group.

Conclusions: Muscle energy technique produced an immediate increase in passive knee extension. This observed change in range of motion is possibly due to an increased tolerance to stretch as there was no evidence of visco-elastic change.

INTRODUCTION

Muscle energy technique (MET) is a manual technique developed by osteopaths that is now used in many different manual therapy professions. It is claimed to be effective for a variety of purposes, including lengthening a shortened or contractured muscle, strengthening muscles, as a lymphatic or venous pump to aid the drainage of fluid or blood, and increasing the range of motion (ROM) of a restricted joint.[1] While muscle energy techniques are widely used by osteopaths and other manual therapists, there is limited research supporting and validating its use, as well as limited evidence to substantiate the theories used to explain the effects of MET.

Several researchers have examined the effect of contract-relax techniques (similar to MET) on hamstring flexibility, and found that these techniques produced increased muscle flexibility.[2,3,4,5] Handel *et al.*[2] identified significant increases in hamstring flexibility along with an increase in passive torque (increase in force used to stretch the hamstring) after a contract-relax exercise program. Wallin *et al.*[3] claimed that contract-relax techniques were more effective than ballistic stretching for improving muscle flexibility over a 30-day period, whereas other researchers, however, have reported no differences between the two techniques.[4]

The mechanical component of muscle flexibility during static stretch is better understood than the mechanisms of therapeutic action of MET. Resting tension in skeletal muscles is taken up mainly by the myofibrils, and as the muscle stretches the limit to the range of motion is attributed to the visco-elastic elements of the connective tissues.[6] Visco-elasticity refers to the response of a tissue to load, a property of elastic and viscous components. The elastic component is the ability of the tissue to return to its previous form after deformation. The viscous component relates to the fluid part of the muscle, which deviates in response to mechanical forces. When visco-elastic structures are held at constant stretch, the stress or force of the material gradually declines. Taylor *et al.* have demonstrated visco-elastic change in rabbit foreleg muscles.[7] In human experiments, visco-elasticity seems harder to demonstrate. While a small number of studies have found that visco-elastic stress relaxation is evident in human skeletal muscle,[5,8,9] both Magnusson *et al.*[5,10,11] and Halbertsma *et al*.[12,13] demonstrated that increased muscle extensibility was attributed to use of increased torque. A visco-elastic change would have been evident if increased muscle length was achieved using a constant torque (force of stretch). The change in extensibility after stretching can only be attributed to an increase in stretch tolerance (the subject can tolerate more force applied to the muscle) because increased muscle flexibility resulted only when the torque increased.

Apart from the flexibility of the myofascial tissue itself, other structures are involved in the resistance of a muscle to stretch. When measuring the range of motion of a joint, the structures surrounding the joint itself – joint capsules, ligaments and physical structures of the bone articulation - provide resistance to the overall range of motion of a particular joint. In addition to this, the skin and subcutaneous connective tissue may also play a large part in the restriction of a joint's motion.[14, 15] Johns and Wright[16] have shown that the passive torque that is required to move a joint is contributed by the joint capsule (47%), tendon (10%), muscle (41%), and skin (2%).

Some authors[17] have speculated on the neurological mechanisms that may produce increased range of motion of a joint after MET, however, there is little research to substantiate these theories. Kuchera[17] attributed the effectiveness of MET to the inhibitory golgi tendon reflex. This reflex is believed to be activated during isometric contraction of muscles, which is claimed to produce a stretch on the golgi tendon organs and a reflex relaxation of the muscle.[14, 18] This theory, however, is poorly supported by research. Taylor et al.[7] showed in rabbit muscles that no difference in response to stretch was found between innervated and denervated muscles, suggesting that the neural component to muscle flexibility is negligible. Various studies have shown that passive stretch does not influence the electrical activity of the hamstring muscle (using EMG)[8, 19, [20, 21,] demonstrating that low level muscle contraction does not limit muscle flexibility, disputing the proposal of a neurological mechanism.

It has been suggested that a viscoelastic change in muscle is responsible for the increase in muscle flexibility after MET,[22] but this theory remains largely untested. Stretching of the connective tissue elements when the muscle isometrically contracts from a lengthened position has been offered as another explanation of the observed range of motion increase, and explains the greater flexibility achieved with contract-relax exercises when compared with static stretch.[22] Increased tolerance to stretch, which has been demonstrated following passive static stretching of the hamstring muscles,[11] may also play a role in the apparent increased flexibility of muscles following MET. Handel *et al.*[2] suggest that an increased stretch tolerance is a possible mechanism behind the increased ROM seen in their study after the contract-relax exercise program.

Mechanisms underlying improved muscle flexibility following static stretch, contract-relax stretching or MET remains obscure, and may be a result of biomechanical or neurophysiological changes, or an increase in tolerance to stretching. The present study aimed to determine whether a single application of MET could produce an immediate significant change in the flexibility of the hamstring muscle and whether any such increase was due to changes in the mechanical property of the muscle, or a result of increased tolerance to stretch. Single applications of MET are often used in osteopathic practice and it is hoped that this study may clarify the mechanisms behind immediate increased flexibility.

MATERIALS AND METHODS

Participants

The Human Research Ethics Committee of Victoria University approved the study. Subjects were recruited from students enrolled at Victoria University, Melbourne who volunteered after being informed of the nature and purpose of this study. 40 volunteers (22 female, 18 male) aged between 18 and 45 (average age 23.4 years) gave written consent prior to participation and were free to withdraw at any time from the study. The subjects did not exhibit any lower extremity or low back pathology at the time of the study.

Experimental design

The design was a randomised, controlled and blinded experimental study. Following recording of the initial measurements (ROMpre and torque 1), subjects were moved to a separate room and randomly assigned to either control (n=20; female=11, male=9) or experimental group (n=20; female=11, male=9) to which the researcher conducting the measurements was blinded. Subjects in the experimental group were treated with MET, whereas those in the control group lay on the treatment table for the same amount of time. All subjects then returned to the first room for re-measurement.

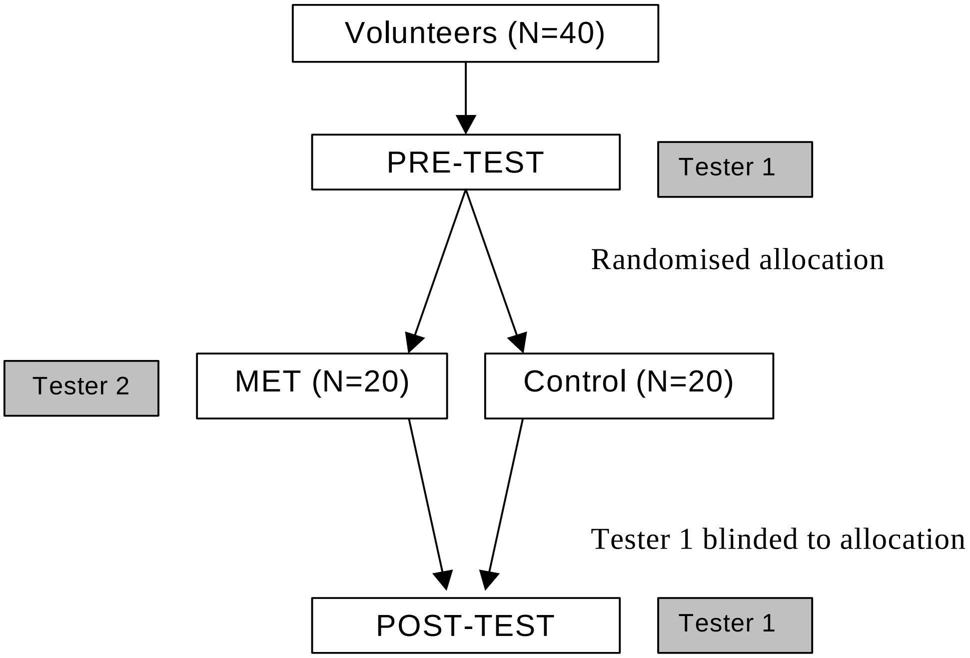

Figure 1: Study design

Measurement techniques

A Nicholas hand-held dynamometer (Lafyette, USA) (Figure 2) was used to assess resistance to stretch (defined as passive torque (Nm) of hamstring muscles) during passive knee extension. During the measurement all subjects were supine with the randomly selected experimental thigh flexed to 90° at the hip. The thigh of the opposite leg was firmly secured to minimise rotation of the pelvis during measurement (Figure 3).

Figure 2: Nicholas hand-held dynamometer

Figure 3: Passive knee extension (PKE) measurement procedure

Measurement of the range of passive knee extension (PKE) was achieved by joint marking, pre and post-photography of bony landmarks (greater trochanter, lateral femoral condyle and lateral malleolus), and analysis of digital photos by Swinger 1.29 Professional software.

Muscle ROM was recorded at three stages:

1. **ROMpre** – pre-test ROM was recorded with the participant reporting the first sense of hamstring “discomfort”.[23]
2. **ROMpost1** – post-test ROM was recorded with the same amount of passive torque as used in **ROMpre**.
3. **ROMpost2** – post-test ROM was recorded when the hamstring was further extended to the first sense of hamstring “discomfort”.

Measurements of **ROMpre** and **ROMpost2** were completed three times and the average recorded. Only one measure of **ROMpost1** was conducted to avoid producing further visco-elastic change after treatment. Passive torque was recorded in **ROMpre** and repeated for **ROMpost1** to ensure the same torque (**torque 1**) was applied. Another recording (**torque 2**) was made for **ROMpost2** if hamstring discomfort was not produced at ROMpost1 and could be extended further.

Muscle Energy Technique

The muscle energy technique was then applied to the experimental group. The subject’s knee was extended to the first report of hamstring discomfort and a moderate isometric contraction (approx 75% of maximal) of the hamstring muscle was then elicited for a period of five seconds.[1] After a period of three seconds relaxation, the technique was repeated three times (for a total of four contractions).

Analysis

The raw data was collated using Microsoft Excel. Repeated Measures ANOVA was used to analyse pre and post test ROM and torque values in both control and experimental groups. This analysis was performed using SPSS v11 software.

RESULTS

Mean data indicates that there were minimal changes across time for the range of motion data (Table 1). However, in both the control and experimental groups, these differences were large enough to produce significant results (Table 2).

On further analysis, it would appear that in the control group, the mean score for the first post-test measurement (165.1°), is different to both the pre (167.8°) and second post test (167.9°) scores. This result was not expected.

In the experimental group, there is a difference between the second post-test measure (170°) and both the other measures. The difference between the pre-test score (167.3°) and the second post-test score indicates an increase in ROM produced by the intervention. However, the variability in the data necessitates caution when interpreting these results.

There was a significantly greater amount of torque required to produce end range in the experimental group (p=0.047). This would equate to an increase in ROM.

	Control				**Experimental**			
	ROM		**Torque**		**ROM**		**Torque**	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD.***
Pre test	167.8	7.3	14.6	3.3	167.3	7.3	13.7	3.2
Post test 1	165.1	8.1			166.6	9.7		
Post test 2	167.9	7.0	14.6	3.2	170.0	8.0	14.3	3.4

Table 1: Descriptive statistics of control and experimental groups. ROM measured in degrees, torque in N.m

	F	***p***
ROM (Con)	6.029	0.005
ROM (Exp)	4.421	0.019
Torque (Con)	0.004	0.948
Torque (Exp)	4.534	0.047

Table 2: Repeated measures ANOVA summary

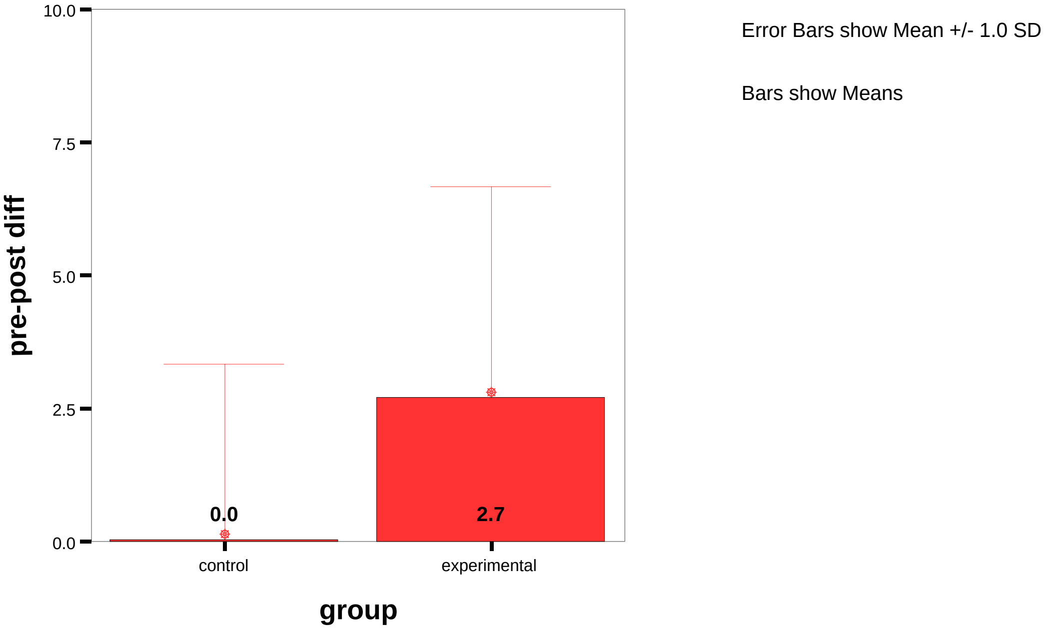

Figure 4: ROMpost – ROMpre mean differences (degrees)

DISCUSSION

This study demonstrated that a significant increase in hamstring extensibility (measured as ROM at the knee following PKE) occurred following MET (when stretched to the point of discomfort), but did not occur in the control group. The data suggests that no viscoelastic changes occurred as a result of a single application of MET. If a significant increase in joint angle was observed at the initial pre-test load (Torque1) following the MET, a change in tissue property could be the only logical explanation.[11] This was not the case as no significant change in range of motion at the knee occurred in the experimental group when the same initial load was applied (ROMpost1 = ROMpre). A greater torque (Torque 2) was tolerated in the experimental group before discomfort occurred (ROMpost2), supporting the theory that increased flexibility was a result of an increased tolerance to stretch.

A significant decrease in PKE was observed in the control group when the knee was extended with the original torque. There were four outliers within the control group that were not excluded. Measurement error may have occurred as a result of a design flaw in the study. The knee was extended to the torque determined prior to the intervention and the angle recorded (ROMpost1) only once in both groups, so as to not produce further visco-elastic change and mask a potentially small treatment effect. The other measurements (ROMpre and ROMpost2) were performed three times and averaged, minimising the influence of individual outliers.

In the experimental group, there was no significant change in ROM following MET at the pre-test torque (Torque 1). If this had occurred, a change in the tissue property (visco-elastic change) could be concluded.[11] Hamstring stretching at pre-test torque, however, did not reproduce the sense of discomfort following MET, and could be increased to a greater torque (Torque 2) and range (ROMpost2). This observation suggests that the increased PKE (greater ROM at the knee) is a result of an increased tolerance to stretch in the absence of any viscoelastic change.

Recommendations

While the concept of visco-elasticity is accepted in relation to muscle physiology, it is likely that a single application of MET is not enough to produce a change in biomechanical tissue property. This is not surprising in light of the research examining the effects of static stretching.[8,9,11] Future studies should explore whether repeated use of MET over a period of time produces any lasting viscoelastic changes, and the effect of varying the duration of isometric contraction. It would also be of interest to observe the effects of MET in subjects with a history of hamstring injury. It is possible that such injuries involve deposition of abnormal fibrous tissue and cross-linkages,[22] and may respond differently to healthy muscle. It is also recommended that future studies use the average of three measurements for the recording of the joint angle at every stage the angle is measured, to eliminate the influence of individual measurement outliers.

CONCLUSION

This study found that a single application of MET produced an increase in passive stretch of the hamstring muscle. When the post-test torque applied to the muscle remained constant (the same as used in pre-testing), no significant change in length occurred. This suggested that a single application of MET produced no biomechanical change to the muscle, but created a change in tolerance to stretch.

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