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ABSTRACT

Background: Muscle Energy Technique (MET) has been advocated for the treatment of restricted range of motion in the upper neck. There is little evidence, however, to support the effectiveness of MET to increase motion in the cervical spine, or determine the optimal duration of isometric contraction during the technique.
Objectives: The aim of this study was to investigate the effect of various durations of MET isometric contractions on active atlanto-axial rotation range of motion.
Methods: 52 asymptomatic subjects (age range 18-43) who displayed a unilateral active atlanto-axial rotation asymmetry of 4º or more were randomly allocated to either a 5 (n=17) or 20-second (n=18) isometric contraction MET group, or a sham (n=17) treatment control group. Active atlanto-axial end-range measurements were recorded pre and post-intervention, and the examiner was blinded to group allocation.
Results: Analysis with a one-way ANOVA revealed significant differences (P=0.04) in the mean change between the 5-second MET group and the control, but not between the 20-second MET group and control. MET using 5-second contractions produced the largest mean increase in rotation, both to the restricted (+6.65º) and non-restricted sides (+0.71º). The 5-second MET produced a large pre-post effect size (d=1.01), whereas the

20-second MET (*d*=0.68) and control (*d*=0.33) produced moderate and small effect sizes, respectively.

Conclusion: This study failed to demonstrate a significant benefit in the use of a longer (20-second) isometric contraction when treating the upper cervical spine with MET. The use of a 5-second isometric contraction appeared to be more effective than longer contraction durations for increasing cervical range with MET, but further investigation is recommended.

Keywords: Cervical, isometric, muscle energy, range of motion, osteopathy

INTRODUCTION

MET (Muscle Energy Technique) is a technique commonly used by osteopaths and other manual therapists when treating the cervical spine. Authors in the field of osteopathy claim that MET can be used to lengthen shortened musculature and improve joint function and range of motion.[1-3] MET is a method of treatment that involves the voluntary contraction of a subject's muscle(s) in a precisely controlled direction, against a counterforce provided by the operator. Greenman[1] described it as a technique in which the patient contributed corrective muscular force against the practitioner's counteracting resistance. Greenman[1] proposed that MET applied to a restricted atlanto-axial joint may produce improvement in joint range of motion. The clinical benefits of MET have not been well established in the scientific literature and the duration of the isometric contraction used in MET applied to the spine has not been previously examined.

The effect of MET – or similar isometric techniques, such as contract-relax and proprioceptive neuromuscular facilitation (PNF) – has been examined on muscle extensibility, particularly the hamstring complex.[4-6] Few studies, however, have examined the effect of MET on spinal range of motion (ROM).[7-9] In the only study found which examined the effect of MET on cervical ROM, Schenk *et al.*[7] investigated the effect of MET on cervical flexion, extension, side-bending, and rotation in subjects with limitations of active motion in one or more planes. The subjects underwent seven

treatment sessions over a four-week time frame, consisting of three repetitions of MET using approximately 5-second contractions. The researchers found that the treatment group demonstrated increased range in each of the six planes of motion, whereas the control group showed little or no change, although only a statistically significant increase in cervical rotation was found. In a similar study, Schenk *et al.*[8] found that MET significantly increased spinal extension in the lumbar spine of asymptomatic subjects who presented with limited lumbar extension.

Lenehan *et al.*[9] conducted a blinded and controlled study which examined the effect of MET on seated active trunk rotation in 59 asymptomatic subjects. These researchers found that a rotational MET performed into the direction of restricted motion (the side with the least range, as determined by active seated trunk rotation) significantly increased the restricted trunk rotation ($P<0.01$), but not on the non-restricted side, or in the untreated control group.

A number of studies have examined the effectiveness of HVLA thrust techniques for increasing ROM of the cervical spine.[10-12] Surkitt *et al.*[10] found that manipulation of the atlanto-axial joint significantly increased rotation ROM toward the restricted side. This finding was confirmed in another study by Clements *et al.*[12] who reported that a single HVLA manipulation applied to the atlanto-axial joint reduced the atlanto-axial rotation asymmetry (8º or greater asymmetry, confirmed on two separate occasions), regardless of whether the manipulation was applied towards or away from the restriction, or performed bilaterally.

The duration of the isometric contraction in MET has received little attention in previous research. Various authors and researchers have suggested different durations for the muscular contraction for MET and similar techniques. Greenman,[1] and other authors in the field of MET,[2,3] have advocated 3 repetitions of 3-7 second resisted contraction for adequate therapeutic effect. Other researchers have used 5-second,[7] 5 and 10-second,[4] 6 and 12-second,[13] and 20-second[14] contraction durations.

Schmitt *et al.*[13] examined the relationship between durations of sub-maximal isometric contraction on hamstring flexibility, by comparing the effects of 6 and 12-second isometric contraction phases in 10 subjects, using PNF techniques. Both groups produced increases in ROM, measured by an active sit-and-reach test, but showed no significant differences between one another. Given the small numbers in each group (n = 5), this study may have lacked sufficient power to detect differences between the contraction durations. Mehta and Hatton[4] treated the hamstring muscles of asymptomatic subjects with MET using a 5-second sub-maximal contraction, and, after a fourteen-day washout period, treated them again using a 20-second contraction MET. The authors reported a significant increase in the passive range of motion following both the 5-second and 20-second contractions, but no significant difference between the two treatments. The authors concluded that using a 5-second contraction duration was as equally effective as using 20-seconds. Similarly, Nelson and Cornelius[15] examined the effect of a 3-second, 6-second, and 10-second maximal contraction phase in a PNF stretching procedure on the range of internal rotation of the shoulder joint in 60 subjects, and found no differences between the effect of these contraction durations.

In contrast to these studies, Rowlands *et al.*[16] has reported that using longer contraction times in PNF stretching result in greater increases in hamstring flexibility. Forty-three women were assigned to either a 5 or 10-second isometric contraction group, or a no-treatment control group, and ROM was measured by passive SLR to pain tolerance. The treatment groups followed a stretching program twice a week for six weeks, which involved a 5-minute warm-up, 5-minute static stretching, and two PNF techniques (supine and sitting). Both treatment groups made significant increases over the control group, but the 10-second group made significantly greater gains than the 5-second group at both 3 weeks and 6 weeks.

No study has yet determined the optimal contraction duration for MET applied to the spine, which is commonly advocated in osteopathic texts.[1-3] Active cervical range of motion is a measure that has been used by many researchers.[7,17-18] The Cervical ROM (CROM) device has been demonstrated to reliably measure active cervical range of motion, and contains several inclinometers to measure sagittal and coronal plane motions,

but uses a compass goniometer to measure axial rotation.[19-21] The present study examined the effect of specific rotational MET on restricted atlanto-axial joint motion using a compass goniometer, and aimed to establish if there was increased benefit in using longer isometric contraction durations when applying MET.

MATERIALS AND METHODS

Subjects

Volunteers were recruited from university students enrolled at Victoria University, Melbourne. Sixty-three male and female volunteers (age range 18-43 years; mean age 23.27 ± 4.24) presented for preliminary goniometric assessment. Suitable subjects had no historical features of cervical pathology or substantial trauma, were receiving no form of manual treatment to the cervical spine, and were pain free on days of testing. Of the 63 volunteers tested, 52 exhibited the minimum 4º unilateral atlanto-axial (AA) rotation asymmetry necessary for inclusion in the study. The Victoria University Human Research Ethics Committee approved the study, and all subjects provided written consent prior to participation and were free to withdraw from the study at any stage.

Several researchers have examined the effect of manipulation on the cervical spine using asymptomatic subjects displaying a fixed (recorded on two separate occasions) rotational asymmetry of 8º or more.[10-12] In the present study, an asymmetry of 4º or more was accepted, because the objective was to observe changes in total range of movement (to both restricted and non-restricted ranges), and not just asymmetry. In a study of six cadarval cervical spines, it was found that asymmetrical atlanto-axial joint geometry was common and causes asymmetrical joint dynamics.[22] It is questionable whether fixed asymmetry represents intervertebral dysfunction or simply anatomical asymmetry, which would not likely respond to manual therapy more than in subjects with lesser asymmetries.

Goniometric measurement

This study examined the effect of treatment on AA rotation because it appears possible to reliably measure motion contributed mostly by this single intervertebral segment. It has

been proposed that AA joint rotation can be isolated when the neck is flexed to approximately 45º, because this position effectively locks the lower cervical segments (below C2) and limits their ability to participate in further rotation.[10,12,23] If rotation is introduced from this flexed position, the movement is deemed to occur between the occiput and C2.[23] It has been reported that only 1º of rotation occurs at the occipito-atlanto segment,[24] and so this position effectively produces rotation only at the AA joint, and serves as a suitable testing position to examine the effect of a joint specific technique.

Measurements were performed using a custom made goniometric device consisting of an adjustable head-piece and a firmly attached compass at its apex (Fig 1). Magnetic south was selected as the 'neutral position' for cervical rotation neutral or mid-point, which acted as a reliable starting position. A Biodex chair (Biodex Medical Systems, Shirley, NY) was oriented and locked into the position of magnetic south, and the backrest positioned at an angle of 45º. Once seated and securely fastened in the chair, the subject was asked to flex their head forward (approximately 45º) to a vertical position (Fig 2).

Figure 1. Cervical compass goniometer

The goniometric device was placed on the subject's head, with Researcher 1 ensuring that the subject's head was in a vertical position, and that the goniometer's neutral was accurately facing magnetic south. Each subject was asked to perform three active

rotations left (as far as was comfortable) and then to do three active rotations right (again, as far as was comfortable). After each rotation, the subject held the position for a few seconds so that Researcher 1 could record the goniometric reading. The mean of these recordings was later calculated and used for analysis. Subjects were not informed of the direction of their rotation restriction.

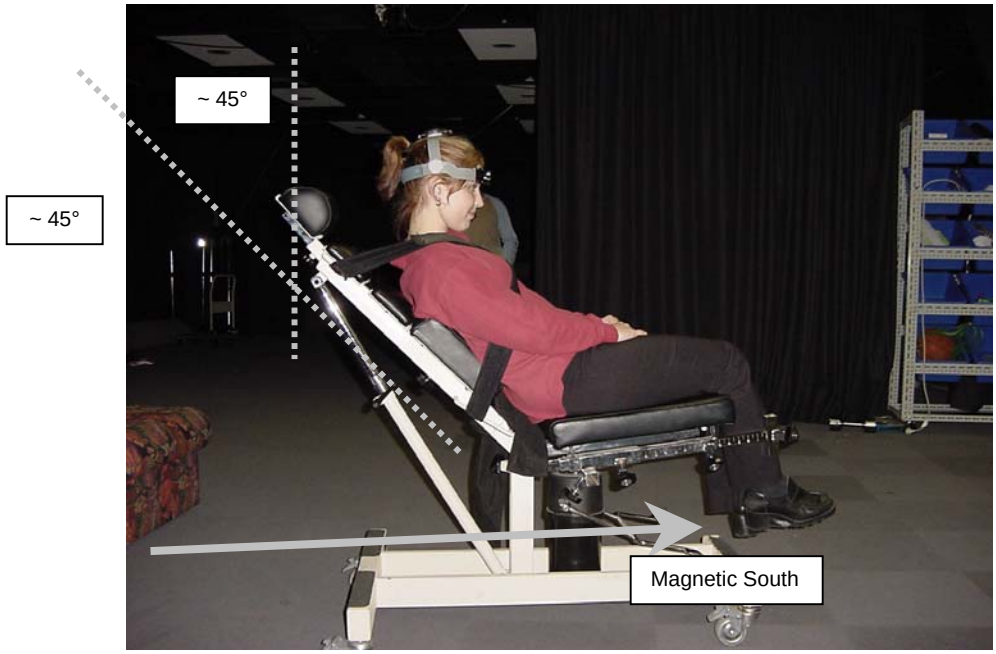

Figure 2. Subject positioning for goniometric measurement of head rotation. Note the angle of the seatback at approximately 45°. With the subjects head in forward flexion this results in a head angle of approximately 45°. The chair was oriented in the direction of magnetic south to provide a reference for the compass goniometer.

Procedure

The design of this study was based on the methodology of Lenehan *et al.*, who examined the effect of MET on active seated trunk rotation.[9] After active cervical ROM pre-testing was completed, Researcher 1 recorded the direction of restriction on a card which was folded to prevent the subject from viewing it, who then took the card to Researcher 2, a registered osteopath (GF), in a separate room. Subjects were randomly allocated by lottery draw into one of the three treatment groups (5-second MET, 20-second MET, functional technique), but they had been informed there was a fourth treatment group – a no-treatment control – to reinforce the impression that the functional technique was

genuine. Researcher 1 (testing operator) was blinded to the group allocation of all subjects. Even grouping was ensured because an even amount of cards for each group (n=20) had been placed in a hat for random lottery selection.

The three treatment groups were as follows:

1. **Control group**: This group (n=17) received a 'sham-functional' technique, where the treatment operator's hands were simply placed on the subject's neck, without taking it to, or away, from the reported restriction. The practitioner placed his hands under the subject's head for a period of 30 seconds. A period of 30 seconds was determined by watching a clock, and was used to give the participant the illusion that a genuine technique was being performed. An effort was made not to engage any perceived sense of ease or bind, or engage any motion barriers to attempt to make the treatment inert. Subjects were informed they were being treated with an osteopathic functional technique and that they should feel little movement because the positioning was very subtle.[27] This 'sham' technique was used instead of a non-treatment 'control' in an attempt to minimise the influence of subject bias and motivation on active range re-testing.

2. **5-second MET group**: Subjects allocated to this group (n=17) received MET treatment into the direction of restriction, with each isometric contraction limited to 5 seconds. Subjects lay supine on a treatment table, with the practitioner present at the head of the table. If the direction of restriction was labeled as "right", the osteopath passively flexed the subject's head and neck to approximately 45^{o} until a sense of resistance was palpated (to relatively "lock" the mid and lower cervical segments), and then rotated the head to the right until a restrictive barrier was palpated.[1] The subject was then instructed to gently push into the practitioner's hand (rotate to the left) for 5 seconds, followed by 5 seconds of relaxation. This procedure was performed three times (Fig. 3). On the final relaxation phase, the subject was instructed to breath in and out to assist relaxation.

Figure 3. Demonstration of patient and operator positioning for the application of MET to the atlanto-axial joint.

3. **20-second MET**: Subjects allocated to this group (n=18) received MET treatment to the direction of restriction, with each isometric contraction timed to 20 seconds. Subjects lay supine on a treatment table, with the practitioner present at the head of the table. The practitioner flexed the subject's head and neck to 45º and applied a MET technique to the restricted side by rotating the head until a perceived barrier was palpated.[1] The subject was instructed to gently push into the practitioner's hand for 20 seconds, followed by 5 seconds of relaxation. This procedure was performed three times (Fig. 4). On the final relaxation phase, the subject was instructed to breath in and out to assist relaxation.

Following treatment, subjects immediately returned to the testing room for re-measurement using the same procedure as before. The examiner was blinded to the group allocation of all subjects.

Data Analysis

To assess the reliability of the compass goniometer, the intra-class coefficient (ICC, based on a one-way ANOVA) was calculated for the three pre-test readings of left and right rotation in each subject. All calculations were performed on SPSS for Windows, version 10. A one-way ANOVA was used to analyse differences in the mean change to both the restricted and non-restricted sides between all groups. Significance was set at the 5% level. A Tukey post-hoc test was performed, and pre-post effect sizes (Cohen's *d*) were calculated.

RESULTS

The average measure ICC for left rotation was 0.95 ($F_{51,104} = 18.76$, $P < 0.001$, 95% C.I.: 0.92 – 0.97), and for right rotation the ICC was 0.90 ($F_{51,104} = 10.41$, $P < 0.001$, 95% C.I.: 0.85 – 0.94). The high ICCs indicated that the compass goniometer was highly reliable for measuring active cervical rotation.

The ROM mean changes for the subjects allocated to the control group (n=17), 5-second MET (n=17), 20-second MET (n=18) are seen in Table 1. There was a mean increase into both directions (restricted and non-restricted) following MET treatment, which was largest for the 5-second MET group (6.65°). In the control group, there was a small increase to the side of restriction, and a drop in range of motion away from the side of restriction post-treatment. In each group, the pre-post difference in range of motion toward the side of restriction was markedly greater than away from the restriction.

Analysis of the mean changes of each group with a one-way ANOVA demonstrated a significant difference between the three groups for the change in the direction of restriction ($F_{2,49} = 3.44$, P=0.04), but not in the unrestricted direction ($F_{2,49} = 0.44$, P=0.64). A Post-hoc Tukey comparison revealed that the significant differences existed between the control group and the 5-second MET in the direction of restriction (P=0.03). No significant differences were found towards the unrestricted side (P=0.63), or when comparing the control group and the 20-second MET, both toward and away from the side of restriction (P=0.31 and 0.79, respectively). There were also no significant

differences between the mean changes of the 5-second and 20-second MET groups, either toward or away from the side of restriction (P=0.48 and 0.96, respectively). Pre-post effect sizes (Cohen's d) were found to be large in the 5-second MET group (d=1.01), moderate-large in the 20-second MET (d=0.68) and small in the control group (d=0.33).

Table 1. Mean change in atlanto-axial rotation for all groups

	PRE-TEST		POST-TEST		DIFFERENCE		
	Restricted Side	Non-restricted side	Restricted side	Non-restricted side	Change to restricted side	Change to non-restricted side	Effect Size (Cohen's *d*)
Control Group	44.11 (8.61)	57.29 (8.45)	49.05 (9.30)	56.11 (8.03)	+1.41 (4.27)	-1.12 (6.95)	0.33 (small)
5-second MET group	52.41 (8.28)	60.24 (8.44)	59.06 (12.07)	60.95 (10.48)	+6.65 (6.59) *	+0.71 (5.77)	1.01 (large)
20-second MET group	51.22 (10.61)	60.05 (10.26)	55.56 (9.97)	60.39 (9.45)	+4.34 (6.33)	+0.33 (6.86)	0.68 (moderate-large)

Notes All figures are Mean (SD), units for all rotation measurement in degrees.

+ sign indicates increase in ROM

- sign indicates decrease in ROM

* = indicates significance at the 5% level

DISCUSSION

This study found that MET applied to the atlanto-axial joint significantly increased the range of active rotation motion towards the side of rotation restriction. The greatest change was found in the 5-second MET group (mean increase 6.65º, *P*=0.03). The 20-second MET group also experienced a mean increase in ROM (4.34º), but this was not significantly different from the control group change. Effect size calculations show that the 5-second MET produced a large effect (*d*=1.02), the 20-second MET a medium-large effect (*d*=0.68), and the control group a small effect (*d*=0.33). Contrary to the expectation of the researchers, MET using a 5-second isometric contraction appeared to be more effective for increasing AA range than with a 20-second contraction. It is interesting to note that the increased range in the direction of restriction was not made at the expense of the non-restricted range, which also increased slightly.

The results of the present study support the study conducted by Schenk *et al.*,[7] who also used 5-second MET contractions to produce significant changes to ranges of motion in the cervical spine. However, there were many differences between these two studies. Schenk *et al.*[7] collected data over a four-week time frame and retested subjects one day after their last treatment session, whereas the present study examined only the immediate effects to the AA joint.

Mehta and Hatton[4] investigated the effect of 5-second sub-maximal contraction MET to the left hamstring muscle, followed by 20-second contraction MET fourteen days later. Their study did not include a control group, but compared the 5 and 20-second isometric contraction techniques directly against one another. They found no significant differences between the two groups, and, like the present study, no benefit in lengthening the duration of the contraction in MET, although the present study suggests there may be benefit in using 5-second MET over the longer contraction. The findings of the present study are also in accordance with those of Nelson and Cornelius,[15] who found that there was no benefit in using longer contraction durations to increase shoulder internal rotation.

Rowlands *et al.*,[16] in the only study to report a benefit of a longer contraction duration in PNF stretching, found that a 10-second contraction phase produced significantly greater hamstring extensibility than a 5-second contraction. It may be possible that differences in ROM only appear with repeated stretching over a longer time period (Rowlands *et al.* used a 6-week stretching program), or following greater contraction forces (maximal contraction) or stretching forces (stronger passive torque is usually applied to the hamstrings, as opposed to light forces applied in spinal MET) which could produce greater viscoelastic change.

The present study measured cervical range using active rotation, in contrast to some other studies that have used passive cervical range.[8-10] Measurement of active cervical rotation with the CROM, which incorporated a compass device to measure rotation, has previously been demonstrated to be reliable.[21] The current study used a more simple measuring instrument, which also used a compass to measure rotation, and the reliability coefficients calculated (ICC=0.90, 0.94) suggested this compass goniometer was a reliable measuring tool in this instance. Active ROM overcomes the uncertainty of applying equal passive torque to right and left sides, however, subject motivation can potentially affect active measurements. For this reason, a sham technique was used as the control. It was uncertain how naive the subjects (all osteopathic students) were to the sham procedure because no follow-up study assessed this, but given the subtle nature of functional technique and the explanation of the 'sham' procedure given to subjects in this group, the authors expect the subjects were largely naïve to their group allocation. In addition, all subjects were informed that there was a fourth no-treatment control group, which would have reinforced the belief that the functional technique was genuine.

While these findings suggest the positive effects of the shorter 5-second contraction in the treatment of the upper cervical spine, caution should be exercised when attempting to extrapolate these findings into the clinical setting. The standard deviations were relatively large compared to the mean changes, and so it would be useful to confirm these results with future studies. The MET treatment was applied to asymptomatic volunteers who displayed a rotational asymmetry, and no attempt was made to diagnose specific upper cervical dysfunctions. Further studies should be performed using more pragmatic

designs in order to gain knowledge about optimal isometric contraction times in MET using symptomatic subjects, as well as using a longer period of follow-up. The present study may have failed to detect significant changes in the 20-second MET group because of small subject numbers (n = 18), giving the study low power. Larger subject numbers would be helpful, because approximately 30 subjects in each group would be needed to achieve 80% power (based on the medium-large effect size of the 20-second MET group and analysis with ANOVA).[26]

CONCLUSION

This study suggests that application of an MET procedure using 5 seconds of isometric contraction produced a significant increase in range of restricted active rotation at the AA joint. The application of MET using a 20-second contraction appeared to be less effective, and was not significantly different from the control group. The increased range in the direction of restriction was not made at the expense of the non-restricted direction, which made small, non-significant increases. This study failed to demonstrate a benefit in the use of a longer isometric contraction when using MET to increase the range of upper cervical rotation.

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