Research Report

A comparison between muscle energy technique and high velocity low amplitude thrust technique on gross trunk rotation range of motion

ABSTRACT

Background: Muscle energy technique (MET) and high velocity low amplitude (HVLA) thrust technique are two techniques commonly used by osteopaths and other musculoskeletal therapists. Despite their widespread use, there has been very limited research to compare the efficacy of HVLA and MET for increasing gross trunk rotation range of motion (ROM).

Objective: The aim of this study was to compare the immediate and lasting effects (30 minutes) of a single application of thoracolumbar MET and HVLA technique on gross trunk rotation ROM, in asymptomatic volunteers with no fixed asymmetry.

Methods : Ninety volunteers (age range 18-40) were randomly assigned to either treatment (MET or HVLA) or control groups, and blinded pre-, immediately post- and thirty minutes post-active trunk rotation measures were recorded using a reliable measuring device. Volunteers in the treatment groups received a single application of either thoracolumbar MET or HVLA in the direction of the side (right or left), with the least ROM.

Results: Analysis with a SPANOVA revealed a statistically significant difference in gross trunk range of motion immediately and 30 minutes following a single application of MET or HVLA ($P = 0.00$). However no significant difference was found when comparing the MET and HVLA groups to the control group ($P = 0.52$).

Conclusion : Although demonstrating a statistically significant difference in gross trunk ROM immediately and 30 minutes following a single application of MET or HVLA, this was meaningless as it was within the error range of the test equipment. Overall this study failed to show a significant benefit in the use of these osteopathic treatment techniques in increasing gross trunk rotation ROM.

Key Words: osteopathy, thoracolumbar, muscle energy technique, manipulation, spine, rotation, range of motion

INTRODUCTION

Muscle energy technique (MET) and high velocity low amplitude (HVLA) thrust technique are two common techniques used by osteopaths and other musculoskeletal therapists. MET and HVLA are both classified as direct techniques because the initial positioning is in the direction of the restrictive barrier, then a final activating force is applied.[1] Restricted mobility, altered quality of motion, and muscle spasm adjacent to an articulation are common indications for the use of both MET and HVLA, with the two techniques often used in combination. Despite their widespread use, there has been very limited research to compare the immediate and lasting effects of HVLA and MET in the thoracolumbar region on gross trunk rotation ROM.

Greenman[2] states that MET 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. The dysfunctional joint is positioned at the end of its limited motion and the patient is requested to lightly contract for approximately five seconds against the specific counterforce offered by the practitioner. After relaxation, the restrictive barrier is often felt to yield, and the procedure is repeated several times. Greenman[2] also claims that MET can be used to lengthen a shortened, contractured, or spastic muscle; to strengthen a physiologically weakened muscle or group of muscles; to reduce localized edema and relieve passive congestion.

Gibbons and Tehan[3] state that the aim of HVLA technique is to achieve joint cavitation, that is accompanied by a 'popping' or 'cracking' sound. This audible release distinguishes HVLA procedures from other osteopathic manipulative techniques. In these techniques, the physician positions the patient in such a way that the restricted joint is placed into its barriers to motion.[4] A direct application of a high velocity corrective force of low amplitude is then used, in order to overcome an abnormal motion barrier. Specific indications for HVLA techniques as listed by various authors include hypomobility, motion restriction, joint fixation, acute joint locking and reflex relaxation of muscles, all contributing to motion loss.[5-11]

Four studies exist in the peer-reviewed literature that have examined the effect of MET on cervical, thoracic and lumbar motion, and have demonstrated increased ROM following treatment. Fryer *et al.*[12] investigated the effect of various durations (5 or 20 seconds) of MET isometric contractions on active atlanto-axial rotation ROM. Subjects who displayed a unilateral active atlanto-axial rotation asymmetry of 4° or more were randomly allocated to either a 5 or 20-second isometric contraction MET group, or a sham control group. Active atlanto-axial end-range measurements were recorded pre- and post-intervention. Results showed that there was a significant difference ($P = 0.04$) in the mean change between the 5-second MET group and the control group to the restricted side (+6.65°, SD 6.59°).

Schenk *et al.*[13] examined the effect of MET on ROM for cervical flexion, extension, axial rotation and lateral flexion over a four-week period involving multiple MET sessions to correct participants' pre-determined cervical restrictions. Post-test ROM measures were recorded at the completion of the treatment series. Cervical axial rotation was the only movement that was significantly increased following the treatment period. Mean ROM values post-treatment for these movements revealed an increase in ROM with a trend towards statistical significance for the treatment group compared with no change for the control group.

Schenk *et al.*[14] later conducted a similar study to investigate the effect of MET on restricted lumbar extension. They found that lumbar extension was significantly increased after treatment, supporting MET as an appropriate therapy for restoring lumbar extension ROM.

The effect of MET on the thoracolumbar spine has also been investigated. Lenehan *et al.*[15] examined whether a single application of thoracolumbar MET could significantly increase the range of motion in asymptomatic volunteers with restricted active trunk rotation. Fifty-nine volunteers were randomly assigned to either treatment (MET) or control groups and blinded pre- and post-active trunk rotation measures were recorded using a repeatable measuring device (ARMDno2). The researchers found that MET applied to the thoracic spine in the direction of restricted rotation significantly increased range of active trunk rotation (10.66°, SD 9.80°; $P < 0.01$), but not on the non-restricted side or in the untreated controls (1.03°, °SD 4.88).

Recent research has been conducted as to whether there is an increase in active range of motion following HVLA techniques. Whittingham and Nilsson[16] designed a double-blinded randomized controlled trial to study the changes in active cervical range of motion after spinal manipulation of the cervical spine. One hundred and five patients with cervicogenic headache were randomized into treatment and non-treatment groups. Active range of cervical motion was measured with a strap-on head goniometer. Results showed that after receiving spinal manipulation, active range of motion in the cervical spine increased significantly in both directions of rotation and lateral flexion ($P < 0.01$) with a mean increase in ROM of 8° to 12° in the treatment group compared with the non-treatment group.

Nilsson *et al.*[17] examined the lasting ROM effects of cervical HVLA. A three-week series of cervical spinal manipulation was performed, in order to observe any lasting effect on passive cervical range of motion. Passive range of cervical motion significantly increased immediately following HVLA, however there was no significant change in passive range of motion one week after the treatment. The authors concluded that any changes in passive range of motion after spinal manipulation were of a temporary nature.

Nansel *et al.*[18] examined the effect of cervical spinal manipulation on pain free subjects exhibiting passive end range lateral flexion asymmetries of greater than 10º. Responses in two groups were compared, one with a prior history of neck trauma and one with no history of neck trauma. 10º was chosen after the examiners had found that on any given day one in three individuals in a population exhibited a cervical lateral flexion passive end range asymmetry of 10º or greater. All subjects received a single lower cervical adjustment delivered to the side of most-restricted end-range, and goniometric reassessments were performed 30 min, 4 hr, and 48 hr post-manipulation. In subjects who had suffered previous neck trauma, manipulative thrust techniques to the cervical spine were found to reduce left-right lateral flexion asymmetry at 30 minutes, 4 hours, and 48 hours post-manipulation.

A study conducted by Wong and Nansel[19] demonstrated that 18.7% of the normal, asymptomatic population possesses fixed AA rotation asymmetry of 8º or more. This level of cervical asymmetry has been demonstrated by Nansel *et al.*[20] to be significant at the $P < 0.001$ level. However, no study has determined a comparable degree measurement of fixed asymmetry at the thoracolumbar junction.

Clements *et al.*[21] investigated the effect of various directions of HVLA manipulation on the amelioration of goniometrically verified passive atlanto-axial (AA) rotation asymmetry. Inclusion criteria was dependent on the persistence of the minimum 8º unilateral AA rotation asymmetry. A significant reduction in AA rotation asymmetry was discovered regardless of whether the manipulation was applied unilaterally either towards or away from the restricted rotation ROM or bilaterally.

Gavin[22] researched the effect of the manipulation of restricted thoracic spine segments on thoracic active range of motion. Forward bending and side bending right and left were measured. In a comparison of pre-treatment versus post-treatment active range of motion, a significant difference was only seen in side bending to the left ($P = 0.12$). Considering that a mean difference of only 1.9° was seen post-treatment, this increase may well have been within the error range of the measuring equipment which was not stated by the author.

In the only study to compare MET and HVLA, Cassidy *et al.*[23] investigated the immediate effects of these techniques on neck pain and cervical ROM. Subject selection however focused on neck pain, and not asymmetrical ROM, and decreased ROM associated with neck pain was assumed. The researchers found that both MET and HVLA increased cervical ROM to a similar degree, however a single manipulation (HVLA) was more effective than MET in decreasing pain in patients with neck pain.

While there is increasing evidence for the effectiveness of MET and HVLA techniques, more research is necessary to examine the benefits of these techniques at the thoracolumbar junction. This study compared the immediate and lasting effects of MET and HVLA technique on gross trunk rotation ROM, in asymptomatic volunteers. By comparing HVLA technique to MET, the relative effectiveness of these techniques on trunk rotation ROM will be evaluated. It was hypothesized that both MET and HVLA would produce lasting increases in trunk rotation ROM, while the control group would display no change.

MATRIALS AND METHODS

Participants

Ninety (90) asymptomatic volunteers (32 male, 58 female; age range: 18 to 40; mean 21.78) were recruited for this study. All volunteers completed a consent form (Victoria University Human Ethics Committee) and those with any thoracic or lumbar pain, pathologies or contra-indications to treatment were excluded.

Measurement of Trunk Rotation ROM and the Thoracolumbar junction

This present study was modeled on a previous study by Lenehan *et al.*[15] which examined the effects of MET on overall trunk ROM without predetermined fixed asymmetry. Gross trunk ROM was considered the most appropriate measurement since the thoracic spine, ribs, lumbar spine and pelvis function synchronously to produce coordinated movement around the trunk, making it difficult to isolate rotation from a specific spinal region.[24]

The thoracolumbar region (T10 – L2) was used as the point of application of the MET and HVLA techniques. The thoracolumbar region represents a significant junction in the spine where the upper and lower trunks meet. Anatomically, the zygapophyseal joints change their orientation abruptly, and this transition zone marks an increase in the size of the vertebral bodies and intervertebral discs, which can lead to limitations in segmental mobility. Chaitow[25] states that restriction of rotation is the most common characteristic of thoracolumbar dysfunction.

Axial Rotation Measuring Device (ARMD no.3)

The ARMD no.3 was similar to the ARMD no.2 used by Lenehan *et al.*[15], with a single modification. Instead of using the 'protractor-style' labeled baseboard to record ROM measurements, the ARMD no.3 was equipped with an electronic measuring device (3DM® Solid State 3-axis Pitch, Roll, & Yaw Sensor, MicroStrain, USA), allowing ROM to be measured in rotation, flexion / extension and sidebending. The electronic device was connected to a computer, which recorded ROM measurements in degrees to the nearest first decimal place (Figure 1).

A concurrent study by Daly and Fryer 2004[26] examined the repeatability of the measuring procedure using the ARMD no.3. This was determined by analysing three ROM measurements using Intraclass Correlation Coefficient (ICC). The average measure ICC for right rotation was 0.9902 ($F_{19,38}$ = 102.47, $P < 0.001$, 95%CI: 0.9794-0.9950), and for the left rotation the ICC was 0.9919 ($F_{19,38}$ = 123.85, $P < 0.001$, 95%CI: 0.9830-0.9966). The results indicate that the ARMD no. 3 was a highly repeatable device for measuring thoracolumbar rotation ROM.

The ARMD no.3 reliability pilot study revealed that the mean (_) difference between the first and last measurement to the left was 0.415° with SD 2.41° therefore calculations showed all left rotation measurements were accurate within 4.82°. In the right direction the mean difference between the first and last measurements was 0.185° with SD 2.51° therefore accurate within 5.02°.

ROM Measurement

Range of motion was assessed using the ARMD no.3 to determine active trunk rotation bilaterally. Each of the volunteers sat on the treatment table in front of the ARMD no.3 and the table height was adjusted to ensure that the horizontal beam of the measuring device was level with the inferior angles of the scapulae. Volunteers were asked to place their arms over the horizontal beam whilst their pelvis was stabilized by one of the examiners (Figure 2 – pelvic stabilisation not shown). Volunteers were then instructed to actively rotate as far as possible to the left, and the ROM value was recorded. Subjects then returned to the neutral position for a latent period of three seconds before the procedure was repeated to the contralateral side. Bilateral rotation measures were completed three times with the mean value being calculated for analysis. To reduce any reading errors, the same examiner read and recorded the ROM values for each subject, and the same examiner stabilized the pelvis.

Group allocation

Following the measurement of pre-intervention ROM, participants were given a card indicating the direction of their restricted motion, which was handed to the treating examiner in an adjacent room. Volunteers (n = 90) were then randomly assigned (lottery draw) to either the treatment group (MET or HVLA) or control group (sham counterstrain treatment), and received their appropriate intervention. The examiner recording the post-intervention ROM measurements was blinded to the intervention allocation of the volunteers.

Intervention

An examiner who is a fully qualified osteopath completed all interventions.

Muscle Energy Technique

A single general thoracic MET[2,15] was applied to correct the participants' rotation restriction. Each participant sat on the treatment table and the treating examiner stood behind. The participant was then instructed to cross their arms over their chest with arms resting on opposite shoulders. With the spine in neutral, the treating examiner was then able to engage the restricted rotation barrier. The treating examiner then resisted a 3 to 5 second isometric contraction of rotation by the participant. After each isometric effort, a new rotation barrier was engaged and the participant repeated the isometric contraction. Three repetitions were completed on each participant (Figure 3).

High Velocity Low Amplitude Thrust Technique

Participants were treated in a neutral, side-lying position with a single thoracolumbar HVLA rotatory thrust. Participants were instructed to lay on their side with the lower body straight and the upper body slightly rotated. The treating examiner stood in front of the participant taking up the axillary hold, with the other forearm placed in the region of the gluteus maximus and gluteus minimus. Rotation was then introduced to the thoracolumbar spine with the treating examiner rotating the upper and lower body levers until a sense of tension was palpated at the desired level. The thrust was directed into the restrictive barrier to achieve joint cavitation (Figure 4).

The Control group

As participant expectations and motivation may have influenced active rotation ROM, the control group was treated with a "sham" osteopathic counterstrain technique. Participants were treated in a prone position where the operator held one of the subject's leg in slight extension and simply palpated the thoracolumbar spine without taking it to, or away from the reported restriction (Figure 5). This position was held for approximately 30 seconds and was used to give the subject the illusion that a genuine technique was being performed. Participants were informed that there would be a non-treated control group, which should have made those in the "Counterstrain Technique" group naïve to the sham nature of that treatment.

Post-intervention rotation ROM measures were taken in an identical way to pre-intervention rotation ROM measures, both immediately post-intervention and thirty minutes post-intervention. Mean values were again calculated following each subject's end range of rotation.

Statistical Methods

All data was collated using Microsoft Excel and analysed using the statistical package SPSS Version 12. A mixed/split plot design (SPANOVA) was used to analyse the differences in the change of gross trunk active ROM within groups over time, and the differences in the mean change of gross trunk active ROM between groups. Statistical significance was set at the alpha 0.05 level.

RESULTS

The mean trunk ROM measurements of the control and treatment groups in both restricted and non-restricted directions are presented in Tables 1, 2 and 3.

In the direction of restricted motion, all groups made gains immediately post-intervention (Control = +3.01°, MET = +3.06°, HVLA = +2.76°). When compared to the immediately post-intervention measures, at 30 minutes post-intervention however, the control and HVLA groups ROM had increased but the MET group had decreased (Control = +4.77°, MET = +1.74°, HVLA = +3.43°).

In the direction of non-restricted motion, the control group remained relatively unchanged post-intervention (+0.04°) and 30 minutes post-intervention (+0.71°). No gain was found in either of the other groups post-intervention (MET = -2.27°, HVLA = -1.54°) or 30 minutes post-intervention (MET = -1.40°, HVLA = -1.95°)

Analysis of the mean differences in the change of gross trunk active ROM over time with a SPANOVA demonstrated a statistically significant difference within the three groups in the restricted direction ($F_{2,87} = 17.17$, $P = 0.00$, $\eta^2 = 0.17$). A Post-hoc repeated measures ANOVA revealed that the statistically significant differences existed between pre- and immediately post-intervention measures ($F_{2,87} = 24.64$, $P = 0.00$, $\eta^2 = 0.22$) and between pre- and 30 minutes post-intervention measures ($F_{2,87} = 21.36$, $P = 0.00$, $\eta^2 = 0.18$) for all treatment groups including the control group. No statistically significant differences were observed over time between immediately post- and 30 minutes post-intervention measures in the restricted direction ($F_{2,87} = 0.49$, $P = 0.49$, $\eta^2 = 0.06$). The non-restricted direction did not show statistical significance in any of the measures over time ($F_{2,87} = 2.13$, $P = 0.122$, $\eta^2 = 0.02$).

There was no statistically significant difference demonstrated with a SPANOVA analysis of the mean differences in the change of gross trunk ROM between the control, MET or HVLA groups in the restricted direction ($F_{2,87} = 0.66$, $P = 0.52$, $\eta^2 = 0.15$) or the non-restricted direction ($F_{2,87} = 0.91$, $P = 0.41$, $\eta^2 = 0.02$).

DISCUSSION

This study demonstrated that there was a statistically significant increase in gross trunk ROM following a single application of MET or HVLA. This was, however, meaningless as the increase was within the error range of the test equipment (i.e. < 5°). No statistically significant difference between the post- intervention gains of the control group and of those in the intervention groups was found.

Mean increases in rotation ROM were experienced in all groups including the control, immediately post- (Control = +3.01°, MET = +3.06°, HVLA = +2.76°) and were still present 30 minutes post-intervention (Control = +4.77°, MET = +1.74°, HVLA = +3.43°) in the restricted direction. It was interesting to note that although all groups showed a statistically significant increase in gross trunk rotation ROM after 30 minutes post-intervention, the MET group was the only one to show a decrease from immediately post- to 30 minutes post-intervention (Control = +1.77°, MET = -1.32°, HVLA = +0.67°). No such increases in mean rotation ROM were experienced in the non-restricted direction.

The statistical data suggests that although MET and HVLA altered gross trunk rotation ROM, there was no difference between the effect of these techniques and that of the 'sham' counterstrain technique used on the control group. These results concur with Gavin[22] (who essentially demonstrated no real change following HVLA), but are in stark contrast to previous studies that investigated the effect of MET on cervical,[12,13] thoracolumbar,[15] and lumbar[14] ROM, and HVLA on cervical[16,17] ROM.

Lenehan *et al.*[15] examined whether a single application of thoracolumbar MET could significantly increase the ROM in asymptomatic volunteers with restricted active trunk rotation. These researchers did not use a fixed asymmetry but found a significant increase in active ROM in the direction of restricted rotation. Their study used a slightly different ROM measuring procedure where the right side was measured 3 times, followed by the left 3 times. The present study measured the right side once followed by the left once, then the right again and so forth. The present study also used the ARMD no.3 which was equipped with an electronic measuring device, whereas the study by Lenehan *et al.*[15] used the ARMD no.2 equipped with a 'protractor-style' measuring device which was likely to be less accurate. Possibly the most important difference between the two studies was the use of a 'sham' functional technique compared with the no-treatment control by Lenehan *et al.*[15]. It is possible that subject expectation and increased motivation may have lead to increased effort and ROM post-intervention to cause the increased ROM found by Lenehan *et al.*[15].

On review of the raw data it was discovered that 49% of participants (44 out of 90) exhibited an asymmetrical rotation ROM of >5º. On closer inspection 22% (20 out of 90) had an asymmetry of between 5 and 10º whilst 27% (24 out of 90) demonstrated an asymmetry of >10º. It should be noted that this was only a 'one off' asymmetry and was not confirmed as 'fixed' over an extended period of time. Perhaps if only this subgroup of participants was used there may have been a greater increase in rotation ROM following intervention leading to significant results.

Due to the number of subjects required (this study was run in conjunction with three others), some subjects were used on more than one occasion. A 'wash-out' period of one week was implemented in order to nullify intervention effects, however it may not have nullified the learned effects. The learned effect is a type of bias which may have influenced the results of this study. Learned subjects would be more familiar with the motor task, which may have lead to improvement of their rotation on the second occasion. This may have been true particularly of subjects in the control group who were blinded to this by being told that there were three treatment groups (MET, HVLA and counterstrain) and a control group. It is probable the Hawthorn effect occurred whereby the subjects felt they had to try harder post-intervention after receiving an indirect technique as opposed to the MET and HVLA, and due to this fact they thought that they were not part of the control, and thus had to 'show an increase'.

Using asymptomatic subjects without a fixed asymmetry may have been a disadvantage, as restricted mobility, altered quality of motion, and muscle spasm adjacent to an articulation, which are claimed to be common indications for the use of both MET and HVLA, may not have been present. The studies by Whittingham[16] and Cassidy *et al.*[23] both obtained significant results by using symptomatic patients. The present study would therefore not have been a reflection of a true clinical situation where asymmetrical motion, pain and tissue texture change are common occurrences.

Extensions on the current study should involve only testing subjects with a fixed asymmetry of gross trunk rotation ROM confirmed on three separate occasions.

However it may be more beneficial to direct future research to the effects of MET and HVLA on the rotation ROM of only symptomatic subjects with pain and or disability.

Another recommendation would be the use of more than one application of MET or HVLA to restricted regions of the spine in order to improve gross trunk rotation ROM. It would also be interesting to investigate the effect of using a combination of osteopathic techniques to more closely resemble an osteopathic consultation.

CONCLUSION

This study found that although a single application of MET or HVLA applied to the thoracolumbar spine in the direction of restricted rotation produced a statistically significant increase in gross trunk rotation ROM, this increase was within the error range of the test equipment and thus was invalid. .

No statistically significant difference was seen between the treatment groups and the control group. The study therefore failed to show a significant benefit in the use of muscle energy and high velocity low amplitude osteopathic treatment techniques on rotation ROM in asymptomatic subjects. It is recommended that future research measuring gross trunk rotation ROM uses symptomatic subjects with a fixed degree of asymmetry.

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TABLES

Table 1. Group means pre- and immediately post-intervention for the treatment and control groups

	Gross trunk range of motion mean scores					
	Control Restricted	Control Non-Restricted	MET Restricted	MET Non-Restricted	HVLA Restricted	HVLA Non-Restricted
Pre-intervention	45.98 (10.47)	52.93 (12.57)	48.77 (9.97)	55.43 (9.13)	45.41 (8.70)	51.90 (8.53)
Post-intervention	48.99 (9.84)	52.97 (12.77)	51.83 (10.83)	53.17 (10.10)	48.17 (9.99)	50.36 (9.74)
Difference	**+3.01 (6.02)**	**+0.04 (4.24)**	**+3.06 (5.17)**	**-2.27 (8.06)**	**+2.76 (5.64)**	**-1.54 (4.89)**

NB. All figures are Mean (SD), units for all ROM measurement in degrees

+ sign indicates increase in ROM

- sign indicates decrease in ROM

Table 2. Group means pre- and 30 minutes post-intervention for the treatment and control groups

	Gross trunk range of motion mean scores					
	Control Restricted	Control Non-Restricted	MET Restricted	MET Non-Restricted	HVLA Restricted	HVLA Non-Restricted
Pre-intervention	45.98 (10.47)	52.93 (12.57)	48.77 (9.97)	55.43 (9.13)	45.41 (8.70)	51.90 (8.53)
30 mins post-intervention	50.75 (10.74)	53.64 (12.63)	50.51 (12.64)	54.03 (11.38)	48.84 (10.03)	49.95 (9.40)
Difference	**+4.77 (6.88)**	**+0.71 (6.94)**	**+1.74 (7.32)**	**-1.40 (7.20)**	**+3.43 (6.15)**	**-1.95 (4.86)**

NB. All figures are Mean (SD), units for all ROM measurement in degrees

+ sign indicates increase in ROM

- sign indicates decrease in ROM

Table 3. Group means post- and 30 minutes post-intervention for the treatment and control groups

	Gross trunk range of motion mean scores					
	Control Restricted	Control Non-Restricted	MET Restricted	MET Non-Restricted	HVLA Restricted	HVLA Non-Restricted
Post-intervention	48.99 (9.84)	52.97 (12.77)	51.83 (10.83)	53.17 (10.10)	48.17 (9.99)	50.36 (9.74)
30 mins post-intervention	50.75 (10.74)	53.64 (12.63)	50.51 (12.64)	54.03 (11.38)	48.84 (10.03)	49.95 (9.40)
Difference	**+1.77 (5.43)**	**+0.67 (6.06)**	**-1.32 (5.29)**	**+0.86 (5.51)**	**+0.67 (4.44)**	**-0.41 (4.38)**

NB. All figures are Mean (SD), units for all ROM measurement in degrees

+ sign indicates increase in ROM

- sign indicates decrease in ROM