The effect of Thoracolumbar High Velocity Low Amplitude Manipulation on gross trunk range of motion – Is the direction of thrust important?

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Abstract

Background and Objectives: High Velocity Low Amplitude (HVLA) is a form of spinal manipulation commonly used by Osteopaths and other manual medicine practitioners. Despite its widespread use, there is little experimental evidence that supports the efficacy of HVLA in the thoracolumbar region or whether the direction of thrust is important in altering rotation range of motion (ROM). This study investigated whether a single application of thoracolumbar HVLA, either into or away from the restrictive rotation barrier, could significantly increase an asymptomatic volunteer's gross trunk rotation ROM.

Methods: Ninety volunteers (30 male, 60 female; mean age 22; age range 18-40) were randomly assigned to either a treatment (HVLA into restriction or HVLA away from restriction) or control group (sham counterstrain) and blinded pre, immediately post and 30 minutes post measurements of active trunk rotation were recorded.

Results: Between group comparisons were conducted for pre-, immediately post, and 30 minutes post-intervention. An analysis of variance (ANOVA) revealed no significant changes in ROM either immediately or 30 minutes post-intervention with thoracolumbar HVLA into, or away from the restrictive rotation barrier in the restricted direction. No significant ROM changes were produced in the control group. The only outcome that showed a statistically significant difference between interventions was pre and immediately post in the non-restricted direction ($F_{2,87} = 3.175$, $P = 0.047$). Pairwise comparisons using Least square differences demonstrated a statistically significant

difference between HVLA away from the restriction and HVLA into the restriction (P = 0.014) of 3.03 degrees immediately post-intervention on the subjects' non-restricted sides, but this change was within the error range of the test equipment.

Conclusion

Thoracolumbar HVLA performed either into or away from the restrictive rotation barrier, had no significant effect on active, seated trunk rotation in asymptomatic volunteers with no fixed asymmetry.

Key Words: osteopathy, manipulation, thoracolumbar spine, range of motion

INTRODUCTION

High Velocity Low Amplitude thrust technique (HVLA) is a form of spinal manipulation commonly used by Osteopaths and other manual medicine practitioners to treat cervicogenic headache, acute low back pain, structural rib dysfunction and other musculoskeletal complaints. Despite the widespread use of HVLA, there has been limited research as to whether the direction of thrust is important in altering rotation range of motion (ROM) in the thoracolumbar region.

Gibbons and Tehan[1] state that the aim of HVLA technique is to achieve joint cavitation that is accompanied by a 'popping' or 'cracking' sound. This audible release represents a sudden decrease in intracapsular pressure which causes dissolved gasses in the synovial fluid to be released into the joint cavity.[2] HVLA techniques involve a direct, rapid thrust or impulse being applied either into or away from the motion restriction which is claimed to reduce pain and also restore movement to hypomobile intervertebral segments.[3] In addition to pain and hypomobility, specific indications for HVLA include joint fixation, adhesions, meniscoid entrapment and reflex relaxation of muscles.[1]

At present, despite its extensive use in the treatment of spinal dysfunction, there is limited experimental evidence that supports the efficacy of HVLA techniques in altering gross trunk rotation ROM in the thoracolumbar region. A number of studies have reported that manipulative techniques can increase active or passive ROM, particularly in the cervical spine.[4-7] However, some of these studies demonstrate problems with experimental design and measurement and thus should be interpreted with caution.

Howe et al.[4] found that cervical manipulative thrust techniques performed upon subjects with neck pain, increased cervical spine ROM both immediately and three hours post manipulation. The authors did not describe the method of examination of cervical rotation so the reliability of this measurement is unknown.

Cassidy et al.[5] reported a goniometric increase in cervical ROM and a decrease in pain (evaluated using the 101-point numerical rating scale) immediately following HVLA toward the pain-free side. The study did not include a control group and was unblinded, which limited the generality of this study.

Nilsson et al.[6] 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 ROM. Passive range of cervical motion significantly increased immediately following HVLA, however there was no significant change in passive ROM one week after the treatment. The authors concluded that any changes in passive ROM after spinal manipulation were of a temporary nature.

Whittingham and Nilsson[7] studied the changes in active cervical ROM following HVLA. Cervicogenic headache patients were randomized into treatment (HVLA to upper cervical spine) and non-treatment (sham manipulation) groups. Results showed that after receiving HVLA, active cervical ROM increased significantly in the treatment group compared with the non-treatment group.

Nansel *et al.*[8] investigated the effect of cervical spinal manipulation on pain free subjects exhibiting passive end range lateral flexion asymmetries of greater than 10º. 10º was chosen after the examiners had found that on any given day one in three individuals in a student 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 lateral flexion asymmetry at 30 minutes, 4 hours, and 48 hours post-manipulation.

No study has determined a comparable degree measurement of fixed asymmetry at the thoracolumbar junction. Wong and Nansel[9] measured atlanto-axial (AA) rotation and found 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.[10] to be significant at the $P < 0.001$ level. The authors found unilateral cervical manipulation to be relatively side specific. When delivered to the side of restriction, dramatically improved mean asymmetries (from 13.8º to 1.8º) were found, while thrusts delivered to the less restricted side, were only marginally effective in ameliorating asymmetries.

Clements et al.[11] investigated the effect of various directions of HVLA manipulation on the amelioration of goniometrically verified passive 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. No researcher has ascertained whether or not these results hold true throughout the spine.

The effects of HVLA on thoracic ROM have also been investigated, albeit not as in depth as cervical ROM. Gavin[12] researched the effect of manipulation of restricted thoracic segments on thoracic active ROM in asymptomatic subjects. Flexion and side-bending left and right were measured using the EDI 320 device by Cybex, which had previously been tested and shown to be reliable. In a comparison of pre-treatment versus post-treatment active ROM, a significant difference ($p = 0.012$) was seen in left side bending, demonstrating that manipulation techniques can influence active ROM in the mid-thoracic spine. This increase in left side bending however was very small and probably within the error range of the test equipment which was not stated by the author.

While a number of researchers have studied the effects of HVLA on ROM, few have given consideration to the most effective direction of thrust. Some authors in the field of manual medicine recommend that HVLA manipulation be directed into the limited range towards the restrictive barrier, [13, 14, 15] while others claim that these techniques are just as effective if the thrust is directed away from the restrictive barrier.[16] It has also been suggested that manipulative procedures should be directed into the pain-free range to optimise not only their effectiveness, but also patient comfort. [17]

This study aimed to investigate whether thoracolumbar HVLA could improve gross trunk rotation ROM and ascertain if the direction of thrust was important in producing lasting (30 minutes) effects on rotation ROM. It was hypothesised that thoracolumbar HVLA would produce lasting increases in gross trunk rotation ROM, while the control group would display no change. It was also hypothesised that HVLA into the restrictive barrier would be more effective in increasing rotation ROM than HVLA away from the restrictive barrier.

MATERIALS AND METHODS

Participants

Ninety (90) asymptomatic volunteers (30 male, 60 female; mean age 22; age range 18-40) were recruited by convenience sampling after responding to advertisements posted around Victoria University. All volunteers gave written informed consent (approved by Victoria University Human Ethics Committee) and completed a questionnaire to exclude any contraindications to HVLA treatment.[1] Other exclusion criteria included presenting pain, or a history of restrictive thoracic or lumbar pathology. Volunteers were not receiving any concurrent treatment for spinal dysfunction.

Materials

Pre- and post-intervention testing required adjustable treatment tables, patient gowns and the Axial rotation measuring device number 3 (ARMDno3). This measuring device was similar to that used by Lenehan et al.[18] which examined the effects of another direct Osteopathic technique, Muscle Energy Technique, on overall trunk ROM without predetermined fixed asymmetry. The ARMDno3 was modified by omitting the linear protraction device for a computerised device (3DM® Solid State 3-axis Pitch, Roll, & Yaw Sensor, MicroStrain, USA), that not only measured rotation but also allowed flexion and extension to be monitored in the seated position (Figure 1).

A concurrent study determined the ARMDno3 to be repeatable for measuring gross trunk ROM.[19] 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 ARMDno3 was a highly repeatable device for measuring thoracolumbar rotation ROM.

The ARMDno3 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°.

Gross trunk ROM and the Thoracolumbar junction

Because the thoracic spine, ribs, lumbar spine and pelvis function synchronously to produce coordinated movement around the trunk,[20] it was decided that the effects of HVLA on active gross trunk rotation ROM would be considered. The Thoracolumbar region (T10-L2) was chosen to be the point of application of the HVLA because it is an important transition region in the spine where a high frequency of tropism and variation of facet joints exist.[21] Chaitow[22] claimed that restriction of rotation is the most common characteristic of thoracolumbar dysfunction.

Procedures

Measurement of Gross trunk ROM

Volunteers sat on the treatment table in front of the ARMDno3 and placed their arms over the horizontal beam. The table height was then adjusted so that the horizontal bar lined up with both inferior angles of the scapulae (Figure 2). Each subject was then instructed to actively rotate towards the right as far as possible and hold. This rotational value (in degrees to the nearest first decimal place) was then recorded. Subjects then returned to a neutral position for approximately 3 seconds before the procedure was repeated towards the left. After the volunteers had engaged their endmost rotation ranges bilaterally three times each, a mean value was calculated for analysis. To reduce any reading errors, the same examiner read and recorded the ROM values for each subject, and the same examiner positioned the horizontal bar in line with the inferior angles of the scapulae.

Group allocation

Volunteers were randomly assigned (lottery draw) to either control or treatment groups (HVLA into restriction or HVLA away from restriction). The examiner recording the ROM measurements was blinded to the treatment allocation of the volunteers. Following the pre-intervention ROM measurements, participants were given a card indicating the direction of their restricted motion, which was handed to the treating examiner (qualified Osteopath) in another room.

Intervention phase

An experienced Osteopath performed all interventions. Subjects in the treatment groups were treated in a neutral, side-lying position with a single thoracolumbar HVLA rotatory thrust (Figure 3). The direction of thrust was either into or away from the predetermined restrictive barrier. The control group received a sham counterstrain technique in the supine position with the leg held in extension and slight abduction for 30 seconds (Figure 4). No perceived barrier was engaged. Post-intervention ROM was assessed in an identical manner to the pre-intervention ROM testing and was measured immediately following treatment and 30 minutes following treatment. Mean values were again calculated following each subject engaging their end range trunk rotation three times.

Statistical Methods

Data was recorded on Microsoft Excel. A randomized, controlled, test-retest design was used, where the participants provided their own baseline measurements (pre-intervention ROM). The initial effect of treatment intervention was measured by the differences of pre- and immediately post-intervention ROM. The differences of pre- and 30 minutes post-intervention ROM were used to investigate the prolonged effects of the interventions. Statistical analysis was performed on SPSS. An analysis of variance (ANOVA) was used to test the hypothesis. The significance level was set at $p < 0.05$.

RESULTS

The mean gross trunk ROM measurements of the control and treatment groups are presented on Tables 1 and 2. Small mean pre-post changes were seen ranging from –1.5º to 3.0º immediately after intervention and –2.0º to 3.8º at 30 minutes post-intervention. There were small ROM increases in all groups in the restricted direction (30 mins post : 1.2º to 3.8º) but little increase in ROM in all groups in the non-restricted direction (30 mins post: -2.0º to 0.7º).

An ANOVA was performed on the mean pre-post differences between each of the intervention groups. The only outcome that showed significant difference between interventions was pre and immediately post in the non-restricted direction ($F_{2,87} = 3.175$, $P = 0.047$). Neither thoracolumbar HVLA into, or away from the restrictive rotation barrier, nor the control showed any significant changes in ROM either immediately ($F_{2,87} = 0.272$, $P = 0.763$) or 30 minutes post-intervention ($F_{2,87} = 2.008$, $P = 0.140$) in the restricted direction. Post hoc analysis using Least Square Differences revealed a statistically significant difference between HVLA performed away from the restriction and HVLA performed into the restriction ($P = 0.014$) of 3.03 degrees on the subjects' non-restricted side. This result suggests that thoracolumbar HVLA performed away from the restriction may increase gross trunk rotation ROM in the non-restricted direction immediately after application.

A within groups ANOVA revealed no significance in the control ($F_{2,87}$ = 1.629, P = 0.202), HVLA performed away from the restriction ($F_{2,87}$ = 0.281, P = 0.756) or HVLA performed into the restriction ($F_{2,87}$ = 1.075, P = 0.346).

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

	Gross trunk range of motion mean scores & (SD) in degrees					
	Control Restricted	Control Non-Restricted	HVLA Restricted	HVLA Non-Restricted	HVLA2 Restricted	HVLA2 Non-Restricted
Pre-intervention	46.0 (10.5)	52.9 (12.6)	45.4 (8.7)	51.9 (8.5)	50.3 (10.8)	55.6 (10.6)
Post-intervention	49.0 (9.8)	53.0 (12.8)	48.2 (10.0)	50.4 (9.7)	52.3 (10.2)	57.1 (12.1)
Difference	**3.0 (6.0)**	**0.1 (4.2)**	**2.8 (5.6)**	**-1.5 (4.9)**	**2.0 (5.0)**	**1.5 (4.8)**

Table 2. Groups means & (SD) pre- and 30 minutes post-intervention for the treatment and control groups

	Gross trunk range of motion mean scores & (SD) in degrees					
	Control Restricted	Control Non-Restricted	HVLA Restricted	HVLA Non-Restricted	HVLA2 Restricted	HVLA2 Non-Restricted
Pre-intervention	46.0 (10.5)	52.9 (12.6)	45.4 (8.7)	51.9 (8.5)	50.3 (10.8)	55.6 (10.6)
30 mins post-intervention	50.8 (10.7)	53.6 (12.6)	48.8 (10.0)	49.9 (9.4)	51.5 (10.0)	55.4 (10.9)
Difference	**3.8 (6.9)**	**0.7 (6.9)**	**3.4 (6.2)**	**-2.0 (4.9)**	**1.2 (7.9)**	**-0.2 (6.1)**

(HVLA = into restrictive barrier, HVLA2 = away from restrictive barrier)

DISCUSSION

This study demonstrated no significant changes in restricted rotation ROM either immediately or 30 minutes after intervention in either of the HVLA groups or the control. However, the change in ROM produced by thoracolumbar HVLA performed away from the restriction was significantly different compared with HVLA performed into the restriction immediately following application to the non-restricted side ($P = 0.014$). Although statistically significant, this finding should be interpreted with caution because a ROM improvement of 3.03 degrees is minute and not quantifiable in a clinical situation. Additionally, the difference is due to a small ROM increase in one group and a small decrease in the other group. Therefore these results maybe clinically insignificant.

Previous studies have shown that HVLA manipulation can have a positive effect on pain[5, 23] and increase ROM,[7, 23] particularly when applied to the cervical spine. The present study supports the findings in the thoracic spine by Gavin[12], that one session of HVLA can produce only minute changes in active ROM that are negligible in a clinical setting. While three of the four HVLA group means did improve immediately post-intervention (HVLA restricted : 2.8º; HVLA non-restricted : -1.5º; HVLA2 restricted: 2.0º; HVLA2 non-restricted: 1.5º), the improvements were not statistically significant and all were within the error range of the test equipment (i.e. < 5°).[19] Therefore the significant difference found was deemed to be clinically irrelevant. From this it could be said that thoracolumbar HVLA may influence rotation ROM but not necessarily improve it.

The statistically significant finding on the non-restricted side that suggests thoracolumbar HVLA away from the restriction is a more effective intervention than HVLA into the restriction is in conflict with many authors who suggest that HVLA techniques are more effective in increasing ROM when performed into the restrictive barrier rather than away from it. [13, 14, 15] Clements et al.[11] demonstrated ~~suggested~~ that irrespective of the direction of thrust, HVLA manipulation of the atlanto-axial joint produced significant immediate increases in rotation ROM. Whether or not changes in rotation range of motion found are consistent at all spinal levels remains to be seen and should be the focus of further investigation along with the importance a clinician should place on the direction of thrust.

On review of the raw data it was discovered that 50% of participants (45 out of 90) exhibited an asymmetrical rotation ROM of >5º. On closer inspection 28% (25 out of 90) had an asymmetry of between 5 and 10º whilst 22% (20 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.

Limitations

Subjects were asymptomatic, with no pain, tissue texture changes and often minimal or no asymmetrical motion. This followed on from the Lenehan et al.[18] study where no fixed asymmetry was used but a significant increase in active rotation ROM was found. The use of asymptomatic subjects is not necessarily a reflection of a clinical situation where most patients are symptomatic with mobility restrictions and therefore no inference can be made about the value of HVLA techniques in a clinical setting.

There appeared to be a learned effect with subjects following each rotation ROM measurement. This could have occurred as the subjects became more familiar and confident in their movements on the ARMDno3. After each measurement the subjects seemed to become more comfortable and skilled at the rotation. Increasing mean rotation ROM measurements in the restricted direction supported this observation.

The longer lasting effects of treatment (30 minutes post) may not have been accurately gauged as some participants returned greater than 30 minutes after intervention. To date, no research has shown any statistically significant long term improvements in rotation ROM in the thoracolumbar region following HVLA manipulation.

Recommendations for future research

Further research should be directed towards investigating the effect of thoracolumbar HVLA using symptomatic subjects with fixed asymmetries within a clinical setting, and examining multiple directions of motion. Results may be more favourable with more than one application of HVLA in subjects with marked asymmetries. A longer treatment regime consisting of multiple applications of HVLA may statistically support the notion amongst practitioners in the field of manual medicine that HVLA can in fact improve ROM throughout the spine. If subjects with greater than 10º asymmetry were used, there could potentially be a more pronounced change in ROM.

It needs to be also ascertained whether or not the direction of thrust is important throughout the spine and if HVLA manipulative techniques can in fact be beneficial over a longer period of time. These extensions of the current study would be beneficial for manual therapists not only in assessing patients with restricted motion but also in predicting outcomes of treatment.

CONCLUSION

A single application of thoracolumbar HVLA, either into or away from the restrictive rotation barrier, showed no significant improvement in gross trunk ROM immediately following treatment in asymptomatic subjects with no fixed asymmetry. No significant improvement was seen in active trunk rotation in the control group. Although these findings contradict the hypothesis, previous authors have claimed that HVLA can influence ROM.

After 30 minutes, neither HVLA into or away from the restrictive rotation barrier demonstrated any lasting changes in gross trunk ROM. Further investigations are required to establish the effectiveness of thoracolumbar HVLA in a clinical setting using symptomatic subjects with fixed asymmetries.

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