The effect of high velocity low amplitude manipulation on the amelioration of cervical spine rotation asymmetries: Is the cavitation important?

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ABSTRACT

Background: High velocity low amplitude (HVLA) thrust techniques are commonly used by manual therapists. One of the primary goals of these techniques is to increase the range of motion within spinal segments. Still, there is much contention about the outcomes of the audible release or cavitation associated with these techniques.

Objective: To investigate the effect that HVLA thrust technique has on total cervical ROM asymmetries with and without cavitation.

Methods: 15 participants (22.2 ± 4.5 years) exhibiting a persistent total cervical range of motion asymmetry in right rotation of greater than 12° were included in the study. The first group (n=6) received a single HVLA thrust with cavitation to the AA joint directed away from the restriction. The second group (n=9) received a similar HVLA thrust but without the cavitation. Measures of active cervical range of motion were performed pre-, immediately post- and 30 minutes post-manipulation.

Results: HVLA manipulation of the atlanto-axial joint with cavitation was found to produce a significant ($p=0.043$) immediate amelioration in total cervical right rotation asymmetries whereas HVLA without cavitation did not produce a statistically significant effect over time. There was found to be no significant difference between the treatment groups on cervical ROM asymmetry alteration.

Conclusion: HVLA thrust technique to the AA joint with cavitation produced a significant amelioration in total cervical rotation asymmetry immediately post-manipulation. A significant amelioration in total cervical rotation asymmetries was not found when HVLA failed to produce a cavitation. The reduction in the asymmetry

immediately post-manipulation had reduced or returned to the pre-manipulation level at 30 minutes post-manipulation.

Key terms: Manipulation, Cavitation, Cervical, ROM, Asymmetry, Atlanto-axial joint, Amelioration, Osteopathy.

INTRODUCTION

HVLA manipulation is a manual technique that is distinguished from other interventions by its association with an audible release, usually referred to as a 'pop' or 'crack'. This audible release is thought to represent cavitation of the joint, involving a sudden drop in pressure releasing gasses dissolved in synovial fluid[1]. Cavitation has also been demonstrated to increase the range of motion (ROM) immediately post manipulation in metacarpophalangeal joints.[2] This is thought to be the result of the gas bubble creating an increased volume; however, this is absorbed again within minutes.[1] There have been many studies that have demonstrated increases in spinal ROM following HVLA.[3,4,5,6,7,8,9,10] Authors attribute this to cavitation of the zygapophyseal joints between vertebrae.

Sukitt et al[10] found that HVLA manipulation to the AA joint performed on asymptomatic participants produced a significant ($p < 0.02$) amelioration on cervical rotation asymmetries immediately post-manipulation. In this study the success of the manipulation was based upon the presence of an audible release. Interventions that did not include the audible release were excluded from the study. Subjects in this study were

included if that had a cervical rotation asymmetry of 8º measured on two occasions, one day apart. This period of time between measurements is probably too short to conclude that the asymmetry was fixed or persistent. The long term effect of manipulation was also investigated and there was found to be no lasting effect of HVLA manipulation on cervical ROM asymmetries. Clements et al[9] investigated the effect of HVLA manipulation at the AA joint on cervical spine rotation asymmetry. They showed that the direction of the HVLA thrust, either towards the restriction or away from it, was not important as both directions improved ROM. The participants were asymptomatic and included if they had a cervical rotation asymmetry present on two separate occasions one week apart.

Some indications for the use of HVLA are the alleviation of joint restriction fixation and motion restriction;[1,11,12,13,14] but is the audible release or cavitation important in achieving these ROM alterations? Authors suggest that the audible release can have a powerful effect on the patient[15,16,17] but there is divided opinion as to the significance of the audible release associated with HVLA thrust technique. DiGiovanna [18] is of the opinion that "eliciting this noise is not essential to the correction of a dysfunction. Feeling the joint move is more important than hearing it pop." Kappler opines that osteopathic physicians focus more on joint function rather than the noise.[19]

If two HVLA thrust procedures are of a similar velocity and force, but one lacks the audible release, could they reasonably be expected to have similar effects on ROM? Only the HVLA thrust with the audible release is most likely to cause gas bubble formation

and may therefore have a greater effect on ROM increase in the short term. This raises the question of whether the cavitation is important in obtaining measurable ROM effects or can HVLA thrust technique without cavitation produce comparable effects?

The purpose of this study was to determine the effect of a HVLA thrust technique to the AA joint, with and without cavitation, on total cervical ROM asymmetries. Previous studies have shown that HVLA to the atlanto-axial (AA) joint is effective in the amelioration of cervical ROM asymmetries[10] and the direction of thrust was unimportant.[9] For this reason the AA joint was chosen as the joint to be manipulated. The AA joint plays a major role in rotation of the cervical spine,[20,21,22,23] with up to 77% of total cervical rotation occuring at this joint.[23] Very little rotation of the cervical spine occurs above and below the AA joint.[24,25,26,27] A previous study investigated the effect of HVLA thrust technique to the AA joint on total cervical rotation.[10] The results demonstrated a significant reduction in total cervical ROM asymmetry. Total cervical rotation was used as the outcome measure for this study. It has been stated that ROM assessment via goniometry may be a valid and reliable method of evaluating at least one parameter of vertebral function.[28,29,30]

METHODS

Ethics approval was obtained from the Victoria University Human Research Ethics Committee. All participants gave written informed consent and were free to exit the study at any stage.

Study Design and Data Analysis

This was a randomised and controlled quantitative experimental study with blinding of the examiners about the intervention received by the participants. A SPANOVA was used to detect whether there was any significant change over time on the ROM asymmetries and whether there was a significant change in the asymmetries due to either of the treatments. T-tests were used to detect exactly where any differences arose in the data as found using the SPANOVA. A previous study of a similar nature with pre-, immeadiately post- and one hour post-manipulation measures used t-tests to statistically analyse its data.[10] The data is in degrees of rotation to the nearest whole degree. Pre-test, immediately post-test and 30 minutes post-test readings were analysed within and between groups to detect significant differences. The statistical analysis was carried out using SPSS version 11 and 12.

Participants

106 university students and staff volunteered to participate in the study. Participants were excluded from the intervention study if they did not have a fixed right unilateral rotational asymmetry of greater than 12° on three separate measurements over a period of three weeks. Participants were also excluded if they had any conditions that contraindicated HVLA thrust technique. Contraindications included the presence of any bony or neurological pathology, vascular disorders such as VBI, usage of medications known to weaken bones or thin the blood or existing neck pain. Participants were informed that they should withdraw in the event of developing neck pain, experiencing trauma to the neck, the development of pathology or medication administration and were

free to withdraw at any time. Before entering the intervention groups it was necessary for all participants to have been cleared of vertebro-basilar artery insufficiency and upper cervical instability. The safety protocol used is outlined in Gibbons and Tehan.[29] After screening for cervical ROM asymmetries, 15 were included in the intervention groups. Participants were aged between 18 and 40 years. There were 7 females (mean age = 20.3 years) and 8 males (mean age = 25.2).

Procedure

Asymmetry of 8° or greater has been used in previous studies to determine the effectiveness of HVLA in ameliorating ROM asymmetries in the AA joint of the cervical spine.[10,31] In one of these studies 19% of the population was found to have rotational asymmetries of 8° or greater. [32] We decided to include only participants with an asymmetry of greater than 12° measured over three weeks, because we were measuring the effect of the intervention on total cervical rotation and not AA joint rotation alone. Participants cervical ROM had to be measured once a week for three weeks before being included in the intervention.

Total cervical ROM was measured using an electronic goniometer commissioned and validated[32] by the School of HMRP at Victoria University and made by 3DM USA. The goniometer is a small electrical device that is fastened onto a fitted head cradle and connected to a computer program that measures movement of the device in three dimensions. Rotation to the left and right in whole degrees were the measures being recorded in this study.

To obviate the effects of operator handedness only participants with reduced right rotation of greater than 12° were included. This meant all HVLA thrusts performed by the osteopath made use of their dominant hand. Participants were secured into a chair (Biodex, USA) that restricted motion of the lumbar and thoracic spine. Thus the motion of rotation was restricted almost exclusively to the cervical spine. Once in the chair, the participant was asked to look ahead at a fixed point directly in front of the Biodex chair. The goniometer was reset to zero using the software program. Each participant was then asked to actively rotate as far as possible to the left and then to the right, holding for three seconds on each side.

Studies have been previously published using either passive or active ROM. Active cervical ROM was chosen in preference to using passive ROM measurements as this reduces examiner bias.[33] A previous study using active ROM on the cervical spine produced significant increases in ROM and stated that "…past research has shown that there are likely no lasting changes to passive range of motion…" after HVLA thrust technique.[6] This study also showed that active cervical motion was a reliable measure to detect changes in ROM following spinal manipulation. There is on the other hand a subject bias associated with active ROM measurements.[34] Other studies on the effect of HVLA thrust technique in ameliorating ROM asymmetries have used passive ROM and shown significant amelioration of ROM asymmetry.[9,10] When measuring passive ROM it is at the examiners discretion to find a consistent point of end-feel across the population. In the end active ROM was used as it has been shown to detect changes in cervical ROM

following spinal manipulation and also to rule out inconsistencies related to examiner bias.

The first attempt to rotate left and right to end range was used as practice and one examiner watched and gave instructions on correction of their technique to avoid lateral flexion or movement in the sagittal plane. The second rotation was used for data collection. Another examiner recorded the data from the computer. Both right and left ROM were recorded. Subsequently, a difference was calculated which represented the extent of the rotational asymmetry. The ROM was not communicated to the participants at any time so that they remained unaware of the direction of rotation asymmetry. Those participants with asymmetries greater than 12° on three separate occasions, one week apart, were included in the intervention study.

Treatment Groups and Intervention

Fifteen participants with a fixed asymmetry of greater than 12° were recruited to the intervention groups. Participants were randomly allocated into two groups. The two intervention groups were as follows:

1. HVLA with cavitation (n=6).

   Atlantoaxial joint C1-2 – cradle hold, subject supine with rotation thrust.[35]

2. HVLA without cavitation (n=9).

   The technique had all the elements of the manipulation described above but with the application of a HVLA thrust to the right AA joint without cavitation.

An experienced osteopath performed the HVLA thrust technique. The HVLA thrust techniques were performed with the applicator on the articular pillar of the 1st cervical vertebrae, away from the restriction at the right zygapophyseal joint. The decision to manipulate away from the restriction was made to negate the effect of participant bias. The participants involved were aware that a HVLA manipulation into the direction of a restriction should increase the ROM into that direction, therefore at post-manipulation they may have consciously or sub-consciously tried to rotate further in that direction. Clements et al[9] showed that the direction of thrust was unimportant in reducing cervical rotational ROM asymmetries. This meant that by manipulating away from the restriction there should still be a reduction in the rotational asymmetry without the effect of participant bias.

Participants had their cervical ROM recorded directly before they received the intervention. Once receiving the intervention they immediately returned to the recording room and had their cervical ROM taken again. One final reading was taken approximately 30 minutes post intervention.

RESULTS

Of the 106 volunteers, 15 participants were found to have a right rotation cervical asymmetry of greater than 12°. Of the 15, 6 received HVLA with cavitation and 9 received HVLA without cavitation. Group mean asymmetries were calculated pre-, post- and 30 minutes post-intervention, see Table 1. In the cavitation group the mean cervical asymmetry pre-manipulation was 21.83° +/- 4.45°. A reduction of 9.3° to a statistically

significant ($p = 0.043$) mean of 12.5° +/- 6.77° occurred immediately post-manipulation. The asymmetry had almost completely returned to the original value at 30 minutes post-manipulation, measuring 18° +/- 4.56°. In the non-cavitation group the mean cervical asymmetry pre-manipulation was 18.3° +/- 6.28°. This was reduced by a lower margin of 1.53° post-manipulation and not being statistically significant, measuring 16.77° +/- 4.63°. At 30 minutes post-manipulation the asymmetry had increased to a value greater than at pre-manipulation, measuring 20.7° +/- 3.56°. These results can be viewed graphically in Figure 1.

Table 1. Group mean asymmetries at pre-, post- and 30 minutes post-manipulation for both intervention groups.

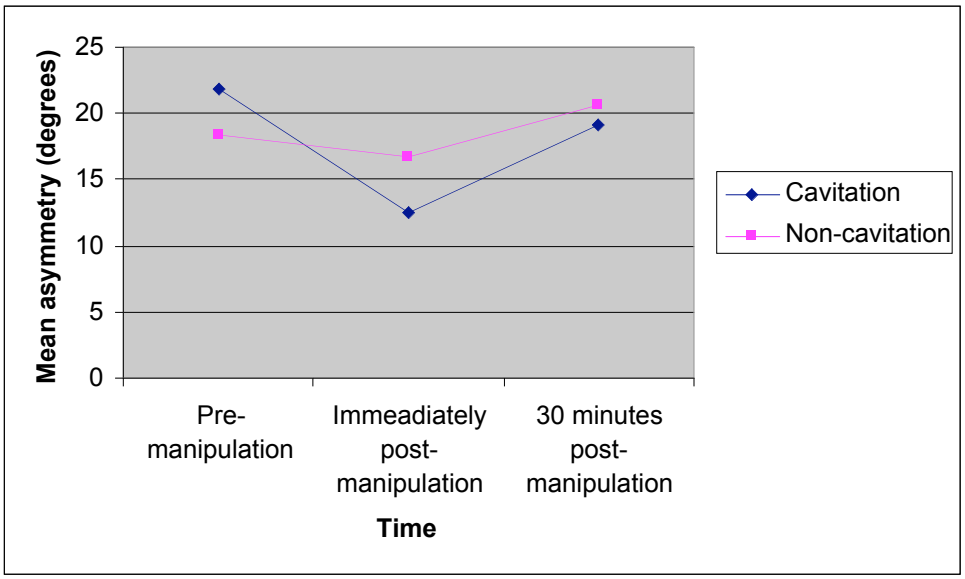
Cavitation

	Pre-manipulation			Post-manipulation			30 min post-manipulation		
	Left	Right	Asymm	Left	Right	Asymm	Left	Right	Asymm
Participant									
1	84	70	14	86	66	20	85	71	14
2	87	64	23	75	70	5	88	69	19
3	94	74	20	87	81	6	92	73	19
4	92	65	27	100	80	20	96	71	25
5	94	70	24	89	74	15	95	76	19
6	74	48	23	68	59	9	71	59	12
Mean	**87.5**	**65.1**	**21.8**	**84.1**	**71.6**	**12.5**	**87.8**	**69.8**	**18**

No Cavitation

	Pre-manipulation			Post-manipulation			30 min post-manipulation		
	Left	Right	Asymm	Left	Right	Asymm	Left	Right	Asymm
Participant									
1	111	97	14	114	98	16	119	103	16
2	77	63	14	78	57	15	84	61	23
3	87	74	13	90	69	21	90	68	22
4	93	71	22	98	72	26	91	71	20
5	86	63	23	78	68	10	86	65	21
6	70	57	13	76	59	17	73	58	15
7	87	73	14	93	78	15	100	76	24
8	82	61	21	76	58	18	77	57	20
9	94	63	31	80	67	13	90	64	26
Mean	**87.4**	**69.1**	**18.3**	**87**	**69.5**	**16.7**	**90**	**69.2**	**20.7**

Figure 1. Comparison of pre-, post- and 30 minutes post-manipulation for the manipulation with and without cavitation intervention groups.



A SPANOVA was used to detect whether there was any significant change over time on the ROM asymmetries and whether there was a significant change in the asymmetries due to either of the treatments. The results of the SPANOVA indicate that there was an effect over time meaning that there was a significant ($p = 0.12$, $F = 5.257$, $\_^2 = 0.288$) change in the asymmetries within the data but there was no effect between the treatments meaning that there was no significant ($p = 0.493$, $F = 0.498$, $\_^2 = 0.037$) difference in the asymmetry change between the treatment groups. T-tests were used to determine where the difference over time was in the data. At the alpha level $p > 0.05$ there was found to be a significant difference ($p = 0.043$, $t = 2.697$) between the asymmetries for the cavitation group between pre-manipulation and immediately post manipulation.

DISCUSSION

Participants were screened over three consecutive weeks to find those that had a persistent right rotational ROM asymmetry of greater than 12°. Of the 106 participants screened there was found to be 17% of the population with a right cervical rotational ROM asymmetry in the first week, 34% in the second week and 45% in the third week. Other studies have found cervical rotational asymmetries at slightly higher percentages of 19%[10] and 22%,[32] however they used 8° asymmetry rather than 12° as was used in the present study and included right or left asymmetries whereas the present study only considered right asymmetries.

The results of this study show that manipulation with cavitation produced a statistically significant reduction of right cervical ROM asymmetries over time, specifically between pre-manipulation and immediately post-manipulation. Manipulation without cavitation

did not produce a significant reduction in cervical ROM asymmetries over time. There was found to be no significant difference between the treatments on alterations in cervical ROM asymmetries. In both intervention groups the cervical ROM asymmetry had returned or become greater at 30 minutes post-manipulation, therefore a lasting effect in the amelioration of cervical ROM asymmetries was not observed.

One of the indications for using HVLA is to increase spinal segmental ROM. [1,11,12,13,14] In this study the HVLA thrust technique was directed into the range of greatest freedom, away from the direction of the rotation restriction. Clements et al[9] investigated the effect of HVLA into the restriction, away from the restriction and also bilaterally. Their results showed that there was a significant amelioration in the AA joint ROM asymmetries with all directions and combinations of HVLA and concluded that the direction of thrust was unimportant in the amelioration of rotational asymmetries. Results from the present study demonstrate that HVLA thrust technique with cavitation and away from the direction of restriction caused a short term amelioration of rotational asymmetries. As mentioned earlier the present intervention was performed in the opposite direction to that of a similar study involving manipulation of the AA joint (the direction of the thrust was into the restriction) which also found a significant amelioration of cervical ROM asymmetries.[10]

An osteopath with much experience in the application of HVLA thrust technique performed the intervention. There was a strong likelihood that all applications of HVLA would produce cavitation so it was necessary for the osteopath to limit the amplitude of the thrust in order to even up the groups. It is possible that this slight difference between the interventions was responsible for a small part of the discrepancy between the mean

asymmetry changes immediately post-manipulation. It is likely that the remainder of the discrepancy can be attributed to gas formation within the zygapophyseal joints of the AA joint. Participants were randomly allocated into intervention groups, however if the intervention they received did not match what they were allocated then they were changed into the appropriate intervention group.

Total cervical rotation asymmetry was used as the outcome measure in this study with asymmetries of 12° or less being excluded. Previous studies of a similar nature used AA joint rotation as their outcome measure with asymmetries of less than 8° being excluded.[9,10] They found a significant immediate improvement in right-left asymmetry following HVLA to the side of the restriction and away from the restriction in subjects with an 8° or greater asymmetry. There is a greater degree of rotation when using total cervical ROM as opposed to AA joint rotation therefore in this study an exclusion criterion of asymmetries greater than 12° measured over three weeks was used. In future studies on the importance of cavitation it would be useful to measure isolated AA joint ROM and total cervical rotation with an increase in the participant numbers.

Active ROM was chosen as the outcome variable rather than passive motion to remove researcher bias. This was in contrast to the studies that used passive ROM as their outcome measure.[9,10] Using active ROM did not account for participant bias however, and as the studied population is educated about the effect of HVLA there is the possibility of a Hawthorn Effect occurring. Defined, the Hawthorn Effect is where the participants or subjects in research projects, instead of acting naturally, try to please the researcher by giving them the results they are looking for.[36] This may have been a possible flaw of this

study as at post manipulation the participants may have altered their responses at a conscious or subconscious level and altered the accuracy of the measurements. We chose to manipulate away from the direction of restriction to negate the effect of participant bias.

Longer term effects on spinal ROM following HVLA thrust techniques have been observed.[37,38] In the present study there was no lasting effect on rotational ROM observed. The ROM changes had returned to normal in both intervention groups at 30 minutes post-manipulation.

CONCLUSION

The results of this study suggest that HVLA manipulation of the atlanto-axial joint with cavitation and directed away from the restriction produces a statistically significant ($p<0.05$) reduction in active cervical rotation asymmetry immediately post-manipulation. HVLA manipulation of the AA joint without cavitation under the same conditions did not produce a statistically significant reduction in active cervical rotational asymmetries. There was found to be no significant difference between the effects of the treatment groups on asymmetry alteration.

At 30 minutes post-manipulation the reductions in the asymmetries had approximately returned to their pre-manipulation levels and. Therefore, this study found there to be no lasting effect on the amelioration of rotational ROM asymmetries using HVLA manipulation with and without cavitation at the AA joint.

The findings of this study imply that HVLA manipulation with cavitation significantly reduces rotational ROM asymmetries immediately post-manipulation while HVLA manipulation without cavitation did not demonstrate a significant asymmetry alteration over time. There was however no significant difference found between the effects of both treatment groups. Caution should be exercised when extrapolating these results to the clinical setting. Further study is required in symptomatic populations and it would be useful to measure the alteration of pain using standardised outcome measures as cavitation may have an important effect on pain modulation as well as ROM alteration.

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