THE EFFECT OF HIGH-VELOCITY, LOW-AMPLITUDE MANIPULATION ON SUBOCCIPITAL TENDERNESS

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Masters Journal Article

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Abstract

Background and Objectives: High-velocity, low-amplitude (HVLA) manipulation is commonly advocated by manual therapists to relieve spinal pain and dysfunction. The aim of this controlled, single blinded study was to investigate whether HVLA manipulation of the occipito-atlantal (OA) joint had any lasting effect on pressure-pain thresholds (PPT) in the suboccipital musculature in an asymptomatic population.

Methods: Participants (N = 60, mean age = 23±5, 21 males & 39 females) were screened for suitability and PPT measurements were made using a hand-held electronic algometer which was positioned centrally in the suboccipital region. Participants were randomly allocated into two intervention groups and then received either HVLA thrusts to cavitate the right and left OA joints or a sham 'functional' technique, which served as a control treatment. Post-intervention PPT measurements were recorded at 5 and 30 minutes following the intervention.

Analysis: Analysis of the PPT data using a SPANOVA revealed a significant difference over time ($F_{2,116} = 3.915$, $P = 0.02$), but no difference between the groups ($P = 0.40$). Within-group changes were further analysed using paired t-tests and revealed significant changes in the HVLA group at 5 minutes ($P = <0.01$), but not in the control group ($P = 0.35$). A significant difference was not found following HVLA at 30 minutes ($P = 0.29$) or in the control group at the same interval ($P = 0.21$).

Conclusion: HVLA manipulation of the OA joint did not significantly change the PPT of the suboccipital muscles in asymptomatic participants. HVLA produced a greater mean increase in PPT and effect size compared to the control group over both time intervals, and therefore investigation of the effect of this technique with a symptomatic population is warranted.

Keywords: Manipulation, suboccipital, muscles, occipito-atlantal joint, algometry, osteopathic medicine.

INTRODUCTION

Osteopathy is a form of health care which involves manual treatment of the musculo-skeletal system to influence the inter-relationship between the bodies' structure and function. High velocity low amplitude (HVLA) manipulation is a manual technique advocated by osteopathic authors[1,2,3] to relieve spinal pain and dysfunction. This technique involves the application of a fast non-forceful thrust, which is often associated with an audible 'pop' or 'crack'.[1]

A small number of studies support the short-term hypoalgesic effects of HVLA manipulation. Terret et al[4] reported an immediate and statistically significant rise in cutaneous pain threshold following spinal manipulation, and noted distinct and progressive elevation in pain tolerance within two minutes, lasting at least ten minutes post-manipulation in comparison to the control group. Similarly, Vernon et al[5] found individuals suffering chronic neck pain who received HVLA manipulation experienced a significant rise (40-55%) in pressure pain thresholds (PPT) for all four points around the manipulated spinal segment, when compared to the lack of change in individuals who received a mobilisation treatment. However, because of the small sample size (n = 9), the findings of this study should be treated with caution.

It was reported in a study by Fryer et al[6] that both HVLA and mobilisation had a significant effect on perceived tenderness over the thoracic spine in a group of asymptomatic participants. However, HVLA was less effective for increasing the PPTs when compared with mobilization, because a significant difference existed between the mobilisation and the control group ($P = 0.01$), but not in the manipulation and control group ($P = 0.67$).[6] This conflicted with the findings of Cassidy et al who reported a single HVLA technique was significantly more effective in 85% of participants when compared to mobilisation (in the form of muscle energy technique) for treating neck pain.[7] In a recent systematic review, spinal manipulation has been recommended with some confidence to be a viable option for the treatment of both low back pain and neck pain.[8]

The mechanisms by which HVLA produces a hypoalgesic effect are largely speculative. Melzack and Wall[9] proposed the gate control theory, where large diameter myelinated neurons from mechanoreceptors possibly modulate and inhibit the smaller diameter nociceptive neuronal input at the spinal cord level. Joint manipulation would activate mechanoreceptor afferents and may therefore provide pain relief by activating this spinal gate control mechanism. According to Fryer[10] any technique that stimulates joint proprioceptors via the production of joint movement or the stretching of a joint capsule may be capable of inhibiting pain.

It has been speculated that HVLA may have a therapeutic effect by reducing zygapophyseal joint effusion and peri-articular oedema to improve the drainage of flow within a joint, or the stretching of zygapophyseal joint capsules to improve joint range of motion. Manipulation induced hypoalgesia and the improvement of proprioception and motor control may play a role in the short and long-term relief of patients.[10] These proposals, however, would not be relevant in hypoalgesia following HVLA in asymptomatic individuals.

The dorsal periaqueductal grey (dPAG) has been proposed in the descending control of nociception.[11] Manipulative techniques may provide an adequate stimulus to activate descending pain control systems projecting from the dPAG to the spinal cord. A strong correlation was reported between hypoalgesia and sympatho-excitation ($r = 0.82$) following spinal manipulation, suggesting the dPAG had been activated.[12] In addition, Sterling et al proposed that manipulation of the cervical spine had a hypoalgesic effect specific to mechanical nociception, an excitatory effect on sympathetic nervous system activity and also an effect on motor activity.[13] A central structure may be responsible for the initial effects of HVLA. Another study found that plasma ß-endorphins were released following spinal manipulation; heart rate, blood pressure and anxiety levels were monitored and controlled to establish that the release of endorphins was not stress induced.[14]

Pressure algometry is a method of quantifying soft tissue tenderness which has been proven to be very reliable.[15,16,17] The PPT is defined as the least stimulus intensity at which an individual perceives pain; it is the point where the sensation of pressure turns to one of pain.[15] Sterling et al[17] found that measurement of pain thresholds with an electronic algometer was reliable between weeks (1 week period) in both asymptomatic subjects and in subjects with chronic back pain. Nussbaum et al[16] recommended that the measurements be taken by one examiner, because this was more reliable than from multiple examiners.

Significant regional differences in spinal PPT values have been reported, where the PPT increases in a caudal direction. Cervical segments have been determined to be the most sensitive to pressure, followed by the thoracic region and the lumbar spine.[18,19] Vanderweeen et al[15] suggested this pattern might be due to the higher nociceptor density in the cervical spine. In the absence of unilateral pathology, the left and right sides of the body have been found to have highly correlating PPT values.[20]

The suboccipital region is the triangular area inferior to the occipital bone and includes the posterior aspects of C1 and C2 vertebrae and four small muscles: rectus capitis posterior major, rectus capitis posterior minor, obliquus capitis superior and obliquus capitis inferior. The suboccipital muscles have been suggested to act as a 'kinesiological monitor' for the sense of proprioception, as well as having an affect on movement of the head.[21] It has been proposed that these muscles are a causative factor in both cervicogenic neck pain and headache, and in addition may become atrophic further complicating the pain syndrome.[22,23,24,25] Research investigating the suboccipital region and what effects manual treatment may have on a potential problematic area is therefore warranted.

To date, no studies have examined the effect of HVLA manipulation on suboccipital tenderness. The little research into HVLA has focused on the mid to lower cervical spine, [5,7,13,25] with emphasis on different techniques to this area and what effects they have had on decreasing pain and increasing the range of motion. Authors who have conducted research into spinal manipulation have recommended investigating how long the changes in pain intensity last post-manipulation.[6,7,26] The aim of this study was to investigate whether HVLA manipulation of the occipito-atlantal joint has a lasting effect on PPTs in the suboccipital musculature within an asymptomatic population.

METHODS

Participants

60 participants (21 males, 39 females, mean age = 23 years ± 5) were recruited and randomly allocated into either the control group (n = 25) or the experimental group (n = 35). All participants were recruited from the student and teaching body at Victoria University and those who took part in the study were required to sign consent forms and provide information in a questionnaire regarding the presence of cervical spine problems and other recurrent health risks. Participants were excluded if they had received upper cervical spine manipulation in the previous three days, had any cervical spine pathology, were long-term cortico-steroid users, or had vertebro-basilar insufficiency, because this contraindicated the use of HVLA.[1] The Victoria University Human Research Ethics Committee granted ethics approval for the study.

Measures

Pressure Pain Thresholds: The PPTs were measured using a hand held electronic algometer (Somedic algometer II, Sweden) consisting of a pressure transducer and an output screen that measured and displayed the pressure and the rate of applied pressure. The algometer was calibrated before the testing began. Participants were requested to lie prone on a bench with their head in the face hole. The head end of the bench was angled approximately 30° towards the floor to expose the suboccipital region adequately and allow a researcher to palpate a tender point in the area between the occiput and the C2 spinous process. The measurement procedure was similar to that of Fryer et al[6], where the PPT was measured with the transducer of the algometer positioned centrally and at 90° to the site to be measured in the suboccipital region. Pressure was applied at 30 kPa/second. When the pressure being applied changed to a sensation of pain, the participants were instructed to press a button on an extended hand-held device linked to the algometer. As the button was depressed the on-screen counter froze and an audible beep alerted the researcher to arrest the force that was being applied. The reading (when the button was pressed) was displayed on the screen of the algometer and was recorded. Three readings of PPT were performed with a 20-second break between the individual readings. The mean was calculated to determine the PPT measurement. The PPT was recorded at three time intervals: an initial reading, at 5 minutes and at 30 minutes.

Figure 1. *Algometer*

Figure 2. *PPT Measurement*

Pilot Reliability: To assess the test-retest reliability of the examiner using the algometer, a pilot study was conducted prior to the main study. Three measurements of PPT were performed on 20 participants at the time intervals of interest (initial, 5 minutes and 30 minutes). The average measure intraclass correlation coefficient (ICC) was 0.96, indicating high reliability for the PPT measurement. The initial – 5 minute mean difference was 7 kPa (SD = 43 kPa) and the initial – 30 minute mean difference was 11 kPa (SD = 52 kPa). The error range of the measurement procedure to be considered was 50 kPa at 5 minutes and 63 kPa at the 30 minute interval.

Intervention

The treatment group received two HVLA thrusts to the right and left occipito-atlantal joints (C0/1).[1] The participant lay supine on a bench and a registered osteopath contacted the posterior aspect of the occiput or the posterior arch of the atlas, positioned the head and neck using a small amount of rotation and side-bending leverage, and a thrust was delivered to the joint, as described by Gibbons & Tehan.[1]

A modified sham "functional technique" was utilised as a control treatment. Pain thresholds may be influenced by the expectation of a treatment effect and so the sham treatment was designed to control for the placebo effect. Participants were informed that they were to be treated with an osteopathic functional technique which involved subtle positioning of the upper neck and this was held for 30 seconds, but no 'position of ease'[2] or barrier was engaged, in order to keep the technique inert.

Figure 3. *Experimental Technique (HVLA)*

Procedure

Three researchers were involved in the study: Researcher 1 explained the testing procedure and recorded PPTs, Researcher 2 used the algometer to measure the PPTs, and Researcher 3 (a registered osteopath) performed the treatment. Researchers 1 and 2 were blinded to the group allocation of participants during the testing procedure.

Three measurements of PPT were recorded initially and used as the pre-intervention PPT. The participants were directed to another room where they were randomly allocated into the treatment or control group via a lottery draw procedure. After receiving the allocated treatment intervention, the participants were asked to return to the original testing room and the PPT measurements were recorded again. The participants were asked to return to the room in 30 minutes for a third measurement of PPT.

Statistical Analysis

All data was analysed using the statistical package SPSS Version 11. The pre-, post-5 and post-30 mean PPT measurements were analysed for differences over time and between groups with a SPANOVA. Paired t-tests were used for further analysis of within group changes. The effect size (Cohen's d) was calculated for each pair and can be interpreted as small (d = 0.2), medium (d = 0.5) or large (d = 0.8).[27] Statistical significance was set at alpha 0.05.

RESULTS

Analysis with SPANOVA revealed a significant difference over time ($F_{2,116}$ = 3.92, *P* = 0.02), but not between groups ($F_{2,116}$ = 0.95, *P* = 0.40). The partial eta squared value for the between groups was small (R^2 = <0.01).

Mean PPT values are shown in Table 1. The greatest mean differences occurred between the initial and 5 minute interval for the HVLA group (39.37 kPa). Further analysis using paired t-tests found that the PPT improvement was significant in the HVLA group at 5 minutes (*P* = <0.01) with a medium effect size (d = 0.52). A small increase was detected in the control group between the initial and 5 minute measurements (15.88 kPa), however, no significant difference was found between the control group values over this time (*P* = 0.35) and only a small effect size was noted (d = 0.19).

A significant difference was not found in the HVLA group between the initial and 30 minute interval (*P* = 0.29), only a slight improvement in the mean difference (15.89 kPa) and a small effect size (d = 0.18) were found. There was a similar change in the control group at the same interval (16.12 kPa & *P* = 0.21), and the effect size in the control was also small (d = 0.26).

When analysed with a paired t-test, the within-group changes between the post-HVLA group at 5 minutes and the post HVLA group at 30 minutes was significant (*P* = 0.03), with the mean PPT value decreasing (23.49kPa). The effect size was slightly below medium(d = 0.40). Conversely, the mean difference at this interval for the control group was minimal (0.24 kPa), there was no significant difference (*P* = 0.99) and a small effect size was calculated (d = <0.01).

Table 1. *Mean (SD) PPT values (kPa).*

	Pre	Post – 5 minutes	Post – 30 minutes
HVLA	358.69 (132.12)	398.06 (133.51)	374.58 (127.50)
Control	352.56 (155.76)	368.44 (208.16)	368.68 (192.62)

Table 2. *Mean differences (SD), P values (t-tests) and effect sizes (Cohen's d).*

	Mean Differences (SD)	*P*	Effect Size (d)
preHVLA - HVLA-5	-39.37 (76.07)	0.01*	0.52
preHVLA - HVLA-30	-15.89 (87.50)	0.29	0.18
HVLA-5 - HVLA-30	23.49 (59.26)	0.03*	0.40
preControl - Control-5	-15.88 (83.62)	0.35	0.19
preControl - Control-30	-16.12 (62.49)	0.21	0.26
Control-5 - Control-30	-0.24 (81.55)	0.99	<0.01

* Significant at $P \leq 0.05$

DISCUSSION

Upper cervical manipulation of the occipito-atlantal joint is a commonly advocated technique in the osteopathic field.[1,2,3] In the present study, no significant difference was calculated between the intervention groups when analysed using a SPANOVA ($P = 0.40$) and the partial eta squared value was not significant ($P = 0.73$). A relatively large mean PPT increase following the HVLA intervention at 5 minutes was noted (39.37 kPa), but this was within the error range established in the pilot study. Paired t-tests revealed that the increase was significant at 5 minutes within the treatment group ($P = 0.01$), but not in the in the control group ($P = 0.35$). A medium effect size was calculated (d = 0.52) for the treatment group at this interval. Despite the significant t-test, it cannot be claimed that HVLA manipulation had an immediate hypoalgesic effect on suboccipital tenderness due to the results of the more robust SPANOVA and the PPT increase being between the error range of the equipment. The finding of a large mean PPT increase in the HVLA group, the results of the t-test and the medium effect size all suggest that HVLA might have an effect and this may be greater in a symptomatic population.

At the 30 minute retest, the PPT was not significantly different from the initial measure (P = 0.29). The large standard deviation may be a contributing factor as to why a significant difference was not found at 30 minutes when compared to the baseline (SD ±87.5). Therefore, the study failed to demonstrate that HVLA had any lasting effect on suboccipital tenderness.

The results from the present study differ from previous research conducted by Fryer et al[6] which found that HVLA had a significant improvement on perceived tenderness in the thoracic spine of asymptomatic participants. Other studies have reported improvements in PPT following mid to lower cervical spine manipulation in a symptomatic population.[5,7] The results of the present study have some similarity to that of Terret et al[4] who observed a progressive elevation in pain tolerance following thoracic spinal manipulation noting a distinct increase at two minutes which lasted for at least ten minutes post-manipulation. In the present study, a 'peak' cannot be identified because PPT measurements were only recorded at 5 and 30 minutes post-manipulation.

A significant difference was found between the post-HVLA PPT values at 5 minutes and at 30 minutes (P = 0.03), when analysed with t-tests. A decrease in the mean PPT scores occurred from 5 minutes to 30 minutes (398.06 to 374.58 kPa), suggesting that the PPT resets back to 'normal' in time. No differences existed within the control groups at the time intervals tested and this may indicate that any benefit from HVLA was short lived.

All of the participants had some degree of osteopathic education and may have been aware of the sham nature of the control group. The control treatment was a modified functional technique where no motion barriers were engaged, and, given the leverages are normally very subtle it is unlikely that participants would have been aware of the sham. The small mean changes of the control groups (15.88, 16.12, and 0.24 kPa respectively) and the respective small effect sizes suggest a placebo effect was unlikely.

The pilot study demonstrated that the PPT measurement procedure appeared to be highly reliable (ICC = 0.96) which was similar to a previous study that used the same algometer (ICC = 0.93).[6] However, there were some large variations between the PPT measurements and this resulted in relatively large standard deviations and error range. Reliability was improved in an earlier study when the first of the three measurements was excluded for estimating the average PPT.[16] There was little change in mean differences when the first value was removed to improve reliability and therefore was not employed in the present study.

Pain is a subjective experience and therefore difficult to measure. Studies which assessed pain using PPT have reported large amounts of variability in the measurements (SD between 95.22 kPa – 150 kPa).[6,18] The participants in this study had nine measurements (3 readings on 3 occasions) of PPT in the same location of their suboccipital region. Rest periods of 20 seconds occurred between each PPT reading to prevent irritation of the 'tender spot'. One study demonstrated that changes in PPT sensitivity do not occur following repeated application of an algometer,[16] however, this may have been dependant upon the length of the rest period. The 20-second break in this study had a small but insignificant effect on subsequent PPT recordings, with the general trend being a decrease in PPT readings 1 to 3.

The rectus capitis posterior minor (RCPM) has been found to be continuous with the posterior atlanto-occipital membrane which is intimately related to the dura mater.[22,24] This relationship is important as the RCPM prevents crimping of the dura and impingement of the spinal cord at the occipito-atlantal junction when the head is extended. Chronic postural stress has been proposed to cause hypertonicity of the suboccipital musculature, leading to tension being transmitted to the pain sensitive dura resulting in chronic headaches.[22,24] It has also been suggested that chronic neck pain may cause RCPM atrophy, where muscle is replaced with fatty tissue, causing a reduction in the proprioceptive input to the dorsal horn of the spinal cord, facilitating impulses from nociceptors that may further develop a chronic pain syndrome.[28]

The suboccipital muscles are supplied by the dorsal ramus of C1 (suboccipital nerve) and structures innervated by C1-C3 are capable of producing cervicogenic head pain.[23] Cervicogenic headaches account for approximately 15% – 20% of all recurrent benign headaches.[23] Nilsson et al[25] reported that HVLA had a significantly positive effect on the number of headache hours per day (which decreased by 69%), the use of analgesics (decreased by 36%) and the headache intensity per episode (decreased by 36%).

Caution needs to be exercised when generalising the results of this study to a symptomatic population. The changes in PPT would possibly be more dramatic or longer lasting in individuals with neck pain, and a symptomatic population should be examined using the methods of the present study to determine this.

The present study measured suboccipital PPTs initially, at 5 minutes and at 30 minutes only. Future studies could investigate the effects of HVLA manipulation to the upper cervical spine over a greater length of time (e.g. hours or days) to explore what degree the PPT changes and the rate in which it does so. No studies have examined the cumulative effects of several manipulations to determine if there is a dose-dependent relationship. Similarly, research into other osteopathic techniques, such as counterstrain, articulation, functional and cranial techniques may establish the most efficacious prescription for treating suboccipital tenderness.

CONCLUSION

This is the first study to examine the effect of HVLA techniques to the occipito-atlantal joint on suboccipital tenderness. HVLA did not significantly increase suboccipital PPT in an asymptomatic population. Greater increases in PPT following HVLA manipulation, significant within-group changes and small to medium effect sizes over both time intervals compared to the control group suggest that HVLA may be an effective technique in a symptomatic population, and further studies are recommended to investigate this.

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