The Effect of Manipulation and Mobilisation on Pressure Pain Thresholds in the Thoracic Spine

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ABSTRACT

High velocity low amplitude (HVLA) thrust manipulation and mobilisation are commonly used by manual therapists to relieve spinal pain and improve mobility. The aim of this controlled, single blinded study was to investigate the effect of manipulation and mobilisation on pressure-pain thresholds (PPT) in the thoracic spine in an asymptomatic population. Subjects (N=96) were screened for tender thoracic segments, and PPT measurements were made using an electronic pressure algometer immediately before and after treatment intervention. Subjects were randomly allocated into three intervention groups, and received either a single high velocity extension thrust, thirty seconds of extension mobilisation, or thirty seconds of sham treatment (control) consisting of 'laser acupuncture'. Within-group pre and post-intervention PPT values were analysed using dependent t-tests, revealing significant changes in the mobilisation ($p<0.01$) and manipulation ($p=0.04$) groups, but not the sham treatment group ($p=0.88$). Analysis of mean group changes with a one-way ANOVA and post-hoc analysis revealed a significant difference between the mobilisation and control group ($p=0.01$), but no significant difference between the manipulation and control group ($p=0.67$). Pre-post effect sizes in the mobilisation group were medium to large (d=0.72), small to medium for manipulation (d=0.32), and small in the control group (d=0.02). Both manipulation and mobilisation produced significantly increased PPTs (decreased sensitivity to pressure) in the thoracic spine, whereas the sham treatment did not. Mobilisation appeared to be more effective than manipulation for increasing PPTs when applied to the thoracic spine in asymptomatic subjects.

Keywords: Manipulation, mobilisation, pain, algometry, osteopathy

INTRODUCTION

Manipulation and mobilisation are two manual techniques that are commonly used by osteopaths, chiropractors and physiotherapists to treat spinal pain and dysfunction. Mobilisation (or “articulation”, as it is know in osteopathy) involves passive rhythmic and repetitive movements within a range of motion or against a restrictive barrier. It is an extension of passive motion testing and can be applied to a single articulation or a group of spinal segments. It is a gentle technique where the force and amplitude can be controlled depending on the response of the tissues and the severity of the condition being treated.[1-3]

High velocity, low amplitude (HVLA) thrust manipulation (known also as mobilisation with impulse, and grade V mobilisation) involves a small amplitude thrust to produce joint cavitation, and is often accompanied by an audible ‘cracking’ sound.[1, 2, 4] Brodeur[5] suggested that the audible release is produced by the sudden ‘snap back’ of the synovial capsule, in association with formation of a gas bubble within the joint.

Spinal manipulation and mobilisation have been proposed to have a number of therapeutic benefits, including the stretching of shortened and thickened peri-articular soft tissues to improve range of motion, improved drainage of fluid within and surrounding the joint, and changes in pain modulation, motor activity and proprioception.[1, 6]

Pain is the perception of an adverse or unpleasant sensation. A variety of nociceptors may be activated by noxious chemical, thermal, or mechanical stimuli, and convey information to the dorsal horn of the spinal cord, which after processing may ascend via spinal tracts to higher centres within the brain. Pain may be generated primarily by activation of these peripheral tissue receptors, or from the central nervous system (central sensitisation) as appears to occur in many chronic pain sufferers.[7, 8]

The exact mechanism of pain relief from manipulation is unclear, but it has been suggested that pain is modulated at either the spinal cord or in the higher centers of the central nervous system.[8, 9] Manipulation has been suggested to affect pain processing at the spinal cord level via a phenomenon known as the gate control theory, which was first described by Melzack and Wall in 1965.[10] They proposed that large diameter myelinated neurons from mechanoreceptors would modulate and inhibit the incoming nociceptive information. Passive joint mobilisation and manipulation would activate mechanoreceptors and may therefore providing pain relief by activating this spinal gate control mechanism. [10]

Descending inhibition of pain from higher centres in the CNS may also play a role in manipulation-induced hypo-algesia. These descending pain modulatory pathways are activated by a number of endogenous opioid peptides, such as enkephalins, endorphins and dynorphins.[7] In 1986, Vernon *et al.*[11] found that serum beta-endorphin levels significantly increased following a single manipulation compared with sham treatment and a control group. However, a later and larger study produced conflicting results, finding that manipulation had no effect on beta-endorphin levels in blood samples taken 5 minutes and 30 minutes post-manipulation.[12]

The dorsal periaqueductal grey region (dPAG) of the brain has been suggested to be involved in manipulation-induced hypo-algesia. Stimulation of the dPAG produces a profound and selective analgesia,[7] and it has been implicated that spinal manipulative therapy may exert its initial effects by activating this region.[9, 13]

The majority of clinical trials that have investigated the effects of manipulation on spinal pain have focussed on the cervical and lumbar spine.[14-17] A number of studies have reported cervical manipulation to be effective for pain relief,[14-16] with one study finding pain reduction in as many as 85% of subjects.[15] An extensive systematic review of randomised clinical trials investigating lumbar manipulation and pain concluded that manipulation may be effective in some subgroups of patients with low back pain, and recommended additional research on the topic.[17] Manipulation of the spine has also compared favourably with other interventions. Cassidy *et al.*[15] found manipulation to be more effective than muscle energy technique for pain relief in the cervical spine, while other studies have reported between 40-55% improvement in pain following manipulation when compared with mobilisation.[18, 19]

In the thoracic spine, both Terret and Vernon[20] and Schiller[21] recorded manipulation–induced effects on pain. Using an electrical pain inducer, Terret and Vernon demonstrated an immediate increase in pain threshold in myofascial tissue following thoracic manipulation. They found a marked increase in pain tolerance in the manipulated group within 30 seconds, which was maintained in measurements taken at 2 minutes, 5 minutes and 10 minutes post-manipulation. At 10 minutes post manipulation, the manipulated group showed a statistically significant elevation of pain tolerance (140%) when compared with the control group.[20] Schiller reported a lasting increase in pain threshold after a six-week treatment period of manipulation or nonfunctioning ultrasound. There was no significant improvement in objective pain measurements in those receiving placebo treatment, whereas subjects receiving the manipulation showed a significant improvement between the first and final treatment. This improvement was maintained in a one-month follow up.[21]

Similarly, a few researchers have investigated the effects of mobilisation on pain levels,[13, 22, 23] although no study has yet investigated this in the thoracic spine. Clinical trials by Sterling *et al.*[23] and Wright and Vicenzino[13] have demonstrated increases in pain thresholds in symptomatic and asymptomatic subjects respectively following posterior-anterior mobilisation applied to the cervical spine. Sterling reported an increase in pain measures in the order of 23% while Wright and Vicenzino reported an increase in pain measures ranging from 15% to 25%. Vicenzino *et al.* [22] also discovered increases in pain thresholds occurring at sites remote from the application of mobilisation. They found mobilisation at the level of C5/6 in subjects with lateral epicondylitis produced a resultant increase in pressure pain thresholds of up 25% at the head of the radius.

Similar results were found following mobilisation of the lumbar spine. Goodsell[24] observed an improvement in pain levels following posterior-anterior mobilisation applied at a spinal level for three one-minute repetitions on symptomatic subjects. However, the treatment did fail to produce any objective measurable change in the mechanical behavior of the lumbar spine (posterior-anterior response and range of movement) and the authors suggested that improvement in pain levels may have been due to a placebo effect.

Although the experience of pain is entirely subjective, there are a number of methods to measure and monitor it. Self reported pain using visual analogue scales, and pain and disability questionnaires such as the McGill and Oswestry are commonly used research tools that have proven reliability.[25-27] Another form of pain measurement is pressure algometry. The algometer is a calibrated pressure gauge that quantifies pain by assessing the pressure-pain threshold (PPT) in an individual. PPT can be defined as the minimum force that induces pain or discomfort in an individual. The use and reliability of pressure gauges to determine PPTs on bony and muscle landmarks have been well established.[28-31]

Algometric measurement has been used to establish normal PPT values by measuring values in asymptomatic subjects. [31-33] In the thoracic spine, T4 has been shown to have a normal mean PPT of 324 kPa/cm^2, and T6 a normal mean PPT of 302 kPa/cm^2.[32] Although no significant difference was found within the thoracic spine (P=0.184), Keating *et al.*[32] has demonstrated a normal regional variance within the spine with PPT increasing in a caudad direction from cervical, to thoracic, to lumbar spinous processes. Fischer[33] and Hogeweg *et al*.[28] have shown that left and right sides of the body have highly correlating PPT values. Hogeweg *et al*.[28] has suggested that in the case of unilateral pathology, comparison with the non-affected side can be used to determine the severity, while Fischer[33] also suggested that normal PPT values could aid with diagnosis.

Few researchers have examined the effect of manipulation or mobilisation on the thoracic spine or thoracic pain, and none have compared the two manual techniques in this region. This study aimed to investigate and compare the effect of manipulation and mobilisation on PPT in the thoracic spine in an asymptomatic population

METHOD

Subjects

Ninety-six (96) asymptomatic volunteers (39 male, 57 female, aged 19-34) were recruited for this study from a student population after completing a consent form and a questionnaire to exclude thoracic pathology. Testing was performed in the Victoria University Osteopathy Clinic. The Victoria University Human Research Ethics Committee granted ethics approval for the study.

Volunteers were excluded from this study if they were suffering from a spinal condition or pathology, if they were a long-term cortico-steroid user, or if their spine had been treated with manipulation or mobilisation in the previous three days.

Measurement of pressure pain thresholds

Pressure-pain threshold (PPT) was measured using a hand held electronic pressure algometer (Somedic Algometer Type 2, Sweden) (Figure 1). The electronic algometer used in the present study has been shown to have excellent reproducibility for recording PPTs over thoracic spinous processes (ICC=O.93 at T4 level, ICC=0.90 at T6 level).[32] The algometer consisted of a plastic handle with a built-in pressure transducer and an LCD display showing pressure and slope (the rate of applied pressure). The algometer was calibrated before testing began, and a

2cm rubber tip was used because the researcher using the algometer found this was easier to stabilise on the thoracic spinous processes, and was therefore more reliable.

The methodology for the measurement of PPTs was similar to that used by Keating *et al.*[32] With the participant lying prone on the plinth, the algometer was positioned perpendicular to the spinous process of the marked vertebrae. Pressure with the algometer was then applied at a steady and consistent rate of 30 kPa/second. A visual indicator on the algometer enabled the force to be applied at a reasonably accurate rate. Subjects were instructed to say 'now' as soon as they felt the sensation of pressure change to one of pain. The downward force was then immediately ceased, and the maximal pressure applied (ie. the PPT) was then recorded (Figure 2). Three PPT measurements were taken, with a break of 20 seconds between each one, and the average of the three readings was calculated as the PPT for that participant. Studies have previously demonstrated that repeated application of the algometer does not result in a change in sensitivity.[30]

Figure 1. The algometer

Figure 2. PPT measurement

Procedure

Subjects undressed to expose their thoracic spines, and were offered open-backed gowns. Three researchers were involved in this study: Researcher 1 identified the most-tender thoracic vertebra by twice springing on each thoracic vertebra, and marked the spinous process of this level with a skin pencil. Researcher 2 measured the PPT of this level, and Researcher 3 (a registered osteopath) applied all the interventions. Researchers 1 and 2 were blinded to the group allocation of all subjects. Subjects were randomly allocated (by lottery draw) into three intervention groups: manipulation (n=32), mobilisation (n=32) or non-operational laser acupuncture (n=32), which acted as the control group.

Subjects were directed to another room, where they received their intervention treatment from Researcher 3. Immediately following treatment, subjects returned to the measurement room, and were re-measured by Researcher 2, who was blinded to their treatment intervention.

Treatment intervention

Manipulation

Those in the HVLA manipulation group were instructed to sit on the plinth and cross their arms across their chest. Standing behind the participant, and using a small towel as a fulcrum, the researcher delivered an extension thrust to the marked thoracic level (Figure 3). If an upper thoracic segment (ie. T1-T4) was marked, the technique was modified by using a padded knee contact (see Figure 4). Although the technique was directed at the indicated level, it cannot be certain whether the joint cavitation occurred at this or adjacent levels. These manipulative techniques have been described in osteopathic technique texts.[4, 34]

Figure 3. Thoracic manipulation for mid and lower levels

Figure 4. Thoracic manipulation for upper levels

Mobilisation

Subjects in the mobilisation group were treated with a seated extension mobilisation (articulation) technique as described by Tucker and Deoora.[3] Subjects were positioned seated on a treatment bench facing the practitioner, who contacted the marked vertebra and repeatedly applied an extension articulation for thirty seconds (Figure 5). This technique was modified slightly if the marked level was in the upper thoracic region (Figure 6).

Figure 5: Mobilisation of the middle and lower thoracic spine.

Figure 6: Mobilisation of the upper thoracic spine.

"Sham" laser treatment (control)

Because participant expectation could potentially influence pain perception, it was decided that a 'sham' treatment was preferable to a no-intervention control group, because this may produce a similar expectation bias as the other treatment groups. Sham treatment consisted of 30 seconds of 'laser acupuncture' to the marked thoracic region using a laser pointer (Laserex LP2000). All subjects in this group were informed that laser acupuncture is practised widely by acupuncturists, and were shown the laser being applied to their forearm. Before starting they were told that they should feel no sensation, and if they did they were to inform the researcher and the intervention would stop. This was done to reinforce the impression that laser acupuncture was a genuine therapeutic technique. The laser was turned off throughout the whole treatment.

Statistical Methods

All data was collated and analysed using the statistical package SPSS Version 10. To assess the reliability of the PPT measurement procedure, the Intraclass Correlation Coefficient (ICC, based on a one-way ANOVA) was calculated for the three PPT recordings taken in all subjects. Pre- and post-intervention PPT measurements were analysed for the three intervention groups using paired t-tests, and the pre-post effect sizes (Cohen's *d*) calculated. A one-way ANOVA was then conducted to determine if differences existed between the changes produced by the three interventions. Statistical significance was set at the alpha 0.05 level.

RESULTS

Audible joint cavitation was noted for all but one subject during the administration of HVLA manipulation, although it cannot be certain at what level the cavitation occurred, or if only the joints of one level cavitated. The Average Measure ICC for algometer PPT readings 1, 2 and 3 was 0.93 (95 % C.I.: 0.91 – 0.95; $F = 14.28$, $p < 0.01$), which indicated a high reliability for the three readings.

Statistical comparison of pre- and post-intervention PPT scores using a two-tailed t-test showed there to be a large improvement in the group receiving mobilisation (28.42 kPa), a smaller improvement in the group receiving manipulation (11.88 kPa), and virtually no difference in the group receiving laser acupuncture (0.94 kPa). The PPT improvement shown in the mobilisation and manipulation groups were both significant ($p<0.01$ for mobilisation, $p=0.04$ for manipulation), whereas the small improvement shown in the laser acupuncture group was not significant ($p=0.88$). Effect sizes where calculated using Cohen's *d* and can be interpreted as small ($d=0.2$), medium ($d=0.5$) or large ($d=0.8$).[35] Pre-post effect sizes in the mobilisation group were medium to large ($d=0.72$), small to medium for manipulation ($d=0.32$), and small in the control group ($d=0.02$). These results are outlined in Table 1.

A one-way ANOVA found there to be a statistically significant difference between the intervention groups (see Table 2). Post-hoc testing (Bonferroni) showed the difference to be between the laser and mobilisation groups ($p=0.01$). No significant difference was seen between either the laser and manipulation groups ($p=0.67$), or the manipulation and mobilisation groups ($p=0.20$) (Table 3).

Table 1. Within-group differences (pre-post intervention) in PPT (kPa) scores (paired t-test) and effect sizes (Cohen's *d*)

	Laser Acupuncture	Manipulation	Mobilisation
Pre-intervention	243.70 (95.22)	204.64 (85.52)	218.71 (82.91)
Post-intervention	244.64 (91.59)	216.51 (90.50)	247.13 (96.87)
Difference	0.94 (35.07)	11.88 (31.83)	28.42 (39.68)
P value	0.88	0.04*	0.00*
Effect size (*d*)	0.03	0.35	0.72

* indicates statistical significance ($p<0.05$) (SD)

Table 2. One-way ANOVA: mean differences between groups

	df	F	Sig.
Between Groups	2	4.81	0.01

Table 3: One-way ANOVA: Bonferroni Post-hoc analysis

		Mean difference	Sig.
Mobilisation	Manipulation	16.54	0.20

	Control	27.48	0.01*
Manipulation	Control	10.94	0.67

* indicates statistical significance (p<0.05)

DISCUSSION

Manipulation and mobilisation are popular manual techniques in osteopathy, physiotherapy and other manual therapy disciplines. Despite their wide use, however, there remains a lack of convincing evidence of their therapeutic action and efficacy. Previous studies have shown that they can have a positive effect on pain in the cervical and lumbar spine, [13-17, 22, 23] but there is limited evidence in the thoracic region. This study indicated that, in the thoracic spine, manipulation and mobilisation do have an effect on perceived tenderness. Analysis with dependent t-tests demonstrated that pre-post changes were significant for both mobilisation and manipulation (p<0.01 and p=0.04, respectively), but not for the sham laser group (p= 0.88).

Mobilisation appeared to be more effective for pain threshold reduction, producing greater immediate improvement in PPT (a mean increase of 28.42 kPa, compared to 11.99kPa), a medium to large effect size (d=0.72) compared to a small to medium effect for manipulation (d=0.32), and the mean change was significantly different from the control group (p=0.01), whereas manipulation (p=0.67) was not. Analysis with ANOVA and post-hoc testing, however, failed to show a significant difference between the outcomes in these two treatment groups.

A pre-post difference in PPT was not evident in the control group, with the laser acupuncture producing a mean increase of only 0.93 kPa. This lack of treatment effect was expected, as the laser was turned off and there was no therapeutic benefit being applied. The very slight increase in PPT that was seen could possibly be attributed to placebo effect, however it was small and insignificant.

The results of this study support other studies that have demonstrated an immediate hypo-algesic effect of mobilisation[13, 22, 23] and manipulation[14-16] in the cervical spine, and manipulation in the thoracic spine.[20, 21] The results, however, are in contrast with the findings of Cassidy *et al.*[15] who reported that manipulation was more effective than mobilisation (which was muscle energy technique) for reducing pain in patients with neck pain.

The pre-intervention mean thoracic PPTs in the sham control, manipulation and mobilisation groups (243.7kPa/cm^2, 204.64kPa/cm^2, and 218.71kPa/cm^2 respectively) were lower than the normal values of 324 kPa/cm^2 (at T4 level) and 302 kPa/cm^2 (at T6 level) reported by Keating *et al.*[32] A plausible explanation for this difference is that although both studies were based on an asymptomatic population, Keating *et al.*[32] examined a pre-determined level, whereas the most tender thoracic spinal segment was selected and measured in the present study.

The algometer used in this study was one of the most reliable of its type: it was electronic, the rate of pressure applied was easy to control, and its reproducibility and reliability have been proven.[32] The PPT procedure also appeared highly reliable (ICC=0.93). Despite this, some large variations between the three PPT readings were found in some subjects in either the pre or post-intervention measurements, and some subjects experienced large or small changes, evidenced by the large standard deviations. The standard deviations, however, were actually lower than those found in the repeatability study performed as part of the Keating *et al.* [32] study (standard deviation of 141 at T4 level, standard deviation of 147 at T6 level), where the algometer readings were still found to be highly reliable. Pain is a subjective experience, and the perception of it differs widely from person to person. It is therefore likely that most studies assessing pain with an algometer will produce a large amount of variability.

Although the authors felt that most of the subjects believed laser acupuncture to be a genuine form of treatment, it cannot be certain how effective the laser was as a sham. Perception of pain could have been influenced if subjects thought that laser acupuncture was not genuine, and no follow up study was performed to see how many subjects were naïve to the sham. Subjects in this study were from a student osteopath population, and therefore had a certain amount of medical knowledge. It was quite possible that they would have been less naïve than the general population, and developing an adequate sham treatment for this population was a challenge. Despite this, a small mean increase in PPT was found for the sham control group, suggesting a modest placebo effect.

The current study only examined the immediate effect of manual intervention on PPT levels in the thoracic spine. It would be of interest to investigate the lasting effects of manipulation and mobilisation with a longer period of follow-up. Future studies could also examine and compare the effects of other manual treatments – such as muscle energy technique, counterstrain, and functional technique – on PPT levels on the thoracic spine, as well as the cervical and lumbar regions.

It is possible that manual techniques may have a more dramatic and long-lasting effect on a painful joint or spinal region. In the current study, subjects were asymptomatic, but an attempt was made to identify and examine the segment that was most tender to palpation. The natural extension of this research would be to examine the effects of manual intervention on PPT levels in symptomatic patients. Different manual techniques – in isolation or in combination – could be examined to determine the most efficacious techniques or approaches for reducing spinal pain and tenderness.

CONCLUSION

Mobilisation and manipulation both produced a statistically significant increase in PPT in the thoracic spines of asymptomatic subjects. This compared with the control group, which had almost no change in PPT. Mobilisation appeared to be more effective for pain reduction, producing greater immediate improvement in PPT levels, a medium to large effect size compared to a small to medium effect for manipulation, and a mean change which was significantly different from the control group, whereas manipulation was not. Future research is recommended to examine the lasting effect of manual techniques on PPT levels, comparing the efficacy of different techniques, and examining the hypo-algesic effects of these techniques in symptomatic patients.

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