The effect of Manipulation on pressure pain thresholds in the lumbar spine in asymptomatic participants

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ABSTRACT

Background and Objectives: High-velocity, low-amplitude manipulation is commonly advocated by manual therapists for the treatment of low back pain (LBP), however there is little evidence to support its efficacy. This study examined the immediate effects of a single manipulation intervention on pressure pain thresholds (PPT) in the lumbar spine in an asymptomatic population.

Methods: Sixty-four asymptomatic participants (45 female (Age 22.7±4), 19 male (Age 22.3±3.9); aged 18-39) were recruited from an osteopathic student population. Participants were screened by palpation for the lumbar spinous process most sensitive to manual pressure, which was marked with a skin pencil. Three pre-intervention PPT measurements were recorded at the marked lumbar segment using a pressure algometer. Participants were randomly allocated into either a treatment group or a sham treatment control. The treatment group received a single application of high-velocity low-amplitude (HVLA) manipulation. A post intervention PPT measurement was recorded immediately following the treatment.

Analysis: A small mean increase in PPT (14.08 ±47.10 kPa/cm^2) was demonstrated in the manipulation group. A dependent *t*-test revealed this change to be not significant (t=1.74 P=0.09), and a small pre-post effect size (d=0.29) was determined. The sham treatment group mean PPT decreased significantly (-17.15 ±45.02 kPa/cm^2, t=2.08, P=0.045) and produced a medium effect size (d=0.38). An independent *t* test revealed a significant difference between the changes in the control and manipulation group (t=0.009, P>0.05), with a mean difference of 31.24±11.55 kPa. All pre-post changes were found to be within the error range of the testing procedure. The error range was −38.38 to 50.04 kPa.

Conclusion: Manipulation of the lumbar spine in asymptomatic participants did not produce a statistically significant change in PPT. Research using symptomatic subjects is recommended for future studies.

Key words: manipulation, algometry, lumbar spine, osteopathic medicine

INTRODUCTION

Low back pain (LBP) is a prevalent and disabling disorder in western society[1]. Spinal manipulation is commonly advocated for its treatment, by researchers, authors[2,3] and professional associations[4,5]. In the osteopathic profession, manipulation refers to a low-amplitude, manipulative thrust technique performed with high-velocity (HVLA). The mechanisms underlying the therapeutic benefits of spinal manipulation are poorly understood[6], but some authors[2,7] have proposed that manipulation improves joint range of motion[7], induces a reflex relaxation of muscles[2,7] and reduces pain[8].

Investigation into the effects of spinal manipulation on pain reduction is continuing and one particular method of measuring pain is pressure algometry[9-12]. Pressure algometry involves the use of a calibrated pressure gauge (the algometer) to measure the least stimulus intensity (pressure) at which a participant perceives pain; this is known as the pressure pain threshold (PPT)[9]. PPT values of individual muscles and bony landmarks have been used to assess the effect of therapeutic techniques[10,11], and their use as outcome measures[12] in asymptomatic subjects. Algometry has been found to be reliable in asymptomatic participants when the site to be measured was marked, flat, bony and broad, such as the lumbar spinous process[10,13]. Furthermore, the reliability was improved when one practitioner performed the testing and pressure was applied at a gradual speed and a constant rate (*i.e.* 1kg of pressure applied for every second)[14].

Normative PPT values have been reported for spinal regions in asymptomatic participants[10]. Regional differences were reported, with spinal PPT values increasing in a caudal direction. In

the lumbar spine, L4 was shown to have a mean PPT value of 445 kPa/cm^2, in the thoracic 302-324k Pa/cm^2 and the cervical, 255kPa/cm^2. These authors found good reproducibility (ICC>0.75) using pressure algometry at the level of L4. However, excellent reliability was reported in the cervical (ICC>0.93) and thoracic regions (ICC>0.9-0.93).

Fryer *et al.*[15] investigated the efficacy of thoracic manipulation and mobilisation to reduce PPTs in asymptomatic participants. Ninety-six participants were examined using manual palpation to locate and mark the thoracic segment most sensitive to manual pressure. The PPT value was measured and the subjects randomly assigned to either an intervention (manipulation or mobilisation) or sham control (non-functioning laser) group. The intervention group were administered either a 30 second extension mobilisation or a high velocity extension thrust technique to the thoracic spine. Manipulation (P=0.04) and mobilisation (P<0.01) both produced an immediate significant increase in PPT, whereas the sham control group that did not (P=0.88). These researchers recommended investigation of the hypoalgesic effect of manual techniques in the lumbar and cervical regions.

Manipulation is claimed to have positive effects on spinal pain[2,7,8,16], and there is limited evidence that manipulation may lower PPTs in the thoracic spine of asymptomatic participants[15]. There has been no investigation of these effects following manipulation of the lumbar spine in asymptomatic participants. This study aimed to investigate the immediate effect of lumbar manipulation on lumbar pressure-pain thresholds in asymptomatic participants.

MATERIAL AND METHODS

Participants

Sixty-Four (64) asymptomatic participants (45 females, age 22.7±4.0; 19 males, age 22.3±3.9) were recruited from an osteopathic student population. Participants were excluded if they reported current lumbar pain or leg pain, a history of lumbar disc pathology, spinal pathologies or any conditions that contraindicated HVLA techniques[2]. All participants signed consent forms and the Victorian University Human Research Ethics Committee granted ethics approval. Testing was performed at the Victorian University Student Osteopathic Clinic. This study was conducted simultaneously with other studies investigating the effects of mobilisation and muscle energy technique on PPTs in the lumbar spine.

Materials and Measures

Procedure

Each participant exposed their lumbar spine and lay prone on the treatment table. Based on the procedure used by Fryer *et al*.[15], Researcher 1 applied a gentle springing movement (anterior translation, using thumbs) on each of the lumbar spinous process of each participant. The participant reported the spinous process that was most relatively tender/painful, which Researcher 1 then marked with a skin pencil.

Researcher 2 measured the PPT values for the marked spinous process on each participant as described below. The participants were then directed to another room where they were randomly allocated by lottery draw into a HVLA manipulative group (n=34) or a sham control treatment group (n=30), by Researcher 3.

Participants then received the allocated intervention by Researcher 3, a qualified Osteopath with 15 years experience. Once the treatment was applied, the participant returned to the initial room where Researcher 2 re-measured the marked site. Researcher 1 and 2 were blinded to the allocation of treatment intervention.

Manipulation Procedure

A registered osteopath with 17 years experience performed the manipulations on the participants in a neutral spine side-lying position (Figure 3). Using the participants' upper torso and pelvis as levers, a rotational force was applied by the practitioner, taking the lumbar spine to the limit of passive movement[2]. A high-velocity low-amplitude (HVLA) thrust was then applied to the marked level and this was repeated with the participant lying on the opposite side.   Cavitation was audible in all participants.

Sham Functional Procedure (placebo)

The control group received a thirty-second sham "functional treatment" to marked lumbar spinal level. The technique was performed with the participant lying prone on treatment table with the practitioner positioning the participant's lower limb into slight hip extension (Figure 4). Participants were informed they should feel little movement and if they experienced any pain to report this to the researcher.

The participants in the sham control group were told they are receiving an "Osteopathic Functional technique"[17]. In order ensure make the treatment was inert, there was no attempt by the practitioner to palpate tissue 'bind or ease', and the leverages used were minimal.

Osteopathic functional technique involves subtle patient positioning[17] and it was reasoned that participants would not be able to detect whether the treatment was performed correctly. The sham technique controlled for subject bias, because the expectation of a treatment effect may have an influence on pain perception.

Pressure algometer

A handheld electronic pressure algometer (Somedic Type II, Sweden) (Figure 1) was used to determine the PPT value of each participant, pre- and post- intervention. The algometer is a cylindrical metallic probe attached to a plastic handle with a LCD screen that displays the amount and rate of pressure (kPa/cm2/sec) applied. The algometer was fitted with a 2 cm^2 rubber tip because this was found to improve the stability on the lumbar spinous process, making the process of measuring PPT more reliable. A hand held button that immediately froze the pressure reading was connected to the algometer for participants use.

Pressure pain threshold

The procedure for measuring the PPT similar to that used by Fryer *et al*.[15], which was originally adapted from that used by Keating *et al*[10]. The algometer pressure tip was placed perpendicular to the specific marked lumbar spinous process and stabilised between the examiner's thumb and first finger (Figure 2). A steady pressure at a rate of 40kPa per second was applied. The participant was instructed to press the hand-held button when the sensation of pressure first changed to pain. This pressure value was recorded and the PPT measurement was repeated 2 times, with a break of 10 seconds. The mean of these three recordings was used for analysis. The previous study by Fryer *et al*.[15] did not used the hand-held button and instead instructed participants to say 'now' as soon as they felt the sensation of pressure change to one of pain. The

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old procedure inherently involved a small time delay between the participant's saying 'now' and the researcher stopping the procedure. This was negated with the hand-held button allowing an instant cut-off at the PPT point.

Pilot study

To determine the repeatability of the algometer and the testing procedure, a pilot trial was conducted on 20 participants before the main study. Participants were measured for an initial PPT values, and then instructed to leave the room. The participants then returned after two minutes and the PPT values were re-measured. This procedure simulated the time scale of the main study. The mean difference between pre and post values was 5.83kPa ±44.21. An Intraclass Correlation Coefficient (ICC) was calculated and found to be very high (ICC=0.93), indicating excellent repeatability of the measurement procedure. The error range of the procedure (mean difference plus/minus the standard deviation of the mean difference) was calculated to be −38.38 to 50.04 kPa.

Statistical Analysis

Data was collected using Microsoft Excel and analysed using SPSS Version 12.

Paired t-tests were used to examine the PPT data of both groups for within-group changes over time. The mean changes in both groups were analysed using an independent t test to determine whether there were any differences between the groups. Statistical significance was set at the alpha 0.05 level.

Within and between group effect sizes (Cohen's d) were also calculated for treatment and control groups. Effect sizes (Cohen's *d*) can be interpreted as small (*d*=0.2), medium (*d*=0.5) or large (*d*=0.8)[18].

RESULTS

The means and standard deviations of PPT for the control and treatment groups are reported (Table 1). A mean increase in PPT (14.08 kPa/cm^2, ±47.10) was demonstrated in the manipulation group, whereas the PPT for the control group decreased (-17.15 kPa/cm^2, ±45.02).

There was no significant change over time in the manipulation group (t=1.74 P=0.09), but there was a significant decrease in PPT (t=2.08, P=0.046) in the control group. The within-group changes occurring in the manipulation and control groups were found to produce small to medium effect sizes (d=0.29 and 0.38, respectively). An independent t test revealed a significant difference between the changes in the control and manipulation group (t= 0.009, significant at t<0.05), with a mean difference of 31.24kPa.

DISCUSSION

The purpose of this study was to evaluate the effectiveness of manipulation on PPT in the lumbar spine of asymptomatic participants. A previous study had reported that thoracic manipulation and mobilisation significantly reduced PPTs in asymptomatic participants[15], however, in the present study, manipulation was not shown to be effective. Although a small increase in the mean PPT of the manipulation group occurred following intervention, the change was very small (14.08 kPa/cm^2, ±47.10), was not significantly different from the pre-intervention values, and was within the error range of the testing procedure (−38.38 to 50.04 kPa/cm^2). The results of this study are in contrast to the methodologically similar study by Fryer *et al,*[15], which reported a significant increase in PPT in the thoracic spine following spinal manipulation.

It is possible that changes in PPT in the asymptomatic population following a manipulation may have been too small for the algometer to accurately detect. A modest mean increase of 14.08 kPa/cm^2 occurred in the manipulation group, yet the calculated error range of the algometer during the pilot study was high at −38.38 to 50.04 kPa/cm^2, and far beyond than the average PPT change in the experiment. Notwithstanding, a larger PPT change may occur in symptomatic individuals.

The standard deviations of all mean PPT measurements were large and ranged from 100.95 to 114.48, with a mean of 286.45 kPa/cm^2 to 300.54kPa/cm^2 respectively. This is consistent with other studies that have measured the PPT in the lumbar spine of asymptomatic participants, on vertebral spinous processes[10,15] and paraspinal regions[19]. The standard deviations in this study were comparatively higher than those in Fryer *et al.* (204.64kPa/cm^2 ±85.52, and 216.51kPa/cm^2 ±90.50)[15], which examined the thoracic spinous processes, but lower than those by Keating *et al.*

(513kPa/cm^2 ±164 and 504kPa/cm^2 ±182)[10]. Although the lumbar paraspinal region was measured with a different type of algometer by Jason *et al.*[19], standard deviations were also large. Mean PPT measurements were 262.44 kPa/cm^2 (±133.44) for subjects with chronic LBP and 355.85 kPa/cm^2 (±129) for subjects without pain. Large PPT standard deviations are likely to occur in any such study measuring the subjective nature of pain and mean changes need to be large, in order to be significant.

Researcher familiarity with the PPT procedure was enhanced through a pilot reliability trial. A single researcher performed all the PPT testing and the timing of the force applied was standardised to 40kPa/sec, as recommended by Nussbaum *et al.*[14]. Furthermore, another researcher carefully screened the most tender lumbar spinous process in which the site was marked, flat, bony and broad as recommended by Jensen *et al.*[13]. The calculated ICC value for the experimental procedure was ICC= 0.94 and therefore highly reliable. However, an earlier study by Keating *et al.*[10] that utilised the same type of algometer (Somedic Type II) suggested only a moderate reliability at the lumbar spine (ICC>0.75). Keating *et al.*[10] did not involve screening of the most pressure-sensitive lumbar spinous process, but instead all PPT measurements were completed on a predetermined lumbar spinal level at L4. This may account for the lower mean values in the present study.

This experiment was designed to best simulate a therapeutic process by the selection of the lumbar spinous process most sensitive to pressure in asymptomatic participants. The researchers believed that the most sensitive segment may respond more to manipulation than a segment that was relatively non-sensitive, in the same way that a symptomatic individual may respond more (result in less pain) than an asymptomatic individual. The resultant change after manipulation

was not significant. Although the research is not a substitute for a clinical trial, experimentation on symptomatic participants may produce more significant and clinically meaningful results. Recently, Jason *et al.*[19] compared PPTs in participants with chronic LBP and volunteers without pain. Chronic LBP participants (of at least 6 months duration) were tested at 6 lumbar paravertebral sites bilaterally, and other areas around the body unrelated to the LBP. The authors demonstrated the individuals with chronic LBP had significantly lower lumbar PPT values (p=0.0083) compared to the asymptomatic volunteers. Individuals with LBP have lower PPTs on average than asymptomatic participants[19] and potentially symptomatic participants may also demonstrate a greater increase in PPT after manipulation than asymptomatic participants.

The sham function group had a significantly lower PPT post-intervention value than the 'pre-' (t=0.046, -17.15 kPa/cm^2, ±45.02) and this was an unexpected finding; ideal sham group behaviour should not have significantly changed. In the pilot study, no intervention occurred and the statical analysis revealed no significant differences between pre- and post- PPT measures. It is possible that the participants in the sham functional group focused upon the lumbar spine during the technique and this increased the participant perception of the area, decreasing the amount of pressure stimulus to elicit pain.

Participants were recruited from an erudite population and it cannot be ascertained whether they were aware of a possible placebo treatment effect. An additional non-treatment control group may have provided for a more meaningful comparison. This additional group might have accounted for the additional changes and a follow up study to determine participant perceptions may have been useful.

Investigation into the effects of spinal manipulation for acute and chronic low back pain is continuing. Koes et al.[20] reviewed the results of 36 randomised clinical trials comparing manipulation with other treatments for back pain. Koes et al.[20] concluded that manipulation may be effective in certain subgroups of patients with LBP, but the evidence for manipulation was still questionable because of the variable quality of the clinical trials. Ferreira et al.[21] reviewed 27 randomised clinical trials on the efficacy of spinal manipulative therapy for acute low back pain (less than 3months duration) and found spinal manipulative therapy produced slightly better outcomes than placebo therapy, no treatment and massage therapy. Again, the reviewers could not draw stronger conclusions due to the varied methodological quality of the randomised clinical trials. Recently, Mohseni-Bandpei et al.[22] conducted a randomised controlled trial and demonstrated a significantly greater reduction in pain intensity, functional disability and improved lumbar range of motion following, compared to ultrasound in subjects with chronic LBP, both initially and at 6-month follow up. All of the discussed reviewers and researchers concluded on the need for further research.

Terret and Vernon[8] examined the relationship between manipulation and pain threshold in myofascial tissue. These authors assessed the effect of manipulation on paraspinal pain tolerance measurements, obtained by the electrical induction of pain. They found a marked increase in pain tolerance at 30 seconds, 2, 5 and 10 minutes in the group who received a manipulation. The control group was unchanged. At 10 minutes post manipulation the manipulated group was statistically significant ($P<0.05$) to the control, demonstrating a 140% increase in pain tolerance levels. However, Cote et al.[23] failed to find a significant change in PPTs of lumbar myofascial points following manipulation in participants with chronic back pain.

Schiller[24] reported a small increase in PPT threshold after a six-week treatment period of thoracic manipulation, compared to a non-functioning ultrasound, in participants with mechanical thoracic spinal pain. Although no reliability or error values were provided, and the number of participants was small (n=30), those who received manipulation demonstrated a statistically significant improvement ($P<0.025$) between the first and final treatment, which was maintained after one month.

The analgesic effects of manipulation are yet to be fully understood. Pain fibres innervate all spinal joints and surrounding structures with the exception of the articular cartilage[25]. Manipulation may stretch the spinal joint capsule stimulating large-fibre signals (joint mechanoreceptors) that result in pain inhibition[26] and modulation via the gate control theory of pain[27].

Descending pain modulation pathways to the spinal cord may be influenced by the release of opioid peptides, enkephalins, endorphins and dynorhins that are produced within the CNS[26]. The superficial dorsal horn of the spinal cord contains numerous interneurons with opioid receptors and act, when stimulated, to decrease the neurotransmitters released. This decreases the amplitude of the postsynaptic pain signal. Vernon *et al*.[16] found that β-endorphin levels within the blood rose significantly 5 minutes after a single spinal manipulation, compared to a control and sham treatment. However, subject numbers in this study were small, possibly affecting validity. In contrast, Christian *et al*.[28] found manipulation produced no significant difference in plasma β-endorphin levels 5 minutes and 30 minutes post-intervention.

Manipulation may also exert its hypoalgesic effect by activating descending pain inhibitory pathways that project from the dorsal periaqueductal grey (dPAG) region of the midbrain, to the spinal cord.[26]

Recommendations for future studies that examine the therapeutic effects of manipulation should include: multiple pain measures such as pain scales pain questionnaire and algometry; and, multiple testing intervals in the short and longer-term. Also, future studies could utilise multiple therapeutic techniques and treatment applications and the comparison of such studies would be beneficial to clinicians.

CONCLUSION

Manipulation was not shown to be effective in reducing the PPT in the lumbar spine of asymptomatic individuals. Although researcher familiarity with the PPT procedure was enhanced through a pilot reliability trial, it is possible that changes in PPT in the asymptomatic population following a manipulation may have been too small for the algometer to accurately detect. In addition, the sham functional technique may have not been the ideal control/placebo group. The research supporting the efficacy of manipulation is limited, and further research is needed to determine the pain modulating effects of manipulation.

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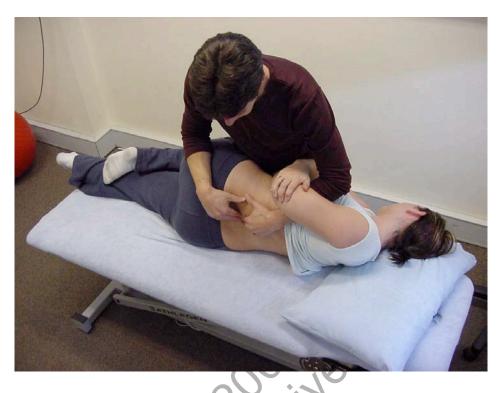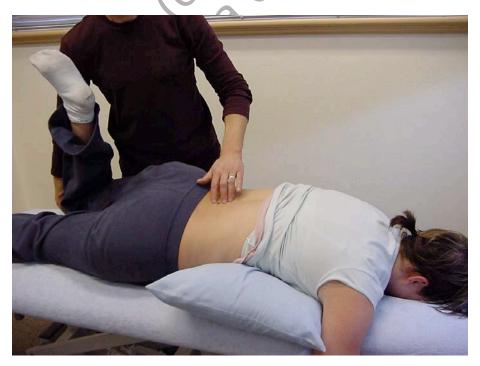**Figure 1.** Electronic algometer (Somedic, Type II)

Figure 2. Pressure pain threshold measurement

Figure 3. Lumbar sideling manipulation

Figure 4. Sham Functional Technique

Table 1: Group means pre- and post- intervention for treatment and control groups (kPa/cm^2).

	Manipulation Mean (SD)	Control Mean (SD)
Pre-intervention	286.45 (100.95)	297.81 (113.14)
Post-intervention	300.54 (114.48)	280.66 (103.24)
Difference	14.08 (47.10)	-17.15 (45.02)
P value	0.09	0.046*
Effect Size (Cohen's *d*)	0.29	0.38

* Significant at *P*<0.05

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Consent Form for Participants Involved in Research

CERTIFICATION BY PARTICIPANT

I**,**
of

certify that I am at least 18 years old and that I am voluntarily giving my consent to participate in the experiment entitled: **A comparison of the effect of different Osteopathic techniques on Pressure-Pain Thresholds in the Lumbar Spine** being conducted at Victoria University of Technology by Dr Gary Fryer, Melanie Medley, Tamara Rogers and Craig Wallis.

I certify that the objectives of the study, together with any risks to me associated with the procedures listed hereunder to be carried out in the experiment, have been fully explained to me by Melanie Medley, Tamara Rogers and Craig Wallis and that I freely consent to participation involving the use on me of these procedures.

Procedures:
The methodology of this study is based on the study by Fryer et. al. (2004). Each participant will lie prone on the treatment table and screened for lumbar spine tenderness via springing of the spinous processes. The most tender level will be marked with a non-toxic skin pencil. Pressure Pain Thresholds (PPT) will be measured at that level, and then each participant is randomly assigned to a treatment group. A qualified osteopath will perform a manipulation, mobilisation, MET or functional technique on the participant who will then return to the measurement room, where PPT values will be re-taken.

Potential risks and their management:
The physical risks associated with the treatment modalities are minimal, but may aggravate pre-existing conditions such as Lumbar disc herniation or protrusion. To participant in this study I acknowledge that I should not have present lumbar pain, leg pain, numbness or weakness in the back or legs. Lumbar mobilisation, manipulation, Muscle-Energy-Technique and functional will be conducted by a fully qualified Osteopath who will discontinue treatment if I report any pain. If I experience any pain I will inform the researchers who may refer me to the Osteopathic Medicine Clinic.

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If I become anxious throughout the screening and/or testing procedures, I understand that I should report these feelings to the researchers. I certify that I have had the opportunity to have any questions answered and I understand that I can withdraw from this experiment at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential.

Signed: ....   **}**

Witness other than the experimenter:**...}**   **Date:**
....

Any queries about your participation in this project may be directed to the researchers (Gary Fryer ph. 03 9248 1210 or Students Melanie Medley, Tamara Rogers or Craig Wallis.)   If you have any queries or complaints about the way you have been treated, you may contact the Secretary, University Human Research Ethics Committee, Victoria University of Technology, PO Box 14428 MC, Melbourne, 8001 (telephone no: 03-9688 4710).

Information to participants form

A Comparison of the Effect of Osteopathic Techniques on Pressure Pain Thresholds on the Lumbar Spine

We would like to invite you to take part in a study investigating the effects of manipulation, mobilisation, muscle-energy-technique and functional technique on Pressure Pain Threshold (PPT) in the low back. These are widely used techniques within manual therapy, and any scientific study investigating possible benefits for their use would be valuable for practitioners and patients.

Criteria for Inclusion/Exclusion

Please inform the researchers if you have any of the following because you will not be eligible to participate:

- Low Back Pain
- Leg Pain
- Numbness or Weakness in Legs or the Lower Back
- Disc Injury
- Corticosteroid use
- Pregnancy
- Other Low Back Condition i.e. trauma or surgery
- Recent treatment of the Low Back
- Adverse reaction to HVLA

Experimental Procedure:

The experimental procedure consists of the following sections.

(a) PALPATION

Each participant will be asked to undress and lie prone on the treatment table and screened for lumbar spine tenderness. The most tender level will be marked with a non-toxic skin pencil by Researcher 1.

(b) PPT

Researcher 2 will measure the pressure pain thresholds (PPT) of each participant's lumbar spine using a hand held electronic pressure algometer. The participant will lie prone on the treatment table and the algometer positioned perpendicular to the marked spinous process. An increasing downward pressure will be applied and participants will be instructed to say 'now' when the sensation of pressure first changes to discomfort. The algometer will then be removed and the PPT value recorded. Three measurements will be taken with a break of 20 seconds between each.

(c) TREATMENT GROUPS

Researcher 3 will randomly assign the participant to the manipulation, mobilisation, MET, Functional or a Control Group. A qualified osteopath will perform each treatment in a separate room. Once the treatment intervention has been carried out, participants will return to the measurement room where researcher 2 will re-measure the PPT.

The risks associated with manipulation of the low back are rare and likely to be associated with existing pathology. Mobilisation, Muscle Energy Technique and Functional are safe techniques and no adverse effects have been reported in the literature. Mild temporary soreness following the techniques is possible.

All treatment procedures will be carried out by qualified Osteopath who will discontinue the treatment if any undue pain is reported. Participants who feel anxious during the screening and/or testing procedures will be encouraged to report these feelings to the researchers and any questions pertaining to any aspects of the study are encouraged, to alleviate concerns. If anxiety continues, they are free to withdraw from the study.

Any participant who reports any lumbar pain or discomfort will be referred to the Victoria University Osteopathic Medicine Clinic for treatment.

Participants will be able to withdraw from the study at any time without any consequence as participation is strictly voluntarily.

Any queries about your participation in this project may be directed to the researcher (Dr. Gary Fryer ph. 03 9248 1210, or students Melanie Medley, Tamara Rogers or Craig Wallis. If you have any queries or complaints about the way you have been treated, you may contact the Secretary, University Human Research Ethics Committee, Victoria University of Technology, PO Box 14428 MC, Melbourne, 8001 (telephone no: 03-9688 4710).

Pilot Reliability Study

Warnings

The space saver method is used. That is, the covariance matrix is not calculated or used in the analysis.

Case Processing Summary

		N	%
Cases	Valid	20	100.0
	Excluded[a]	0	.0
	Total	20	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.938	2

Intraclass Correlation Coefficient

	Intraclass Correlation[a]	95% Confidence Interval	
		Lower Bound	Upper Bound
Single Measures	.883[b]	.729	.952
Average Measures	.938[c]	.843	.975

Two-way mixed effects model where people effects are random and measures effects are fixed.

Intraclass Correlation Coefficient

	F Test with True Value 0			
	Value	df1	df2	Sig
Single Measures	16.136	19.0	19	.000
Average Measures	16.136	19.0	19	.000

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.

b. The estimator is the same, whether the interaction effect is present or not.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

Paired T-Test for within group changes

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	HVLA Avg Pre	286.4512	34	100.95361	17.31340
	HVLA AVG Post	300.5391	34	114.47925	19.63303
Pair 2	Control Avg Pre	297.8117	30	113.14074	20.65658
	Control Avg Post	280.6557	30	103.24013	18.84898

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	HVLA Avg Pre & HVLA AVG Post	34	.912	.000
Pair 2	Control Avg Pre & Control Avg Post	30	.917	.000

Paired Samples Test

		Paired Differences					t
					95% Confidence Interval of the Difference		
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t
Pair 1	HVLA Avg Pre - HVLA AVG Post	-14.08794	47.10360	8.07820	-30.52316	2.34728	-1.744
Pair 2	Control Avg Pre - Control Avg Post	17.15600	45.02133	8.21973	.34476	33.96724	2.087

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	HVLA Avg Pre - HVLA AVG Post	33	.090
Pair 2	Control Avg Pre - Control Avg Post	29	.046

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T-Test

Independent T Test for between group changes

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
PPT	HVLA	34	14.0882	47.10375	8.07823
	CONTROL	30	-17.1553	45.02181	8.21982

Independent Samples Test

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | 95% Confidence Interval of the Difference | |
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PPT	Equal variances assumed	.152	.698	2.703	62	.009	31.24357	11.55800	8.13945	54.34769
	Equal variances not assumed			2.711	61.585	.009	31.24357	11.52489	8.20255	54.28459

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Reference to a book:

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Reference to a chapter in an edited book:

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