# The effect of manipulation on pressure pain thresholds in the thoracic spine

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## ABSTRACT

A controlled, single blinded study investigated the effect of high velocity manipulation on pressure-pain threshold (PPT) in the thoracic spine in an asymptomatic population. Participants were randomly allocated into intervention groups, and received either a single extension thrust or thirty seconds of sham treatment consisting of 'laser acupuncture'. PPT measurements were made using an electric pressure algometer immediately before and after intervention application. Pre- and post-manipulation PPT values were analyzed using a dependent t-test, and demonstrated a significant improvement in the manipulated group (P=0.04) but not in the control group (P=0.88). This study found that a single manipulation did increase thoracic PPT. Further research is warranted to investigate the effect of manipulation on thoracic pain.

## INTRODUCTION

Manipulation can be defined as a small amplitude manipulative thrust technique performed with speed.[1] A number of other terms, such as adjustment, high velocity low amplitude, mobilisation with impulse, and grade V mobilisation are interchangeable with this definition of manipulation.[2] Manipulation produces joint cavitation, which is often accompanied by an audible 'cracking' sound. Brodeur[3] explains that the audible release is generated by the increasing tension placed on the capsule by the manipulation, which causes the sudden 'snap back' of the synovial capsule from the capsule/synovial fluid interface. This creates a sudden decrease in pressure and promotes the coalescence of gases to form a single bubble within the joint.



Spinal manipulation has been proposed to have a number of therapeutic benefits. Improved plasticity and elasticity of shortened and thickened soft tissues, improved dynamics of blood, lymph and synovial fluid, decreased muscle hypertonia, improved visceral function, reduced joint restriction, and pain modulation has been suggested.[2,4,5]

Pain is the perception of an adverse or unpleasant sensation that originates from a specific region of the body. A variety of receptors are activated by painful stimuli. Nociceptors convey information via nerves to the lamina of the spinal cord, which then conveys the painful information via ascending spinal tracts to higher centres within the brain.[6] Other receptors, such as skin, muscle and joint mechanoreceptors, also contribute to pain sensation.[7]

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. Manipulation has been suggested to affect pain at spinal cord level via a phenomenon known as the gate control theory, which was first described by Melzack and Wall[8] in 1965. This proposes that low threshold myelinated neurons can activate inhibitory interneurons, which modulate the transmission of incoming nociceptive information. Excitation of these low threshold neurons will reduce the perception of pain. The mechanical force generated from spinal manipulation may activate mechanoreceptors, producing an inhibitory effect on nociceptive activity and providing pain relief by activating this spinal gate control mechanism.[9]

Descending inhibition of pain may also play a role in manipulation-induced hypoalgesia. Nociceptive signals can be modulated by major pain pathways that descend from the brain to the spinal cord. These descending pain modulatory pathways are activated by a number of endogenous opioid peptides, namely enkephalins, endorphins and dynorphins.[6] In 1986 Vernon et al[10] 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.[11]



The dorsal periaqueductal gray region (dPAG) of the brain may also contribute to manipulation-induced hypoalgesia. Stimulation of the dPAG produces a profound and selective analgesia,[6] and spinal manipulative therapy may exert its initial effects by activating this region.[12]

The majority of clinical trials that have investigated the effects of manipulation on spinal pain have focussed on the cervical and lumbar spine. A number of studies have reported cervical manipulation to be effective for pain relief,[13-15] with one study finding pain reduction in as many as 85% of subjects.[16] An extensive systematic review of randomised clinical trials investigating lumbar manipulation and pain concluded that there are indications that manipulation can be effective in some subgroups of patients with low back pain, and recommended additional research efforts on the topic.[17] Manipulation of the spine has also compared favourably with other interventions. Cassidy et al[16] found manipulation to be significantly better ($P<0.05$) than muscle energy technique (MET) for pain relief. Vernon et al[18] reported an average 45% greater improvement in pain following manipulation when compared with mobilisation ($P=0.0001$). Hadler et al[19] also compared manipulation to mobilisation, and found manipulation to improve pain to a greater degree ($P=0.009$) and more rapidly ($P<0.025$) in the week following intervention.

In the thoracic spine, 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 ($P<0.05$) elevation of pain tolerance when compared with the control group. Schiller reported a lasting increase in pain threshold after a six-week treatment period of manipulation or non-functioning ultrasound. There was no significant improvement in objective pain measurements in those receiving placebo treatment, whereas subjects receiving the manipulation showed a significant improvement ($P<0.025$) between the first and final treatment. This improvement was maintained in a one-month follow up.

Although the experience of pain is entirely subjective, there are a number of methods to measure and monitor the experience of pain. 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 reliable.[22-24] 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 in an individual.

A number of studies have demonstrated the algometer to be a reliable and repeatable tool for measuring local pain and tenderness.[25-28] The latest electric algometer (as used in this study) has been shown to have excellent reproducibility (in the thoracics: ICC=O.93 at T4 level, ICC=0.90 at T6 level).[29] Algometric measurement has been used to establish normal PPT values by measuring values in asymptomatic subjects.[26,29,30] In the thoracic spine, T4 was shown to have a normal mean PPT of 324 $kPa/cm^2$, and T6 a normal mean PPT of 302 $kPa/cm^2$.[29] Although no significant difference was found within the thoracic spine (P=0.184), Keating et al[29], and a number of other studies,[26,27,30] have demonstrated a normal regional variance within the spine with PPT increasing in a caudad direction from cervical, to thoracic, to lumbar vertebrae. Fischer[26] and Hogeweeg et al[30] have shown that left and right sides of the body have highly correlating PPT values.[26,30] Hogeweeg[30] has suggested that in the case of unilateral pathology, comparison with the non-affected side can be used to determine the severity, while Fischer[26] also suggested that normal PPT values could aid with diagnosis. Vanderween et al[27] agreed, and proposed that pressure algometry could be used clinically to evaluate treatment results.

The algometer has been shown to be reliable for taking PPT from muscle or bony points within the body. Kosek et al[31] compared PPT values over bone versus muscle and found no difference. Reeves[25] and Merskey and Spear[32] have also reported reliable pain threshold measures from bony points.

Relatively few studies have examined the effect of manipulation on the thoracic spine or thoracic pain. Studies have previously centred on the cervical and lumbar regions, however the importance of the thoracic spine cannot be forgotten. Greenman[33] has stressed the vital role of the thoracics in respiratory and circulatory function, and its proximity to the sympathetic chain ensures a significant relationship with the autonomic nervous system. This study aimed to investigate the effect of manipulation on PPT in the thoracic spine in an asymptomatic population. It was hypothesized that there would be an immediate increase in PPT following a single manipulation.

## METHOD

### Participants

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



Volunteers were excluded from this study if they were suffering from a spinal condition or pathology, if they were a long-term corticosteroid user, or if their spine had been manipulated or mobilized in the previous three days.

### Measurement

Pressure-pain threshold was measured using a hand held electronic pressure algometer (Somedic Algometer Type II, Sweden) (Figure 1). 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). Before testing began the algometer was calibrated according to the manufacturers instructions by placing a brass weight on the probe and checking that the correct weight was displayed.

The methodology used was similar to that used by Keating et al.[29] While the algometer was also the same, a 2 cm tip was preferred to the 1 cm tip they used. When practising to familiarise himself with the equipment, the researcher using the algometer found the 2cm tip easier to stabilise, which therefore enabled a more accurate reading.

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. Participants 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 that had been applied (ie. the PPT) remained on the algometer display. This was recorded, and the algometer reset. 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 of the subject.[25,28]



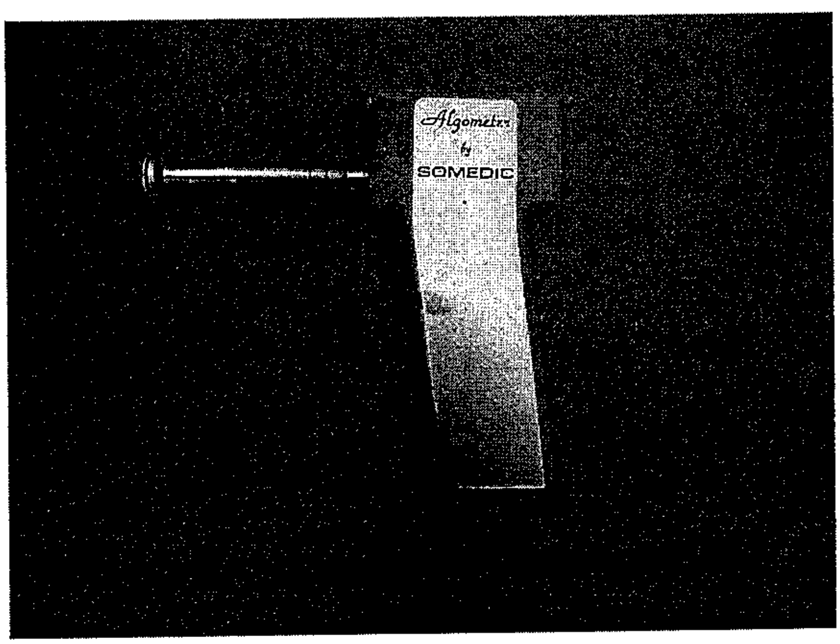


**Figure 1.** The algometer

## Procedure

Three researchers were involved in this study: Researcher 1 determined the most-tender vertebral level in the thoracic spine, Researcher 2 measured the PPT, and Researcher 3 (a registered osteopath) allocated treatment type and applied all the interventions. To remove possible bias, Researchers 1 and 2 were blinded to the treatment allocation and Researchers 1 and 3 were blinded to the algometric measurements. Participants were unaware of their algometric scores. This study was run concurrently with another study that examined the effect of thoracic articulation on PPT. Study participants were randomly allocated (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.



Participants removed clothing to expose their thoracic spine, and were offered an open-backed gown. Researcher 1 identified the most-tender vertebra by twice springing on each thoracic vertebra. This level was then marked, and PPT measurements of the appropriate level were taken with the algometer by Researcher 2 (Figure 2).

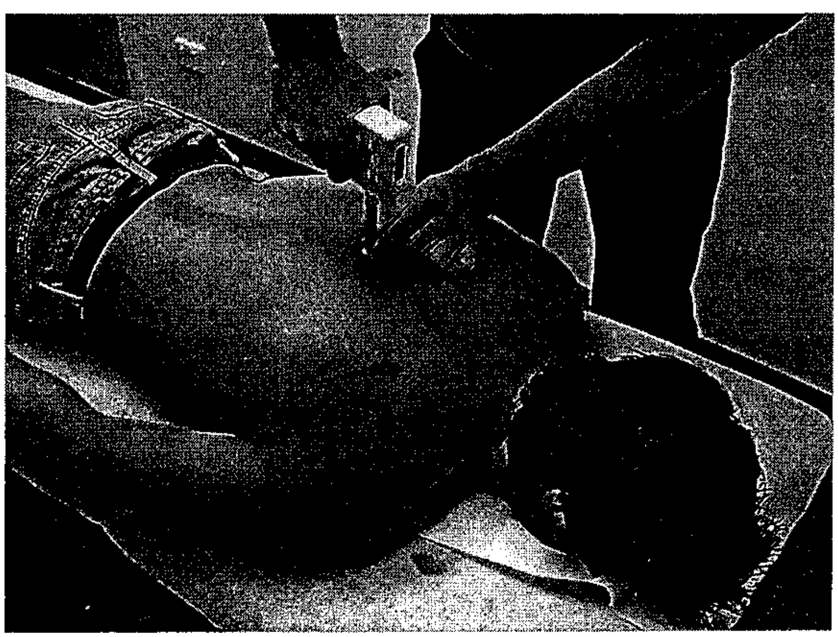

**Figure 2.** PPT measurement

Participants were then taken to another room, where they received their intervention treatment from Researcher 3. Those in the 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 appropriate level (Figure 3). If an upper thoracic segment (ie. T1-T4) was marked, the technique was modified by using a padded knee contact (Figure 4). These manipulation techniques are outlined by Gibbons and Tehan.[2]

**Figure 3.** Thoracic manipulation for lower levels

**Figure 4.** Thoracic manipulation for upper levels



Because participant expectation could potentially influence pain perception, it was decided to use a 'sham' treatment control group, rather than a no-intervention control group. Sham treatment consisted of 30 seconds of 'laser acupuncture' to the back using a laser pointer (Laserex LP2000). All participants 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 not feel any sensation or pain, 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.

Immediately following intervention, algometric measurements were taken in the same manner as stated previously.

## Statistical Methods

All data was collated and analysed using the statistical package SPSS Version 10. Pre- and post-intervention PPT measurements were analysed for each of the three intervention groups using paired t-test. The effect size (Cohen's d) of the pre- and post-intervention differences for each group was then calculated. A one-way ANOVA using the mean differences between pre-and post-intervention values for each participant was then conducted to compare the three intervention types. Statistical significance was set at the alpha<0.05 level.

## RESULTS

Statistical comparison of pre- and post-intervention PPT scores using a two-tailed t-test showed there to be a large mean improvement in the group receiving mobilisation (28.42 kPa) (the concurrent study), a smaller mean 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=0.00 for mobilisation, P=0.04 for manipulation), whereas the small improvement shown in the laser acupuncture group was not significant (P=0.88). Cohen's d can be interpreted as small (d=0.2), medium (d=0.5) or large (d=0.5).[34] These results are outlined in Table 1.



**Table 1.** Differences in pre- and post-intervention PPT scores (t-test)

| | PPT scores (kPa) (SD) | | |
|---|---|---|---|
| | 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* |
| Cohen's d | 0.03 | 0.35 | 0.72 |

* indicates statistical significance (P<0.05)

Table 2 and 3 compare the effect the three intervention groups had on PPT. One way ANOVA revealed a statistically significant difference between the intervention groups (Table 2). Post Hoc testing revealed the difference to be between the laser and mobilization groups (P=0.01).

No significant difference was seen between either the laser and manipulation groups (P=0.47), or the manipulation and mobilization groups (P=0.19) (Table 3).

**Table 2.** Differences between intervention type

ANOVA results

| | Sum of Squares | df | Mean Square | F | Significance |
|---|---|---|---|---|---|
| Between Groups | 12249.18 | 2 | 6124.59 | 4.81 | 0.01* |
| Within Groups | 118327.60 | 93 | 1272.34 | | |
| Total | 130576.78 | 95 | | | |

* indicates statistical significance (P<0.05)



**Table 3.** Differences between intervention type

Post Hoc testing results (Scheffe)

| | Mean Difference | Significance |
|---|---|---|
| Laser & Manipulation | 10.94 | 0.47 |
| Laser & Mobilisation | 27.48 | 0.01* |
| Manipulation & Mobilisation | 16.54 | 0.19 |

* indicates statistical significance (P<0.05)

## DISCUSSION

Manipulation is a popular technique in osteopathy, chiropractic and other manual therapy disciplines. However, despite its wide use, there is not convincing evidence on its efficacy. Previous studies have shown that it can have a positive effect on pain in the cervical and lumbar spine,[13-29] but there is limited evidence for the thoracic region. This study indicated that in the thoracic spine, manipulation does have an effect on pain threshold as measured by a pressure algometer. Manipulation produced an immediate improvement (a mean increase of 11.99 kPa) in PPT. This supports two previous findings,[20,21] which also reported increased pain thresholds following thoracic manipulation. Effect size calculations demonstrated that manipulation achieved a small to medium effect in this study.



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.

Despite the pre- and post-differences being significant for the manipulation group and not the laser acupuncture group (using a t-test calculation), a one-way ANOVA with post hoc testing showed there to be no significant difference in treatment outcome between the two interventions. This concurs with Schiller,[21] who also found no significant differences between manipulation and sham treatment for algometric measurements. The current study may have been underpowered. Because it used an ANOVA calculation with a small effect size, more subjects would be needed to achieve 80% power. It was interesting to note that in the concurrently run study (using mobilisation) a larger improvement in PPT was noted than manipulation, and this improvement was significantly different to manipulation or control.

The mean thoracic PPT of 243.7 kPa/cm$^2$ (standard deviation of 95.22) in the laser group and 204.64 kPa/cm$^2$ (standard deviation of 85.52) in the manipulation group (pre-intervention measurements) were lower than the normal values of 324 (at T4 level) and 302 (at T6 level) stated by Keating et al.[29] A plausible explanation for this is that while both studies were based on an asymptomatic population, in this study the most tender thoracic level was the one measured whereas Keating et al used pre-determined level. A more tender area obviously equates to a lower pain threshold.

Some variation was found between the three PPT readings in some participants, resulting in the reasonably large standard deviations. However, the standard deviations were actually lower than those found in the repeatability study performed as part of the Keating et al[29] research (standard deviation of 141 at T4 level, standard deviation of 147 at T6 level), where the algometer readings were found reliable. Pain is a subjective experience, and its perception 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 algometer is an extremely sensitive instrument, the one used in this study is the best of its type; it was electronic and more accurate than the analogue version, the rate of pressure applied was very visible on its display and therefore easy to control, the angle of application was easy to maintain, and its reliability and reproducibility has been proven.[29]

While the authors felt that most of the participants believed laser acupuncture to be a genuine form of treatment, we cannot be certain how effective it acted as a sham. Perception of pain could have been altered if it was thought that laser acupuncture was not genuine, and no follow up study was performed to see how many participants were naïve to the sham. Participants in this study were from a student osteopath population, and therefore had a certain amount of medical knowledge. It was quite possible that they may have been less naïve than the general population. A different sham treatment, such as non-operational ultrasound, might have been more believable for the control group.

The fact that there is an improvement in PPT following manipulation suggests that further investigation is warranted. It could be expected that manipulation would have a greater impact on an actively painful joint. Certainly in osteopathic practice manipulative therapy is used on symptomatic patients. It may therefore be more relevant for future studies to investigate the impact of manipulation on symptomatic subjects.



Results of this study show manipulation to immediately improve PPT in the thoracic spine. It would be beneficial to see if this improvement was lasting. Future studies could involve longer follow-ups, and examine the effect of multiple manipulative treatments over an extended time period.

## CONCLUSION

Analysis of the results showed manipulation to produce a statistically significant increase in PPT in the thoracic spine, whereas the control group had almost no change in PPT. Despite this, no significant difference was found between the interventions (manipulation and laser acupuncture). More research is needed investigating the effects of manipulation on pain in the thoracic spine, to complement the growing amount of literature involving other parts of the spine.

## ACKNOWLEDGEMENTS

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# APPENDIX B

Consent Form

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VICTORIA UNIVERSITY OF TECHNOLOGY

# Consent Form for Participants Involved in Research

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: The Effects of Manipulation, Mobilisation and Laser Acupuncture on Pain Pressure Threshold on the Thoracic Spine being conducted at Victoria University of Technology by Dr Gary Fryer, Joanne Carub and Steven McIver.



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 Joanne Carub and Steven McIver and that I freely consent to participation involving the use on me of these procedures.

**Procedures:**
I will undertake a screening procedure including a 'health questionnaire', which will highlight any contra-indications to participation. I acknowledge any potential problems identified will result in my exclusion from the study.

**Potential risks and their management:**
I understand that the physical risks associated with the treatment modalities are minimal due to the non-invasive nature of the treatment technique. Thoracic mobilisation, manipulation and laser acupuncture will be conducted by a fully qualified Osteopath who will discontinue treatment if I report any undue pain.

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 that 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 researcher (Dr. Gary Fryer ph. 03 9248 1210 , Joanne Carub: ph. 0412 160 279, Steven McIver: ph. 9592 2311). 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

# APPENDIX C

Information to Participants Form

**Victoria University of Technology**
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# Information to participants form

## The Effect of Manipulation, Mobilisation and Laser Acupuncture on Pain Pressure Thresholds on the Thoracic Spine

We would like to invite you to take part in a study investigating the effects of manipulation, mobilisation and laser acupuncture on pain pressure threshold on the thoracic spine. These are important and widely used techniques within manual therapy, and any scientific study investigating possible benefits for their use would be valuable.

Investigations on the effects of manual therapy on pain pressure threshold have focused primarily on the cervical and lumbar spine. Although there have been reports of beneficial effects in these areas, the effect on the thoracic spine has yet to be investigated. This study will provide accurate and reliable evidence as to whether the treatments do have immediate analgesic effects, and thus help fill the void regarding the efficacy of manipulation and mobilisation techniques on the thoracic spine.



**Potential Risks and their management:**
The physical risks associated with thoracic mobilisation and manipulation are minimal due to the non-invasive nature of mobilisation and infrequent reports of adverse reactions with manipulation of the thoracic spine, however temporary soreness may be experienced after the treatment. The risks associated with laser acupuncture are minimal, but any burning sensations should be reported to the practitioner.

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 thoracic pain or discomfort will be referred to the Victoria University Osteopathic Medicine Clinic for treatment.

**Experimental Procedure:**
Volunteers will undergo a screening procedure to determine their suitability to participate. This will involve identifying any history of thoracic injury, pain, pathology or other potential contra-indications to treatment. Potential problems highlighted will result in the participants exclusion from the study. Participants will be randomly assigned to one of the treatment groups. A fully qualified Osteopath will conduct all treatment intervention, either a single manipulation, mobilisation or an acupuncture laser.

Participation in this study will be strictly voluntary and will be free to withdraw their participation from the study at any time without any consequence.

Any queries about your participation in this project may be directed to the researcher (Dr. Gary Fryer ph. 9248 1210 , Joanne Carub: ph. 0412 160 279, Steven McIver: ph. 9592 2311). 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