Original Article

The initial effects of different rates of lumbar mobilisations on pressure pain thresholds in asymptomatic subjects

Elaine Willett*, Clair Hebron, Oliver Krouwel

University of Brighton, Faculty of Health, School of Health Professions, United Kingdom

Article history:
Received 30 June 2009
Received in revised form
22 September 2009
Accepted 8 October 2009

Keywords:
Mobilisations
Manual therapy
Pressure pain thresholds
Lumbar spine

Lumbar mobilisations are commonly used in clinical practice to reduce pain and increase function. Mobilisations to the cervical spine have been shown to reduce pain using pressure pain thresholds (PPTs). Yet there is no evidence to confirm that this happens in the lumbar spine. Furthermore little is known about the effects of different treatment doses on the amount of hypoalgesia produced. It is unknown if changing the rate of application of mobilisations has an effect on hypoalgesia. The aim of this study was to investigate the immediate effects of lumbar posteroanterior mobilisations performed at different rates on PPT and the extent of the hypoalgesia.

A repeated measures, single blind, randomised-trial was conducted on 30 asymptomatic subjects. PPTs were measured at 4 sites in the upper and lower quadrants, before and after the application of lumbar posteroanterior mobilisations performed at 2 Hz, 1 Hz and quasi-static. The results demonstrated an immediate and significant improvement in PPT measures ($P = 0.000$) irrespective of the rate or site tested. The effects were both local and widespread. There was no significant difference in PPT between the rates of mobilisations.

This study provides new experimental evidence that lumbar posteroanterior mobilisations produce an immediate and significant widespread hypoalgesic effect, regardless of the rates of mobilisation in asymptomatic subjects.

1. Introduction

Passive joint mobilisations are often employed by physiotherapists in the treatment of spinal pain (Foster et al., 1999; Gracey et al., 2002). The underlying mechanisms by which mobilisations produce clinical effects remain largely unknown, a number of theories have been hypothesised including direct effects on articular and periarticular structures and on the biochemical environment, modulation of nociceptive input within the central nervous system and non-specific placebo effects (Zusman, 1986; Wright, 1995).

A number of studies have looked at the immediate effects of mobilisations on pain. Mobilisations to the cervical spine have been shown to provide a hypoalgesic effect as measured by pressure pain thresholds (PPTs) in asymptomatic subjects (Vicenzino et al., 1995), in patients suffering from neck pain (Sterling et al., 2001) and lateral epicondylalgia (Vicenzino et al., 1996, 1998). A hypoalgesic effect has also been demonstrated following mobilisations to peripheral joints in the upper and lower limbs (Paungmali et al., 2003; Moss et al., 2007; Teys et al., 2008). However this effect remains to be demonstrated in the lumbar spine in response to mobilisations.

To date only one study has investigated the hypoalgesic effect of lumbar mobilisations; a drop in PPT values was demonstrated (Dhondt et al., 1999). This research used a combination of lumbar techniques, rotations and posteroanterior (PA) mobilisations on subjects with rheumatoid arthritis (RA). The drop in PPT measures was demonstrated in both the control and treatment groups; however significantly higher PPT values ($p < 0.05$) were found in the group receiving the mobilisations. A number of difficulties arise from this study; the lack of standardisation of the mobilisations, the underlying pathology of the subjects together with the fact some had low back pain (LBP) whilst others did not. There was continued use of medication including analgesics during the study, which may have influenced the endogenous pain relieving mechanisms. It is possible that subjects with acute inflammatory disease respond differently to subjects without inflammatory disease; RA is listed as a precaution to mobilisations especially in the presence of acute inflammation (Grieve, 1984). Further research is therefore required.

* Correspondence to: E. Willett, Physiotherapy Department, South London Healthcare NHS Trust, Queen Mary's Hospital, Fegnall Avenue, Sidcup, Kent DA14 6LT, United Kingdom. Tel.: +44 208 308 3017; fax: +44 208 308 5441.
E-mail address: elaine.willett@nhs.net (E. Willett).
to clarify if there is a hypoalgesic effect in response to mobilisations in the lumbar region in subjects without underlying inflammatory disease.

Mobilisations are used in different dosages and various parameters form the basis of the treatment dose; these include force, amplitude, rate, repetition and time. There is a paucity of evidence on the different aspects of treatment dose and therefore a lack of information on which clinicians base their decisions in order to produce a hypoalgesic effect. The primary aim of this study is to look at one specific aspect of treatment dose, the rate of mobilisation.

It has been reported that physiotherapists using spinal PA mobilisations, mobilise at frequencies between 0 and 2 Hz (static – 2 oscillations per second) (Souvlis et al., 2004), it is unclear if this aspect of the treatment dose is important in producing hypoalgesia. There are currently 4 studies investigating the effects of rate of mobilisations on a range of outcome measures; intervertebral movement (Lee and Evans, 1992; Lee and Svensson, 1993), skin conduction (Chiu and Wright, 1996) and PPTs (Williams et al., 2006).

Williams et al. (2006) using an osteopathic technique on healthy subjects to mobilise the ribs, found mobilising at 0.5 Hz had a greater effect than at 2 Hz on PPT measures, yet the percentage change was below 10% for both sets of mobilisations. However, the faster rate of mobilisation of 2 Hz produced greater changes in skin conduction compared to 0.5 Hz following cervical PA mobilisation in healthy males (Chiu and Wright, 1996). This suggests an application of mobilisations at frequencies of 2 Hz may cause a greater increase in sympathetic efferent activity in the upper limb of asymptomatic male volunteers than the slower rate. Whilst a correlation exists between PPTs and sympathetic nervous system changes (Vicenzino et al., 1998; Sterling et al., 2001), there is no evidence at this point in time as to whether these changes are interdependent and therefore whether pain would be affected.

Still looking at frequency, biomechanical studies investigating the effects of different rates of PA mobilisation on intervertebral movement in asymptomatic subjects, have found sustained (quasi-static) PA mobilisations to the spine have produced greater intervertebral displacement than mobilisations at frequencies of 1 Hz and 2 Hz (Lee and Evans, 1992) and 0.5 Hz and 1 Hz (Lee and Svensson, 1993). Further studies are needed to investigate if there is a correlation between joint displacement and hypoalgesia.

The purpose of this study is to establish if the rate of central PA mobilisations on L5 is significant in producing optimum hypoalgesia as measured by PPTs in asymptomatic subjects and the extent of the hypoalgesia; whether it is local, regional and/or systemic.

2. Method

2.1. Subjects

The study recruited 30 asymptomatic subjects (22 female and 8 males) aged between 18 and 57 years from the University of Brighton by posters and email. Basic demographics can be seen in Table 1.

Volunteers underwent a screening process that ensured those selected for the study were aged between 18 and 60 years, healthy with no contraindications or precautions to manual therapy (Grieve, 1984) and furthermore had no history of LBP within the last 2 years or LBP that had ever required treatment. Eleven of the subjects were physiotherapy naive. The subjects gave their written, informed consent before participating in the study which had been approved by the University of Brighton’s School of Health Professional’s Research Ethics Committee.

2.2. Research design and experimental procedure (independent variable)

The research design used a single blind, randomised, within subjects, repeated measures design which included 3 experimental procedures in a randomised order. Randomisation for each participant was established by “the research randomiser” (Urbanik and Plous, 2007) in order to reduce the effects of researcher and order bias (Altman, 1991). Subjects received all 3 experimental conditions on separate occasions with a minimum of 48 h between testing procedures.

The experimental procedure was applied by a physiotherapist with 23 years postgraduate experience in neuromusculoskeletal physiotherapy. It consisted of large amplitude, grade III, central PA mobilisations using a pisiform grip (Maitland, 1986) to L5 spinous process, for 3 sets of 1 min, with a 1 min rest period in between each set. The rates of the PA mobilisations varied at each experimental session and were performed at either 1 Hz, 2 Hz or as a quasi-static pressure. To maintain a consistent rate of mobilisations a metronome was set at 1 Hz, 2 Hz or left silent. The amplitude of the mobilisations were standardised by the use of a plinth mounted on a force plate (AMTI OR6-7 Advanced Mechanical Technology Inc, MA USA) linked to a computer screen, which showed a trace pattern of the mobilisations. The amplitude of the oscillations for the rates 1 Hz and 2 Hz was standardised by using a force from 100 to 200 N and a near static force of 200 N was used for the quasi-static technique.

2.3. Outcome measures (dependent variable)

Algometry is often used in research as a quantitative measure of pain. Excellent reliability has been demonstrated using algometry to measure PPT (Fischer, 1987; Vanderweeen et al., 1996; Keating et al., 2001; Farasyn and Meeusen, 2005; Potter et al., 2006) ranging from 0.8 to 0.99 between sessions and >0.91 within sessions. Pain pressure thresholds were measured using an electronic pressure algometer (Tracker Computerized Algometry System, JTECH medical). The algometer has a circular 1-cm² metal tip which is applied perpendicular to the skin at a gradual standardised speed of 1 kg/s following a pace on the computer screen linked to the algometer. The subjects were instructed to activate a switch linked to the computer recording the PPT measurement, immediately the sensation turned from one of pressure to pain (Fischer, 1987).

At each experimental session the 4 landmarks (Fig. 1) for the PPT testing procedure were marked with a water-soluble pen. It was found during the pilot work that L5 became sensitised during PPT testing therefore the paraspinal muscles adjacent to L5 were chosen as a landmark local to the mobilisations. The signature zones for the L2 and L5 dermatomes (Wolf, 1981; Nitta et al., 1993) were chosen to help eliminate the invariable overlap between dermatomes and therefore presenting a clear distinction between L2 and L5 in order to measure the extent of any hypoalgesic response. The first dorsal interossei in the hand was selected because to the large amount of

| Table 1 Demographics: standard deviation (SD), number (N), Body mass index (BMI). |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | Age             | Height          | Weight          | BMI             |
| Male           | N = 8           | Mean 36.5       | Mean 175.4 cm   | Mean 87.12 kg   | Mean 28.81     |
|                | range 22–57     | range 14.2      | range 6.3       | range 164–185   | range 22–40.9 |
| Female         | N = 22          | Mean 29.6       | Mean 166.5 cm   | Mean 65.45 kg   | Mean 23.5      |
|                | range 18–53     | range 10.3      | range 7.44      | range 51–95     | range 18.3–33.7|

Please cite this article in press as: Willett E, et al., The initial effects of different rates of lumbar mobilisations on pressure pain thresholds in asymptomatic subjects, Manual Therapy (2009), doi:10.1016/j.math.2009.10.005

ARTICLE IN PRESS
normative data available at this site to compare PPT values against (Vanderween et al., 1996; Chesterton et al., 2003) and to evaluate if there was a systemic response to the mobilisations. In order to familiarise the subject with the procedure, at the start of each session, 2 practice PPT tests were performed on the left hand at the first web space and to the paraspinal muscles 1.5 cm left of L5. Immediately before and after the experimental procedure the PPTs were measured at each of the 4 sites in a sequential order; resulting in a total of 6 measurements (3 before and 3 after) at each point. Fig. 2 demonstrates the order of the experimental procedure.

2.4. Data management

Microsoft Excel 2003 (Microsoft, Redmond, WA) was used to record the data. The means of the 3 PPT measures at each site, from before and after each experimental condition, were calculated. The SPSS statistical package (Version16, SPSS, Chicago, Illinois) was used for further data analysis. A three way repeated measures ANOVA was used to test for differences in the PPT measures. Two dependent variables were used: measurement site and time (before and after conditions). The independent variable was rate of mobilisation. Post hoc testing was conducted using Bonferroni correction to analyse statistical significance between the variables. Percentage change was also calculated from the differences between pre and post intervention to analyse between site differences using 2-way repeated measures ANOVA. Significance levels were set at $p < 0.05$ (Altman, 1991). Interclass correlation coefficient (ICC) was used to measure PPT testing reliability.

3. Results

All 30 subjects completed the study, with no adverse effects. Repeated measures ANOVA (correcting for violation of sphericity using greenhouse geiser correction) demonstrated a significant difference in PPT values following mobilisation to L5 ($p = 0.000$) at each of the 4 sites tested. No statistical difference was found between rates of mobilisation ($p = 0.26$). A significantly greater change in PPT measures ($p = 0.028$) was demonstrated local to the

Figure 1. PPT sites. L5 – 1.5 cm left of L5 spinous process, L5 dermatome – 2 cm proximal to 1st metatarsal phalangeal joint, L2 dermatome – Mid-way between anterior, superior iliac spine + top of patella, 1st dorsal interossei – mid point dorsal web space.

Figure 2. Flow diagram of the experimental procedure.
site of mobilisations in the lumbar paraspinal muscles compared to distally at the hand. Summaries of descriptive statistics for PPT measures are given in Table 2 and Fig. 3 which show baseline PPT values and the average change from baseline for the different rates at each site.

### 3.1. Reliability of baseline data

Acceptable intra-rater reliability was determined for PPT measures at all sites Table 3; this indicates that both the standard error of the mean (SEM) and ICC are indicative of reliable measures, which are in line with other studies (Sterling et al., 2001; Teys et al., 2008).

Recordings were made of each set of mobilisations to enable inspection of the consistency of amplitude and force, an example of the different rates of mobilisation can be seen in Fig. 4.

### 4. Discussion

This study provides evidence that lumbar PA mobilisations, performed at rates between 0 and 2 Hz, on asymptomatic volunteers produce an immediate and significant improvement in PPT measures ($p = 0.000$), irrespective of the site tested, indicating the hypoalgesia is both local and widespread. However there is no statistical difference between the rates of mobilisations.

Unsurprisingly there was a significantly greater change in PTT measures ($p = 0.028$) local to the mobilisations in the lumbar paraspinal muscles compared to distally at the hand. There was no statistical difference between the other areas. The mean percentage change above baseline measures in this study were 19.6% over the paraspinal muscles, 14.2% and 13.4% in the L2 and L5 dermatomes and 12% at the hand. Based on studies done in accident and emergency departments, Moss et al. (2007) suggest a change of 15% in PPT values is need to represent a clinical significant change.

However, the subjects in this study were asymptomatic volunteers. The results suggest mobilisations have the capacity to produce hypoalgesia in the absence of pain or articular dysfunction. Potentially, a greater response to lumbar mobilisations may occur in symptomatic subjects. Vicenzino et al. (1996) recorded a 26% increase in PPT values at the elbow following cervical mobilisation on subjects with lateral epicondylar pain, compared to a 23.5% increase in asymptomatic subjects, in a study with similar methodology (Vicenzino et al., 1995).

Not all studies have demonstrated a widespread response to mobilisations. Sterling et al. (2001) found an increase of 22.5% in PPT measures isolated to the side of treatment following unilateral PA mobilisations to C5/6, but only a minimal change (less than 5%) on the contralateral side, in subjects with neck pain. Furthermore Perry and Green (2008) demonstrated a significant side specific response to unilateral PA lumbar mobilisations as measured by skin conductance (SC), indicating the response to the mobilisations is localised and not systemic. In this study, a statistically significant response occurred in the upper limb in response to lumbar mobilisations, the mean percentage change at the hand was 12% (CI 7.54–16.5); this was higher in men ($n = 8$) at 19.2% when mobilisations were performed at 2 Hz and in women ($n = 22$) at 14.18% following quasi-static mobilisations. Owing to the small sample size the results should be interpreted with a degree of caution. However the results indicate changes following mobilisations are systemic, which suggests the possible activation of the central nervous system involving the descending pain inhibitory pathways, which extends beyond the specific joints and spinal segments stimulated (Schmid et al., 2008). It is difficult to infer clinical significance to this systemic response due to the asymptomatic status of the subjects, but it adds further weight to the understanding of possible involvement of neurophysiological mechanisms.

The systemic response of the men in this study concurs with a study by Chiu and Wright (1996) on asymptomatic male subjects, which demonstrated a greater increase in SC with mobilisations at 2 Hz, as opposed to the slower rate of 0.5 Hz. This study raises some questions with regard to male/female differences in response to mobilisations. From the raw data women had a tendency towards greater changes in PPT measures following quasi-static mobilisations as opposed to the 2 Hz in men. It appears that there may be a difference between male and female responses to mobilisation speeds, unfortunately due to the differences in sample sizes (females = 22, males = 8), a between group statistical analysis was not performed.

### Table 2

<table>
<thead>
<tr>
<th>Rate</th>
<th>Mean kg</th>
<th>Increase in kg</th>
<th>% Change</th>
<th>Mean kg</th>
<th>Increase in kg</th>
<th>% Change</th>
<th>Mean kg</th>
<th>Increase in kg</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quasi-static</td>
<td>7.6</td>
<td>1.18</td>
<td>19.15</td>
<td>7.16</td>
<td>1.08</td>
<td>17.88</td>
<td>6.85</td>
<td>1.18</td>
<td>21.77</td>
</tr>
<tr>
<td>Rate 1 Hz</td>
<td>5.15</td>
<td>0.85</td>
<td>17.33</td>
<td>5.36</td>
<td>0.64</td>
<td>11.30</td>
<td>5.18</td>
<td>0.5</td>
<td>11.50</td>
</tr>
<tr>
<td>Rate 2 Hz</td>
<td>5.32</td>
<td>0.85</td>
<td>14.96</td>
<td>5.55</td>
<td>0.64</td>
<td>11.08</td>
<td>5.07</td>
<td>0.77</td>
<td>16.65</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>Site</th>
<th>ICC</th>
<th>95% CI</th>
<th>Mean Kg</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>L5 Paravertebral</td>
<td>0.94</td>
<td>0.91–0.96</td>
<td>7.2</td>
<td>0.25</td>
</tr>
<tr>
<td>L5 Dermatome</td>
<td>0.96</td>
<td>0.89–0.95</td>
<td>5.23</td>
<td>0.18</td>
</tr>
<tr>
<td>L2 Dermatome</td>
<td>0.94</td>
<td>0.91–0.95</td>
<td>5.31</td>
<td>0.19</td>
</tr>
<tr>
<td>1st Dorsal interossei hand</td>
<td>0.93</td>
<td>0.90–0.95</td>
<td>4.68</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Please cite this article in press as: Willett E, et al., The initial effects of different rates of lumbar mobilisations on pressure pain thresholds in asymptomatic subjects, Manual Therapy (2009), doi:10.1016/j.math.2009.10.005
There is discussion in the literature (Leboeuf-Yde et al., 1997; Bouter et al., 1998; Dankaerts et al., 2006) trying to identify subgroups of patients with LBP who may respond to different types of treatments. In clinical practice a common observation in patients with LBP following lumbar mobilisations is one of three responses: an immediate dramatic change in symptoms, a group with minimal response and a smaller group with a negative response and a worsening in symptoms. A similar response was observed in this study in asymptomatic subjects as measured by PPT, in response to mobilisations. On inspection of the raw data subjects fell into three groups; those with a 15% or greater change in PPT values, a group with smaller changes between 0 and 14.9% and a group with a drop of PPT below baseline measures. Over half the subjects responded with changes at the L5 paraspinal muscles of greater than 15% ranging up to increases of 113% in the PPT measures. A smaller group of 7 demonstrated a decrease in PPT below baseline measures ranging from −1.1% to −27.8%. Similar reactions have been demonstrated in rats during investigations into acupuncture analgesia, which directly related to afferent impulse transmission (Takeshige et al., 1990). Likewise Vicenzino et al. (1995) found a correlation between the time taken to achieve maximum changes in skin conduction and PPT response and hypothesised that perhaps a more efficient neural pathway existed in those who experienced the greatest levels of hypoalgesia. The results of this study indicate that subgroups may occur in a normal population.

4.1. Limitations

The lack of control and placebo groups may be seen as a limitation in the study, however the primary aim was to look at different rates of mobilisations and the appropriate study design was used for this. The lack of control and placebo groups weakens any conclusions reached with regard to the analgesic effect of PA mobilisations to L5, because psychological factors cannot be separated from the physiological response made. However a significant body of work (Vicenzino et al., 1995, 1996; Moss et al., 2007; Perry and Green 2008) has demonstrated a greater change following treatment when compared to placebo and control groups.

Along with other research (Vicenzino et al., 1996, 1998, 2001; Dhondt et al., 1999; Sterling et al., 2001; Paungmali et al., 2003; Collins et al., 2004; Moss et al., 2007; Teys et al., 2008), this current study only set out to examine the immediate hypoalgesic effects of mobilisations, which may be seen as a limitation. It would be of interest to investigate the lasting effects of lumbar mobilisations. A study on rats (Skyba et al., 2003) has demonstrated short-term relief following knee joint mobilisations with an increase in mechanical withdrawal lasting up to 45 min. This remains unreported in human populations.

This study standardised the force and amplitude of mobilisations in order to make a fair comparison between the rates of mobilisations. However it did not take into account subjects innate stiffness or BMI which may have resulted in some subjects receiving a greater or lesser magnitude of force in some circumstances than perhaps they would have in clinical practice, which may have affected the amount of hypoalgesia experienced.

5. Conclusion

This study demonstrates that there is no significant difference between the rates of PA mobilisations to L5 in producing mechanical hypoalgesia. However it has provided new experimental evidence that lumbar mobilisations on asymptomatic volunteers produce an immediate and significant improvement in PPT measures, which is both local and widespread.

Acknowledgements

I would like to thank everyone who has helped me in this publication. Special thanks go to all the participants who gave up their time and took part in the study.

References


Please cite this article in press as: Willett E, et al., The initial effects of different rates of lumbar mobilisations on pressure pain thresholds in asymptomatic subjects, Manual Therapy (2009), doi:10.1016/j.math.2009.10.005


Skyba DA, Radhakrishnan R, Rohlwing A, Wright A, Sluka KA. Joint manipulation reduces hyperalgesia by activation of monoamine receptors but not opioid or GABA receptors in the spinal cord. Pain 2003;106:159–68.


