The effect of increasing sets (within one treatment session) and different set durations (between treatment sessions) of lumbar spine posteroanterior mobilisations on pressure pain thresholds

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ABSTRACT

Spinal mobilisations are a common form of treatment intervention applied by physiotherapists in clinical practice to manage musculoskeletal pain and/or dysfunction. Previous research has demonstrated that mobilisations cause a hypoalgesic effect. However, there is very little research investigating the optimal treatment dose inducing this effect.

Aim: To investigate the effect of the number of sets (up to 5) and different durations (30 vs. 60 s) on pressure pain thresholds (PPTs) at different sites.

Methods: This single-blinded, randomised, same subject repeated measures crossover design included 19 asymptomatic healthy volunteers. The participants received 5 sets of either 30 or 60 s of postero-anterior mobilisations to L4 on different days. PPTs were measured immediately before, between and after the intervention at 4 different standardised sites.

Results: A 4-way ANOVA analysis revealed that there was no statistically significant difference between 30 versus 60 s of mobilisations. However, there was a tendency for PPT values to be higher for the 60 s intervention. All PPT measurements after the interventions were significantly higher than the baseline. Only the measurement after the 4th set of mobilisations was significantly higher than the measurement after the 1st set (p = 0.035).

Conclusions: The results suggest that in order to induce the greatest local hypoalgesia, at least 4 sets of mobilisations are required. The different durations of 30 versus 60 s of mobilisation may not change the extent of the hypoalgesic effect.

1. Introduction

Spinal mobilisations are a common form of treatment intervention applied by physiotherapists to manage various musculoskeletal conditions including low back pain (Maitland et al., 2001). Many studies have demonstrated a hypoalgesic response to mobilisations on a symptomatic population (Vicenzino et al., 1998; Sterling et al., 2001; Moss et al., 2007; Teys et al., 2008). However, there is a paucity of research investigating the optimal treatment dose.

Mobilisations induce biomechanical and neuromuscular effects (Lee and Evans, 1992; Shirley et al., 1999; Krekoukias et al., 2009) in addition to the neurophysiological effects which are the focus of this paper. The two main mechanisms thought to be associated with the hypoalgesic response are pain modulation occurring at spinal cord level, also referred to as “gate control” theory (Melzack and Wall, 1965) and descending inhibition of pain (Wright, 1995; Schmid et al., 2008).

A number of controlled and placebo controlled studies have investigated the effect of spinal mobilisations on pain using pressure pain thresholds (PPT) (Vicenzino et al., 1998; Dhondt et al., 1999; Sterling et al., 2001; Fryer et al., 2004) and markers of sympathetic nervous system (SNS) activity (Sterling et al., 2001; Moulsion and Watson, 2006; Perry and Green, 2008). These studies provide conflicting evidence on the extent of the effect of mobilisations. Research using SNS markers (McGuiness et al., 1997; Moulsion and Watson, 2006) and PPT measurements (Krouwel et al., 2010; Willett et al., 2010) has suggested that the effect is systemic. This would fit the descending inhibition model, which would result in widespread effects as opposed to effects local to the site of intervention. However, Sterling et al. (2001) and Perry and Green (2008) reported side specific effects of mobilisations.

The mobilisation dose used by therapists is a combination of the following elements: grade, rate, amplitude, number of repetitions...
(sets) and duration of each set. The decision regarding the mobilisation dose can be clinically reasoned by the therapist depending on the purpose of the treatment and the response of the patient. Clinically mobilisations are commonly applied for 3 sets of 30–60 s each (Maitland et al., 2001).

There is little evidence regarding the influence of mobilisation dose on pain relief. Previous studies, using an asymptomatic population, have investigated the effect of different rates (Willett et al., 2010) and amplitudes (Krouwel et al., 2010) of lumbar mobilisations on PPT, and reported that these dosage parameters did not change the extent of the hypoalgesic response. However, evidence from animal studies suggests that duration of mobilisations may be important in mediating a hypoalgesic response. Sluka and Wright (2001) investigated the effect of different durations of knee mobilisations in rats after inducing pain to the joint with a Capsaicin injection. The results showed a statistically significant rise in mechanical withdrawal thresholds (MWT) after both 3 sets of 3 min and 3 sets of 5 min of mobilisations. Importantly, 3 sets of 1 min did not elicit a statistically significant difference in MWT values. The effects of different durations of mobilisation treatment remain unreported in a human population.

The aim of this study was to investigate whether sets of 30 or 60 s of mobilisation produced the greatest hypoalgesic effect and to establish the number of mobilisation sets (out of 5) that produced the greatest hypoalgesic effect as measured by PPTs. PPTs were measured at various sites to gain further insight into the extent of the hypoalgesic effect.

2. Methodology

2.1. Subjects

Nineteen (9 female and 12 male) volunteers agreed to participate in this study. The participants, mostly comprising of physiotherapy students, had a mean age of 31.9 (±7.6) and a mean body mass index of 23.9 (±3.29). Participants were excluded if they had a history of back pain in the past year or any precautions or contraindications to manual therapy (Grieve, 1984). Participants gave written informed consent prior to taking part in the study. This study gained ethical approval from the University of Brighton School of Health Professions Research Ethics and Governance Panel.

2.2. Research design and experimental procedure

The study design was a single-blinded, randomised, repeated measures crossover design. Participants received the experimental conditions on different days in a randomised order. Participants were asked to lie prone and the L4 spinous process was located by palpation and marked with a pen. Five sets of large amplitude oscillatory mobilisations were applied to the L4 at a rate of 1 Hz, as commonly used in clinical practice (Snodgrass et al., 2006). The mobilisations were standardised with the help of a metronome. The duration of mobilisation sets varied between experimental conditions, lasting either 30 or 60 s. In order to quantify the mobilisation force used participants lay on a plinth mounted on force plates (AMTI OR6-7 Advanced Mechanical Technology Inc). The force plates measured the force applied by the therapist indirectly. This method has been used previously in the quantification of mobilisation forces (Lee et al., 2005). In the current study, the mean and standard deviation of the force applied was 242.83 (±24.90) Newtons (N). This is in keeping with previous research on the lumbar spine (Snodgrass et al., 2006; Krouwel et al., 2010; Willett et al., 2010).

In order to determine the optimal number of mobilisation sets PPT measurements were taken 6 times (within a single treatment session): prior to the intervention and immediately after each of 5 mobilisation sets. The PPT measurements were taken 3 times (10 s intervals) as recommended by Fischer (1987) and Persson et al. (2004). See Fig. 1 for a flow chart depicting the experimental procedure.

2.3. Outcome measure

Pressure Pain Thresholds (PPTs) were measured using a hand held algometer fitted with a 1 cm² circular tip (Wagner Pain Test™ Model FPK). This has previously been shown to be a reliable tool to measure pain on an asymptomatic population (Fischer, 1987; Chesterton et al., 2003; Persson et al., 2004; Potter et al., 2006). An algometer was used to apply manual pressure at the measurement sites, using a standardised rate of 1 kg per second. A pilot study revealed that some participants, when asked to identify the first point of pain, appeared to attempt to tolerate pain. Because pain threshold rather than pain tolerance was required, participants were asked to identify the transition point at which the sensation of
pressure changed to discomfort or pain. The pressure was applied until the participant identified this point and the value showing on the algometer was documented by a second tester.

In order to demonstrate the extent of the hypoalgesic response repeated PPT measurements were taken at 4 sites. The sites chosen were: the L4 level (3 cm to the right of the L4 SP), the S1 dermatome (standardised point in the right lateral foot), the L4 dermatome (standardised at the mid medial right leg) and at the mid left deltoid. The measurements were taken in the order listed. These locations were marked with a water-soluble pen to allow for accurate repositioning of the algometer. The location of the dermatomal points was based on a study indicating the signature zone of dermatomes which have the least overlap with adjacent levels (Nitta et al., 1993).

2.4. Data analysis

The data was originally documented on the Microsoft Excel software (2007) and later analysed using the statistical package for social science (SPSS) software (version 19, IBM). The mean of the three repeated PPTs was calculated and used for analysis.

A between-day reliability analysis for baseline measurements was performed using intraclass correlation coefficient (single measure, two way mixed). The standard error of measurement (SEM) and real change values were calculated. A 4-way repeated measures analyse of variance (ANOVA) was used to compare the variables. The dependent variable used was the PPT values. The independent variables were: the duration of 30 vs. 60 s of mobilisations, the number of sets, the 4 sites and the order of intervention. Bonferroni correction was used to correct for multiple comparisons. Significance levels were set at $p < 0.05$ (Altman, 1991).

3. Results

3.1. Intra-tester reliability

A between-day reliability statistics demonstrated good reliability (Fleiss, 1986) at all measurement sites (Table 1).

2.4. Data analysis

The mean PPT (across all sets), mean increase in PPT and percentage change for each site are displayed in Table 2. Fig 2. depicts the distribution of the percentage change between the first and last PPT measurements, by using box-plots clustered by experimental condition.

A greater increase was observed in the mean PPT measurements for 60 s mobilisations compared to 30 s at all sites as shown in Table 2. For example at the L4 level there was a 56% vs. 35% increase in PPT for 60 and 30 s respectively. After the L4 level, the order of sites showing the greatest change was the S1 dermatome (41% vs. 32%) and L4 dermatome (41%, 35%). The smallest difference between interventions occurred at the Deltoid muscle site (46% vs. 43%). The mean PPTs for 60 s mobilisations (6.241 ± 0.405 kg/cm²) were slightly higher than those for the 30 s duration (6.206 ± 0.429 kg/cm²) across all measurements.

3.3. Main analysis

The 4 way ANOVA demonstrated that there was no significant effect of duration across all sites combined ($p = 0.890$). However, Pairwise comparisons demonstrated that the effect at the L4 site (local to the site of intervention) was significantly greater compared...
to the other sites \((p = 0.0001)\). The interaction between the duration of mobilisations (30 versus 60 s) and the set number was not significant \((p = 0.846)\).

All PPT measurements taken after each mobilisation set were significantly higher than the baseline measurement \((p = 0.0001)\). As seen in Fig. 3, the mean PPT values of the repeated measurement continued to gradually increase until the last (6th) measurement for the 30 s intervention. The mean of the 6th measurement for the 60 s intervention, was slightly lower than the 5th. However, this gradual increase in PPTs with increasing sets of mobilisations was small and only the mean measurement after the 4th set of mobilisations (the 5th measurement) was found to be significantly higher than the second measurement which was after the first mobilisation set \((p = 0.035)\). The interaction between the site and the measurement set was not significant \((p = 0.996)\). There was no other significant interaction between the measurement sets and the other variables. The order of application of the experimental conditions (30 or 60 s mobilisations) did not have a significant effect \((p = 0.757)\).

4. Discussion

The main analysis demonstrated that there was no statistically significant difference in PPT values between the 60 versus 30 s mobilisations \((p = 0.890)\) for all of the sites together. All of the PPT measurements taken after the first mobilisation set to L4, were significantly higher than the baseline measurement \((p = 0.0001)\) taken prior to the intervention irrespective of site. The hypoalgesic response elicited by 30 or 60 s of PA mobilisations to L4 is in accordance with previous research \((\text{Vicenzino et al., 1996, 1998; Dhondt et al., 1999; Sterling et al., 2001; Fryer et al., 2004)}\). The systemic effect demonstrated in this study had previously been demonstrated as a result of lumbar mobilisations \((\text{Krouwell et al., 2010; Willett et al., 2010})\). This systemic hypoalgesic reaction to mobilisations has been associated with descending pain inhibition mechanisms that are hypothesised to be activated as a result of mobilisations \((\text{Wright, 1995; Schmid et al., 2008})\). However, in this study, the analysis revealed there was a significantly greater hypoalgesic effect at the L4 level, adjacent to the mobilisation intervention site. This would suggest that both local and systemic analgesic mechanism may be involved. To the authors’ knowledge the trend towards a greater local effect within a systemic response has not been demonstrated in previous research.

As displayed in Table 2, the actual change between first and last PPT measurements for both interventions ranges between 1.3 and 2.8 kg/cm². These results are higher than the SEM which averaged 1.15 kg/cm² across sites (see Table 1). This indicates that the increase in PPT values after applying mobilisations cannot be attributed to a measurement error. However, the change seen with treatment is smaller than the real change statistics (average 2.48 kg/cm²). If change resulting from treatment exceeds the real change statistics then, there is 95% certainty that this change can be attributed to treatment. The results of this study indicate that although a statistically significant change was found it may not represent a clinically significant change. Previous studies have reported lower percentage changes in PPT’s than those in the current study, but not compared the effect size to real change statistics \((\text{Vicenzino et al., 1996, 1998; Sterling et al., 2001})\), so the clinical significance of increased PPT values has not been established.

The smallest mean difference in PPT change (3%) between 30 and 60 s of mobilisations was at the deltoild site. The PPT sites in the lower lumbar also showed a trend towards the longest duration being preferable (6–9% greater change with 60 s). Locally at the L4 level, this trend was more evident with a 21% difference between 30 and 60 s of mobilisations. Although this difference was not significant, a study with greater power may find that a greater local hypoalgesic effect occurs with longer durations of mobilisations. A retrospective power calculation was performed in Minitab (v16) to inform future research, based on the difference between 30 and 60 s at the L4 site. The calculation indicated that a sample size of 50 would be required to ensure the null hypothesis is rightly rejected or accepted. Previous research investigating the influence of duration of knee mobilisations performed in rats found that 9 min of mobilisation produced a hypoalgesic effect whereas 5 min was insufficient \((\text{Sluka and Wright, 2001})\). This highlights the potential influence of mobilisation duration. In a symptomatic population a hypoalgesic effect has consistently been reported to result from 1.5 to 3 min of mobilisations \((\text{Vicenzino et al., 1996, 1998; Sterling et al., 2001})\). However no previous research in a human population has investigated the effect of different mobilisation durations.

All measurements taken after the first set of mobilisation were significantly higher than baseline measurements \((p = 0.0001)\). As seen in Fig. 3, the PPT values continued to increase with the repeated sets of mobilisations until the measurement and after the 4th set of mobilisations became significantly higher than the measurement taken after the first set of mobilisations \((p = 0.035)\). This was the same for both 30 and 60 s of mobilisations. These results suggest that in order to achieve the greatest hypoalgesic response, as demonstrated by the increase in PPT values, a minimum of 4 sets of mobilisations would be recommended.

To the author’s knowledge, there is no previous published research that has compared the hypoalgesic effect of increasing sets of mobilisations. As seen in Table 2, the mean percentage change in PPT values after 5 sets of mobilisations were between 32% and 56%. Moss et al. (2007) suggests that a 15% change in PPT values is clinically significant. The percentage change demonstrated in this study are higher than those previously reported, where mean percentage changes have ranged between 12% and 26% \((\text{Vicenzino et al., 1996; Sterling et al., 2001; Krouwell et al., 2010; Willett et al., 2010})\). The difference in findings may be explained by the fact that this study employed a greater number of mobilisation sets. An additional possible explanation for the higher percentage change values reported in the current study is the fact that many of the participants were physiotherapy students. The higher change may
be attributed in part to a greater expectation of a pain relieving effect than a participant who is naive to the possible effects of physiotherapy (Wager et al., 2004). The clinical relevance of increased PPT’s and importance of duration of mobilisation treatment would be supported by using a symptomatic population and incorporating patient reported pain measures, for example resting pain levels or verbal ratings of pain on movement.

This study has demonstrated that in asymptomatic participants 4 sets of mobilisations produces the greatest hypoalgesic response. The measurement after the 5th set of mobilisations, for the 60 s intervention, showed a slight decrease in mean PPT values, but this was not significant and there was no definite plateau or decrease of values established. It is conventional in clinical practice to apply a maximum of 3 sets of mobilisations. This study suggests that there may be additional hypoalgesic benefit from applying an extra set of mobilisation. However further research on patients with symptoms is required.

5. Limitations

The study design did not include a control group, which would have been necessary in order to demonstrate that mobilisations are an effective form of treatment. This has already been demonstrated in previous controlled and placebo controlled studies (Vicenzino et al., 1996, 1998; Sterling et al., 2001; Moss et al., 2007) and was not the purpose of this study.

This study used asymptomatic physiotherapy students. Demonstrating the effects of different durations and number of sets of mobilisations in participants with low back pain, who are naive to the possible effect of mobilisations, could further our understanding and give additional validation to the results shown in this trial.

The sample size in this study is underpowered and was biased towards physiotherapy students. Large scale studies with a varied population in this field should be encouraged in order to give more strength to the evidence produced by mobilisation studies.

6. Conclusions

The results from this study demonstrate that there was no significant difference in the hypoalgesic effect of 30 s and 60 s sets of mobilisations. However there was a tendency towards a greater local hypoalgesic effect for the 60 s intervention. Further research on a larger population is warranted. This study supports the use of at least 4 sets of mobilisations as there was a significantly greater hypoalgesic response observed after the 4th set of mobilisations.

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