Effect of a lateral glide mobilisation with movement of the hip on vibration threshold in healthy volunteers

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Abstract

Background: Mulligan's mobilisation-with-movement (MWM) techniques are proposed to achieve their clinical benefit via neurophysiological mechanisms. However, previous research has focussed on responses in the sympathetic nervous system only, and is not conclusive. An alternative measure of neurophysiological response to MWM is required to support or refute this mechanism of action. Recently, vibration threshold (VT) has been used to quantify changes in the sensory nervous system in patients experiencing musculoskeletal pain.

Objective: To investigate the effect of a lateral glide MWM of the hip joint on vibration threshold compared to a placebo and control condition in asymptomatic volunteers.

Methods: Fifteen asymptomatic volunteers participated in this single-blinded, randomised, within-subject, placebo, control design. Participants received each of three interventions in a randomised order; a lateral glide MWM of the hip joint into flexion, a placebo MWM, and a control intervention. Vibration threshold (VT) measures were taken at baseline and immediately after each intervention. Mean change in VT from baseline was calculated for each intervention and then analysed for between group differences using a one-way analysis of variance (ANOVA).

Results: A one-way ANOVA revealed no statistically significant differences between the three experimental conditions ($P = 0.812$).

Conclusion: This small study found that a lateral glide MWM of the hip did not significantly change vibration threshold compared to a placebo and control intervention in an asymptomatic population. This study provides a method of using vibration threshold to investigate the potential neurophysiological effects of a manual therapy intervention that should be repeated in a larger, symptomatic population.

Introduction

Mobilisation with movement (MWM) is a manual therapy treatment technique whereby a passive accessory glide is applied to a joint and sustained while a previously painful movement is performed (Mulligan, 1993). Randomised controlled trials of peripheral joint MWM have reported significant improvements in: ankle dorsiflexion following lateral ligament sprain (Collins et al., 2004; Vicenzino et al., 2006); pain-free grip force in lateral epicondylagia (Vicenzino et al., 2001; Paungmali et al., 2003) pain and range of motion in anterior shoulder pain (Teys et al., 2008); and pain and range of motion in hip osteoarthritis (Beselga et al., 2016). However, it is not clear how MWM techniques achieve their clinical benefits. Biomechanical studies have challenged Mulligan's original belief that a manual correction of a joint positional fault underpins their clinical effect (Hsieh et al., 2002). Alternatively, it has been proposed that MWM achieve their clinical effect through neuro- physiological mechanisms (Abbott, 2001). It is speculated that during manual therapy

interventions, such as MWM, mechanical stimulation of local proprioceptors activate Aα and Aβ afferents that bombard the central nervous system with afferent information (Pickar and Wheeler, 2001). This initiates a series of responses in the peripheral and central nervous system, including autonomic responses, hypoalgesia, neuromuscular responses, endocrine responses and non-specific responses (Bialosky et al., 2009).

Previous research exploring the neurophysiological effects of MWM has been limited to measuring responses in the sympathetic nervous system (SNS), such as changes in heart rate, blood pressure, cutaneous sudomotor and vasomotor function (Paungmali et al., 2003; Moulson and Watson, 2006; Moutzouri et al., 2012). It is proposed that an excitatory response in the SNS represents activation of the dorsolateral periaqueductal grey region of the brain, which has been associated with a non-opioid form of centrally-mediated analgesia (Wright, 1995).

In a randomised, placebo, control, repeated-measures design Paungmali et al. (2003) investigated the effect of a MWM for chronic lateral epicondylalgia. Twenty-four participants underwent a lateral-glide MWM of the elbow, a placebo (no lateral-glide), and control (no manual contact) intervention, whilst performing a pain-free gripping action ten times. A significant hypoalgesic and concurrent sympathoexcitatory effect for the MWM in the affected arm compared to placebo and control was reported, indicated by simultaneous changes in pain-free grip force ($P < 0.05$), skin conductance, skin temperature, blood flux of the affected limb ($P < 0.0083$), and heart rate and blood pressure ($P < 0.017$). These findings suggest a centrally-mediated response to MWM through excitation of the sympathetic nervous system with a concurrent hypoalgesic effect.

Furthermore, in a randomised within-subject, placebo, control design Moulson and Watson (2006) compared a cervical spine MWM technique – a sustained natural apophyseal glide (SNAG), to a placebo (no glide), and control (no contact) intervention in sixteen asymptomatic subjects. They reported a significant increase in skin conductance in both upper limbs following the C5/6 SNAG compared to a control intervention ($P = 0.001$), supporting a potential sympathoexcitatory response to this spinal MWM technique.

Moutzouri et al. (2012) provided additional evidence for a centrally mediated sympathetic response to MWM. In a randomised, parallel group three-arm design, forty-five asymptomatic subjects received either a lumbar spine SNAG to L4 with lumbar flexion, a no-glide placebo intervention with lumbar flexion, or a control intervention with no contact or movement. A significant increase in skin conductance was reported in both lower limbs following the lumbar spine SNAG compared to a control intervention ($P = 0.04$).

These studies appear to support a sympathetic nervous system response to MWM, and therefore a potential neurophysiological mechanism of action. However, this is not conclusive as the only SNS measure that consistently changed was skin conductance. Skin conductance has been reported to be a less reliable measure of SNS activity as it can be affected by psychological and personality factors (Scerbo et al., 1992).

Thus, to support or refute a neurophysiological mechanism, the authors wished to determine whether MWM resulted in changes in another measure of nervous system processing. Currently, no other neurophysiological measures have been investigated in MWM research. Since MWM is proposed to act via the sensory nervous system, specifically large Aβ afferents, a sensitive measure of sensory processing in response to MWM may offer an alternative neurophysiological measure.

A current measure of sensory nervous system processing is vibration threshold, defined as the smallest displacement that can be detected by an individual (Gandhi et al., 2011). Mechanical deformation of the skin is detected by cutaneous receptors that produce an action potential discharge. This is conducted via large diameter Aβ afferents to the central nervous system, where it is perceived as vibration sense (Gandhi et al., 2011). Traditionally, vibration threshold has been used to detect early signs of nerve damage, specifically large Aβ afferents in the peripheral nervous system (Greening and Lynn, 1998). More recently, it has been used to quantify changes in sensory processing in patients with musculo-skeletal pain (Laursen et al., 2006). Several studies have shown vibration threshold to be a sensitive measure of changes in peripheral and central sensory processing in musculoskeletal conditions (Laursen et al., 2006; Shakoor et al., 2008; Chien et al., 2009). Only one study has previously investigated the effects of a manual therapy intervention on vibration threshold (Ridehalgh et al., 2005). The authors aimed to determine whether mechanical nerve examination and treatment procedures had a detrimental effect on sensory nerve function in the lower limb. Thirty asymptomatic

subjects underwent a straight leg raise (SLR) examination followed by 3 x 1 min SLR mobilisations. No significant differences in vibration threshold between baseline and post-intervention were reported ($P = 0.5$), indicating these techniques do not effect the function of large diameter afferents in asymptomatic individuals.

To date, no studies have used vibration threshold as a measure of sensory nervous system processing following a joint based manual therapy technique. Thus, the aim of this study was to examine the effect of a MWM on vibration threshold in asymptomatic individuals compared to a placebo and control intervention. For the purposes of this study, a lateral glide hip MWM was chosen. This is a popular intervention used by physiotherapists for treating hip pain (French, 2007), and a recent RCT reported significant improvements in pain, hip range of motion, and functional performance compared to sham MWM in symptomatic hip osteoarthritis (Beselga et al., 2016).

Methodology

A single-blinded, randomised, within-subject, placebo, control design was adopted to eliminate subject variability and reduce the effect of researcher and intervention-order bias (Sims and Wright, 2000). Ethical approval was obtained from Coventry University's Research Ethics Committee.

Participants

A convenience sample of fifteen asymptomatic volunteers (10 males and 5 females) aged 23-35 years (mean = 28.07; SD = 4.23) with a mean Body Mass Index (BMI) 24.46 kg/m2 SD 3.79 were recruited via invitation. This sample was chosen because neurophysiological responses to MWM have been reported in a similar sized asymptomatic population (Moulson and Watson, 2006). Participants were included if they were a Coventry University student or staff member, and physically able to complete the testing procedure i.e. mobilise on/off a plinth, sit for fifteen minutes, and lie supine for a minimum of thirty minutes. Participants were excluded if they had any current or previous musculoskeletal disorder of the lumbar spine or lower limbs, any neurological impairment, or diabetes as these have all been shown to affect vibration testing (Gandhi et al., 2011). Other exclusions included previous therapy to the hip joint to minimise expectation bias, and contraindications to manual therapy of the hip including malignancy, infection, haemophilia, bone disease, fracture, soft tissue disease, and aversion to manual contact (Paungmali et al., 2003).

Outcome measure and equipment

Vibration threshold (VT) was the outcome measure for this study as it reflects the entire somatosensory pathway (Gerr et al., 1991), is responsive to changes in sensory nervous system processing (Laursen et al., 2006) and has been shown to be a reliable and valid method of measuring nerve function (Mythili et al., 2010).

A Vibrameter (Somedic AB, Sweden) with a constant frequency of 120 Hz was used to measure vibration threshold. This has been validated against the tuning fork using Pearson's Product Moment Correlation (0.515-0.634) for the assessment of vibration sense in asymptomatic subjects (O'Conaire et al., 2011), and has demonstrated good intra-rater reliability (ICC = 0.55-0.99) (Peters et al., 2003), and inter-rater reliability (ICC = 0.538-0.915) (O'Conaire et al., 2011). The standard error of measurement has been reported as ±0.29 μm (O'Conaire et al., 2011).

Methods

All participants were given written information prior to the study explaining the testing procedure and consent was gained via a signed consent form. All participants attended one testing session in a temperature-controlled laboratory at Coventry University. The right leg was investigated, as leg dominance has been reported to have no effect on vibration threshold in asymptomatic individuals (Urban et al., 1995). Demographic details including sex, age, and body mass index were recorded as these factors can account for individual differences in vibration threshold (Gandhi et al., 2011). Baseline measurements for vibration threshold were then recorded. For this, participants were positioned supine with the right knee flexed to 90°, their head supported on one pillow and left leg fully extended. The anterior tip of the lateral femoral condyle was identified by palpating lateral to the patella, as described by Field and Hutchinson (2006), and marked with a cross using washable ink. This bony site was chosen for vibration testing as it lies within a hip joint referral

pattern (Lesher et al., 2008) and has been used in previous studies (Shakoor et al., 2008). Participants were then familiarised with the Vibrameter through a practice test on the first metacarpophalangeal joint of the right hand prior to testing the lateral femoral condyle. The protocol used was identical to the experimental procedure and is described below (Somedic, 2004).

The operator placed the probe on the lateral femoral condyle perpendicular to the skin surface (Fig. 1), ensuring the application of pressure equalled the weight of the probe, indicated by the feedback display on the machine. An assistant initiated and increased the vibration amplitude at a set rate. Participants said “now” at the point vibration was perceived – the Vibration Perception Threshold (VPT). Readings were recorded by another researcher who was blinded to the testing protocol. The Vibration Disappearance Threshold (VDT) was determined by decreasing vibration amplitude at a set rate until participants said “now” at the point vibration disappeared. Vibration threshold was then calculated as the mean of the VPT and VDT. Three measures were taken to calculate the mean vibration threshold (O'Conaire et al., 2011). The operator and participants were blinded to the vibration amplitude to reduce the risk of bias.

Following familiarisation with the testing procedure, participants underwent the first of the three conditions allocated in a random order via a computer-generated number table. These were a lateral-glide MWM with a mobilisation belt of the hip into flexion (Mulligan, 1996), a placebo technique, and control intervention. A musculoskeletal physiotherapist with 7 years clinical experience performed these three procedures. For the MWM, participants were positioned supine on the plinth with their right knee flexed to 90°, and therapist standing on the right. A mobilisation belt was placed as high as possible around their right thigh and fully aroundthe therapist – just below his hips as described by Mulligan (1996) (Fig. 2). His left hand was placed on the participant's right ilium to counter a lateral force, which was applied via the belt. The amount of force was determined by the therapist (Moutzouri et al., 2012). The therapist's right hand was placed on the subject's lower leg and the subject was instructed to bend the hip towards the chest as far as comfort permitted and return to the starting position. Three sets of ten repetitions with a thirty-second rest between sets were performed, as described by Mulligan (1996). The placebo technique was identical to the MWM, but no force was applied through the belt. Both these interventions lasted two minutes and thirty seconds, measured by a digital timer. The control intervention required participants to lie supine with the right knee flexed to 90° and left leg extended, for two minutes and thirty seconds with no manual contact from the therapist.

Immediately following each intervention, VT was re-measured, as previously described. This procedure was repeated until all three interventions had been received and VT measurements recorded. Between each intervention, participants sat in an upright chair for 15 min to minimise a carryover effect. This period of time was chosen for pragmatic reasons, as the washout period for MWM and vibration testing of the hip is unknown. One previous study reported no statistically significant carryover effect immediately following a lumbar spine MWM in a crossover design (Konstantinou et al., 2007).

Data analysis

Data were analysed using the SPSS statistical package (version 20). The change in VT between baseline and post-intervention was calculated for each intervention and used for analysis. The conditions for a one-way analysis of variance (ANOVA) statistical test were satisfied and a significance level was set at $P \leq 0.05$ (Hicks, 1999).

Results

All fifteen participants successfully completed the study. Demographic data of the participants is summarised in Table 1.

There was a small, insignificant decrease in VT from baseline in all three conditions (Table 2 and Fig. 3), which was greater in the placebo and MWM conditions, respectively.

A one-way ANOVA revealed no statistically significant differences between the three interventions ($P = 0.812$). Therefore, a lateral glide MWM of the hip joint did not significantly change the vibration threshold in 15 asymptomatic participants compared to a placebo and control intervention.

Discussion

This small study did not find a significant change in vibration threshold following a lateral glide MWM of the hip compared to a placebo and control intervention in an asymptomatic population. The mean vibration threshold for all three experimental conditions demonstrated a small, non-significant decrease compared to baseline, which was greater in the placebo and MWM conditions, respectively. However, these differences are within the reported standard error of measurement of the Vibrameter (±0.29 mm) (O'Conaire et al., 2011), and therefore do not represent a reliable change.

Comparisons with previous studies exploring the neurophysiological effects of MWM are difficult due to the different outcome measures used. For example, a consistent increase in skin conductance was reported in response to spinal (Moulson and Watson, 2006; Moutzouri et al., 2012) and peripheral joint (Paungmali et al., 2003) MWM techniques. This is proposed to represent an excitatory response in the sympathetic nervous system (Moulson and Watson, 2006), supporting a neurophysiological mechanism of action. In contrast, this study used vibration threshold to evaluate changes in sensory processing following MWM, and found no significant differences compared to placebo and control conditions.

Our findings are consistent with Ridehalgh et al. (2005), who reported no significant change in vibration threshold immediately following a manual lower limb nerve mobilisation procedure in asymptomatic subjects. This is despite differences in the type of mobilisation used between the studies, i.e. nerve-based verses joint-based. Thus, our study adds to the findings of Ridehalgh et al. (2005) that manual mobilisation procedures targeting both nerve tissue and the hip joint do not have an effect on sensory processing in the lower limb in asymptomatic individuals.

There are several potential explanations for the findings of our study. Firstly, vibration threshold may not be a sensitive enough measure of neurophysiological response within an asymptomatic population. For example, Ridehalgh et al. (2005) used an asymptomatic population and reported no differences in vibration threshold following manual nerve mobilisation techniques. This is in contrast to studies investigating SNS responses that have shown significant differences following MWM within asymptomatic populations (Moulson and Watson, 2006; Moutzouri et al., 2012).

Alternatively, it may be that study limitations did not allow for a large enough change in vibration threshold to be apparent. The authors acknowledge that this study is limited by the small sample size that may not have detected small effect sizes. In addition, the fifteen minute washout period may not have been sufficient time to prevent any carryover effect from each intervention, potentially diluting any significant responses. Previous research on carryover effect is limited to one study that reported no significant carryover effect immediately following a lumbar spine MWM technique (Konstantinou et al., 2007). Currently, the washout period for MWM of the hip joint is not known.

This small scale study was the first to use vibration threshold as an alternative method of investigating the neurophysiological effects of a manual therapy intervention. Further research is recommended to explore the effect of MWM on vibration threshold within a larger, symptomatic population.

Conclusion

Vibration threshold may be an alternative measure of neurophysiological response to manual therapy interventions. This small study found that a lateral glide MWM of the hip did not significantly change vibration threshold compared to a placebo and control intervention in an asymptomatic population. This study provides a method of using vibration threshold to investigate the potential neurophysiological effects of a manual therapy intervention that should be repeated in a larger, symptomatic population.

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Conflicts of interest

None.

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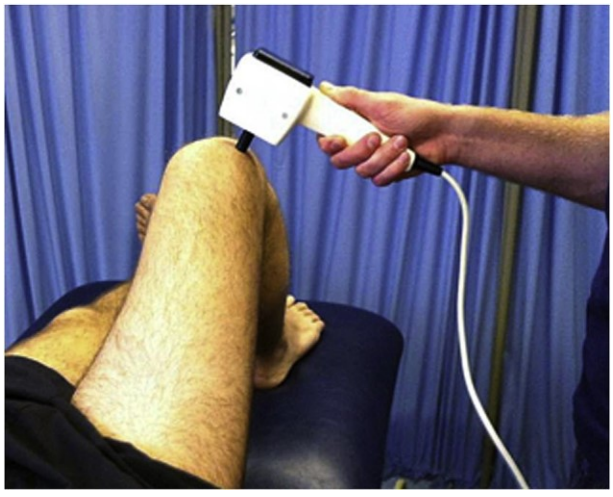

Fig. 1. Vibrameter placement on the lateral femoral condyle of the right leg.

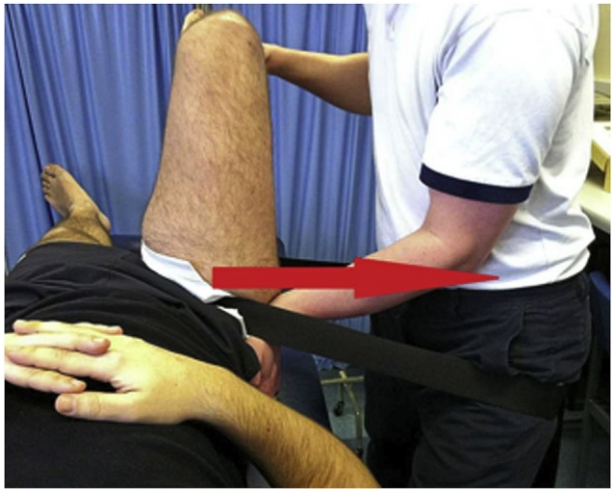

Fig. 2. The lateral glide mobilisation with movement of the hip into flexion. Arrow denotes direction of passive accessory glide.

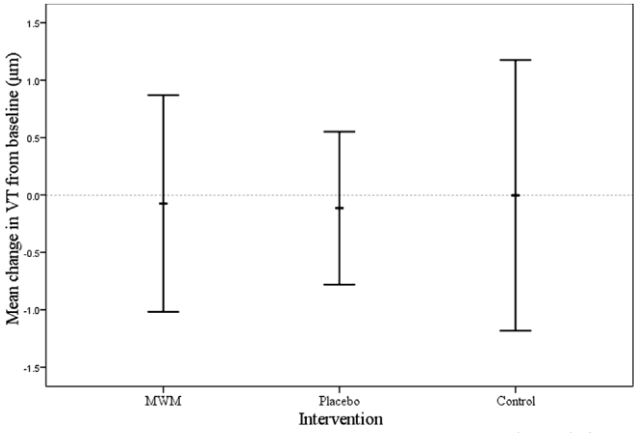

Fig. 3. Mean change in vibration threshold (mm) from baseline for each intervention (n ¼ 15). Error bars represent ± 2 SD.

Table 1
Demographic data of participants (n ¼ 15).

Variable	Mean	SD	Range
Age (y)	28.07	4.23	23e35
Height (cm)	168.01	9.83	156e186
Weight (kg)	67.67	16.41	44.1e102.4
BMI (kg/m2)	24.46	3.79	18.1e33.7
Sex	10 males, 5 females		

Table 2
Mean change in VT from baseline for each intervention (n ¼ 15).

Intervention	Mean change in VT from baseline (mm) ± SD
MWM	0.074 ± 0.47
Placebo	0.115 ± 0.33
Control	0.003 ± 0.59