

Effects of Spinal Mobilisations on Lumbar and Hamstring ROM and sEMG: A Randomised Control Trial

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ABSTRACT

Introduction: This study aimed to compare the immediate effects of Posterior Anterior (PA) L4 and L5 mobilisations on range of motion and muscle activity measures in the lumbar and hamstring regions of asymptomatic individuals.

Methods: Thirty-eight participants were randomly allocated to a mobilisation (n=20) or control (n=18) group. The mobilisation group received central PA mobilisations to the L4 and L5 vertebrae, three times for two minutes. The control group received no mobilisation. Pre- and post-test measures included lumbar range of motion, measured by the modified Schober test and hamstring extensibility by the active knee extension test. Local Erector Spinae and Biceps Femoris muscle activation were also measured by surface Electromyography. Data were analysed using magnitude-based inferences.

Results: Lumbar mobilisations had a *most likely beneficial effect* on active lumbar flexion 18.6% (90% CL 11.8% \pm 25.8%) and active knee extension range 22.8% (-29.6% \pm 15.2%). Mobilisations had a *possible beneficial effect* in sEMG activation reduction of the Erector Spinae -4.7% (-10.5% \pm 1.4%) and Bicep Femoris -6.1% (-13.1% \pm 1.6%) during lumbar flexion. *Likely beneficial effects* of reduced sEMG were found following mobilisations during the active knee extension test for the Erector Spinae -18.3% (-27.7% – 7.6%) and Biceps Femoris muscle activity -20.8% (-30.9% \pm 9.2%).

Discussion: L4 and L5 mobilisations increase lumbar and hamstring range of motion in the immediate term. Our unique finding was that, in this sample population, muscle activity in both local Erector Spinae and Biceps Femoris reduced, most likely due to the mobilisations applied.

Key Words: Lumbar, Hamstrings, Mobilisations, sEMG

INTRODUCTION

Hamstring strains are one of the most common musculoskeletal injuries suffered within high-intensity intermittent sports ^[1-3]. The rehabilitation of hamstring strains continues to be problematic with no universally accepted rehabilitation programme; however the lumbar spine has been suggested as a pertinent area to treat as part of a multifactorial approach ^[4-7]. Evidence exists to support the efficacy of lumbar mobilisations to reduce spinal pain and restore mobility ^[8-12]. Furthermore, PA (Posterior Anterior) mobilisations have also produced increases in posterior chain neurodynamics and hamstring extensibility in a general population ^[13-14] and elite footballers ^[15]. This provides some evidence for the lumbar spine's ability to influence the hamstring complex.

Despite spinal mobilisations improving posterior neurodynamics, the mechanism of how this conservative treatment affects hamstring muscle activity has yet to be investigated. Neurophysiological responses to mobilisations have been suggested to involve centrally-mediated processes ^[16-19]. Research has focused on local muscle changes following PA mobilisations with Krekoukias et al ^[22] reporting reductions in the average sEMG (surface Electromyography) activity of the lumbar erector spinae. Taylor et al ^[23] and Sterling et al ^[24] have all reported decreased local muscular activity following central mobilisations. The metabolic activity within the hamstring complex is higher post hamstring injury compared to a non-injured control ^[25]. However, the ability for lumbar mobilisations to decrease the activity of distal muscle groups such as the hamstring complex has yet to be investigated.

Lumbar mobilisations may offer the clinician a method of treating the hamstring group indirectly, in the acute injury stage, where traditional rehabilitation techniques including strength training and flexibility are restricted due to local tissue pathology ^[26-27]. Accordingly, due to the current lack of evidence, the aim of our study was to investigate and quantify the potential effect of central PA lumbar mobilisations on active lumbar flexion range, hamstring extensibility and surface electromyography activity of the Erector Spinae and Biceps Femoris.

METHODOLOGY

Population

An original population of forty-five participants were recruited from staff and students at Teesside University, United Kingdom. Recruitment took place between May 2014-February 2015. Table 1 displays the sample descriptions of both testing groups.

Table 1 – Description statistics for intervention and control groups

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Participants were included if they were aged over eighteen, without current spinal or lower limb pathology. All participants were required to complete a medical questionnaire prior to testing. Exclusion criteria included current symptomatic low back pain, hamstring or hip pathology. Previous neurological disorders or current neurological symptoms also prevented inclusion. A history of lumbar surgery or any contraindication to spinal mobilisation prevented participation ^[28]. Following screening thirty-eight participants were eligible for inclusion. The study was granted ethical approval from Teesside University Research Ethics Committee (SSSBLREC230616).

Protocol

This study involved a randomised controlled trial pre-test/post-test parallel groups design to investigate the effects of central PA lumbar mobilisations on measures of lumbar and hamstring range of motion and muscle activity. This reporting will follow recommendations from CONSORT for publishing non-pharmacologic intervention studies ^[29]. Participants were electronically randomised by concealed allocation to the intervention or control groups, via a blind assessor, without restriction to replicate clinical practice. Outcome measures taken at initial assessment included active lumbar flexion (ALF), active knee extension (AKE) and sEMG of the Erector Spinae and Biceps Femoris. All outcome measures were recorded by an assessor blinded to group allocation. sEMG during ALF and AKE were recorded together with resting potential. The order of the ALF and AKE were

counterbalanced to prevent the order of assessment adversely influencing measurements. The study took place within a biomedical sciences laboratory at Teesside University at same time of day preventing diurnal differences.

Pre-conditioning

A pilot study conducted with six participants reported four ALF and AKE were required to counteract against variations in tissue extensibility [30-31]. The final ROM (range of motion) on the 4th repetition was recorded as the pre-intervention measurement. A 20-min period was required for the clinician to explain, identify and perform lumbar mobilisations prior to re-testing.

Lumbar Mobilisations

Participants allocated to the intervention group received central PA lumbar mobilisations to the L4 and L5 vertebrae segments. Participants lay prone on a plinth which was placed upon two force plates measuring the mobilisation force. The force applied during the mobilisation protocol was an average force of $104.18\text{N} \pm 11.2$ in line with previous studies for a grade three PA mobilisation [22]. Grade three mobilisations were applied to the intervention group by a physiotherapist with 9 years' clinical experience and postgraduate manual therapy qualifications. The mobilisation was performed for two minutes, three times alternating between L4 and L5, without rest in between [28,32]. Each vertebra level was determined by the palpation of relevant spinous processes and passive physiological intervertebral movement. The mobilisations were applied at a frequency of 1Hz maintained by a metronome. Force plate data was recorded at 500Hz above the frequency of the mobilisations preventing sampling errors.

The control group following pre-measurement lay in prone on a plinth for the twenty minute interval determined by the pre-conditioning study. Post intervention and control ALF and AKE were re-assessed immediately via a single test with measurements taken. The reassessment process took approximately three minutes per participant.

Active Lumbar Flexion Measurement

The modified Schober (mSchober) test was performed to measure lumbar flexion. The mSchober test has been reported to obtain high reliability and has been recommended as an appropriate clinical evaluation tool of lumbar spinal motion [33-34]. The mSchober test was performed with the participant standing on a wooden box 60cm in height with feet positioned 8cm apart indicated by tape. The lead researcher, via a skin marker, identified one point 5cm below and one point 10 cm above the lumbosacral junction, determined by a passive physiological intervertebral movement [28, 34]. Participants were instructed to actively flex forward as far as possible, whilst keeping the knees extended, and to maintain this position until instructed to return to neutral. The distance between the two skin marks was measured by a tape measure (seca Germany) in centimeters pre and post-test with the difference recorded as the range of lumbar flexion.

Active Knee Extension Measurement

Active hamstring extensibility of the dominant leg determined by kicking foot was assessed via the AKE test, a reliable method of measuring hamstring tissue extensibility [35-37]. Participants lay supine on a padded plinth secured by a 5 centimeter mobilisation belt placed across the anterior superior iliac spine. Another mobilisation belt was placed 20 centimeters above the tibial tuberosity preventing motion of the non-dominant/testing leg [38]. The belt positions were marked for re-measurement purposes. A purpose made wooden wedge provided a right angle surface to ensure the hip was supported at 90 degrees. Hamstring extensibility was tested till the end of maximal range determined by the participant and was acknowledged by a manual trigger [39]. An inclinometer (Dr Rippstein, Zurich, Switzerland) recorded positional change and was placed on the anterior tibial border midway between the inferior pole of the patella and the line between the malleoli [40]. The ankle was maintained in plantigrade by a medical brace.

EMG Application

sEMG of the Bicep Femoris and Erector Spine was recorded on the participant's dominant side. As the most common hamstring tendon injured, Biceps Femoris, was chosen for EMG application [41].

These superficial muscles provide an accurate recording, clearer signals and reduce potential issues with sEMG cross talk ^[42]. sEMG was recorded for 10 seconds at rest pre and post intervention in prone, at end range of ALF and AKE pre and post intervention and control. Average values for the 10 seconds were used for analysis. Recording in a static position eliminated any movement artefact noise originating at the electrode-skin interface.

Prior to the bipolar electrode application the area of skin was shaved and cleaned with a 70% isopropyl alcohol wipe. Noraxon, self-adhesive Ag/AgCl snap electrodes (Noraxon USA) were then applied providing a stable transition with low noise ^[43]. Noraxon electrodes have an inter electrode space of 20mm and were placed on the relevant muscle tissue in accordance to Seniam recommendations ^[43]. The position of the electrode for the Erector Spinae (longissimus) was placed two finger widths lateral to L1. The electrode for the Biceps Femoris was placed on the line half way between the ischial tuberosity and the lateral epicondyle of the tibia. Electrodes remained in position throughout the testing procedure minimising potential electrode placement error.

EMG Data Collection and Filter

The sEMG was recorded at 2000Hz using the Cometa wave wireless EMG system. The A/D data logger converted the collected data at 2000HZ for each intervention. The sEMG signal was processed and filtered using Cometa v1.6 software. The data was processed using a high pass Butterworth filter with a cut off frequency of 20Hz ^[43-45].

The data was rectified and smoothed using a RMS filter with a floating window of 20ms ^[22, 46, 47]. The zero wire system eliminated any cable motion artefacts that could contaminate the sEMG signal. This study compared low level sEMG data, which is inherently unstable, and therefore no Maximum Voluntary Contraction (MVC) was recorded. Recording MVC would have increased muscle activity potentially influencing data recorded at rest, during ALF and AKE ^[48]. Within a data collection session where no individual changes to the configuration of the EMG set-up (electrode placement, amplification, filtering) has taken place and whilst under constant temperature and humidity conditions EMG data does not need to be normalised against a MVC to be interpreted ^[49-50].

Statistical Analysis

Raw data is presented as the mean \pm SD. Before analysis, data were log transformed and then back transformed to obtain the difference between lumbar flexion range, hamstring extensibility and sEMG of the lumbar extensors and Bicep Femoris as accurate percentages. This method also reduced the error rising from non-uniform residuals. The use of the P value alone fails to provide information about the direction, effect size or the range of feasible values ^[51]. We therefore used the magnitude-based inference approach to examine the range of motion change in the lumbar spine and hamstring, sEMG activity in the local lumbar extensors and biceps femoris following PA lumbar mobilisations. Effect sizes of 0.2, 0.6, and 1.2 multiplied by the pooled between-participant SD were considered small, moderate and large, respectively ^[52], with uncertainty of the estimates shown as 90% confidence intervals. Subsequently, inference was based on the disposition of the confidence interval for the mean difference to this smallest worthwhile effect (0.2 of the between-subject SD); the probability (percent chances) that the true population difference between pre- and post-test, and also the pre-post intervention-control difference is substantial ($>$ smallest worthwhile effect) or trivial was calculated as per the magnitude-based inference approach ^[53]. These percent chances were qualified via probabilistic terms assigned using the following scale: 0.5%, most unlikely or almost certainly not; 0.5–5%, very unlikely; 5–25%, unlikely or probably not; 25–75%, possibly; 75–95%, likely or probably; 95–99.5%, very likely; and .99.5%, most likely or almost certainly ^[54]. Inferences were categorised as clinical, with the default probabilities for declaring an effect clinically beneficial being $<0.5\%$ (most unlikely) for harm and $>25\%$ (possibly) for benefit. All data were analyzed using a custom-made spread sheet ^[53].

RESULTS

The baseline outcome measures, along with effect statistics and inferences for the within- and between-treatment comparisons are presented in Table 2. Outcome measures were obtained from all thirty-eight participants. After controlling for baseline imbalances and test order, the

application of lumbar mobilisations had a *most likely beneficial effect* on active lumbar flexion 18.6% (90% CL 11.8% \pm 25.8%) and active knee extension range 22.8% (-29.6% \pm 15.2%).

During ALF mobilisations had a *possible beneficial effect* of reduction in sEMG activation of the Erector Spinae -4.7% (-10.5% \pm 1.4%) and Bicep Femoris -6.1% (-13.1% \pm 1.6%) when directly compared to the control condition. *Likely beneficial effects* were found following the intervention in sEMG during the AKE for the Erector Spinae -18.3% (-27.7% – 7.6%) and Biceps Femoris muscle activity -20.8% (-30.9% \pm 9.2%). No harm or unintended effects were reported.

Table 2 - Outcome measures at baseline with effect statistics and inferences for within- and between-group comparisons

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DISCUSSION

The effective treatment of the hamstring region continues to be one of the most difficult within sports medicine. Lumbar spine mobilisations are a conservative technique used by clinicians to treat not only the lumbar region but the hamstring complex, despite a lack of evidence to support its effectiveness. Therefore, this randomised control trial aimed to investigate the effects of central PA lumbar mobilisations on range of motion and muscle activation of the Erector Spinae and Biceps Femoris. PA mobilisations had a *likely beneficial* increase in range of motion in the ALF and AKE tests. Following L4 and L5 mobilisations a *possible beneficial effect* on the reduction of sEMG activity of the Erector Spinae and Biceps Femoris was reported compared to the control. A *likely beneficial effect* in the reduction of both the Erector Spinae and Biceps Femoris occurred during the AKE test following the intervention. Accordingly, this is the first study of its kind to report changes in the ROM and sEMG activity of both the Lumbar and Hamstring following spinal mobilisations.

A key and unique finding of this study is the beneficial effect of central PA L4 and L5 mobilisations on hamstring range and Biceps Femoris sEMG activity. Chesterton et al ^[15] reported an increase in hamstring range following spinal mobilisations; however the underlying mechanisms were not investigated. This study suggests that range increases in the hamstring are also associated with sEMG activity reduction. Local reduction in sEMG has been observed by Krekoukias et al ^[22] and Pentelka et al ^[54] in the Erector Spinae following PA mobilisations to the lumbar region. Both studies findings are consistent with findings following mobilisations to the temporomandibular joint ^[23] and the cervical spine ^[24]. sEMG reduction in these studies have been linked to decreased associated pain and increased range of motion. Perry and Green ^[55] concluded that unilateral lumbar mobilisations result in side-specific peripheral sympathetic nervous system changes. Therefore, neurophysiological and anatomical inter-relationships within the lumbar spine exist and can be externally modulated through the application of mobilisation.

A number of mechanisms for this sEMG reduction have been described previously within the literature. Following passive mobilisations muscle spindle activity may increase, stimulating golgi-tendon organ activity and in turn produce a muscle reflex inhibition ^[56-58]. A hypoalgesic response has also been found following mobilisation to the cervical spine ^[24, 59-61], the knee ^[62] and shoulder ^[63]. This study suggests these changes may be found in the hamstring following PA lumbar mobilisations.

These results provide clinicians with a clearer understanding of the effect mobilising the lumbar spine has on the hamstring muscle group. Despite this asymptomatic population this type of conservative technique has the potential to be employed as part of a wider holistic approach to hamstring management. Clinicians have been advised to account for complex neuromuscular mechanisms within the hamstring complex, with the quantity of hamstring muscle activation and recruitment critical to injury risk ^[25]. Increased activation has been linked to hamstring injury causing premature fatigue. Therefore, decreasing muscle activity and increasing extensibility, may have a role in prevention and rehabilitation, especially in the lumbar related hamstring described by Orchard et al ^[64].

Furthermore, this study also suggests L4 and L5 central PA mobilisations have the ability to increase spinal ROM in the immediate term. These results are in contrast to Petty ^[65], Chiradejnant et al ^[66 -67] and Stamos-Papastamos et al, ^[32] who all found no significant effect of lumbar mobilisations on range of motion. However, both Powers et al ^[68] and McCollam and Benson ^[69] both have reported increases in ROM post mobilisation. Powers ^[68] reported an average increase of 17.8% compared to 7.1% by McCollam and Benson ^[69]. The actual range required to be deemed clinically significant has yet to be identified but importantly all studies do not have a follow-up to understand the treatments longevity. The current study differs in intervention dose from Powers ^[68], two minute spinal mobilisations at one vertebral level, and McCollam and Benson ^[69], three one minute applications at L3, L4 and L5. The vast number of variables including study design, technique, grade, dose and level of mobilisation mean that study comparison is difficult. At least one key differing variable is found within each design, and careful consideration of methodology is required for future studies to allow direct comparison.

Limitations and Future Research

This study was conducted on asymptomatic participants and therefore the ability for lumbar PA mobilisations to influence the ROM and sEMG activity of symptomatic individuals remains unknown. Only immediate effects were investigated due to the study objectives and therefore conclusions of the short and medium term effects of the intervention are unidentified. These limitations in themselves pave the way for future research on mobilisations assessed in symptomatic participants across short, medium and long-term timeframes. Optimal dose, grade and level of mobilisation need further research for a deeper understanding of how lumbar mobilisations may support hamstring management. The study was not powered and therefore it is appropriate to interpret the conclusions generated with this understanding. The application of sEMG itself has limitations. The quality of sEMG signal can be affected by external noise, the pickup of electrical activity of adjacent muscle, the amount of active motor units at the time of recording and the depth of adipose tissue the signal has to travel through ^[70].

Implications

Mobilisations continue to form part of the management of patients with lumbar spine and hamstring pathology. The results of this study suggest PA lumbar mobilisations decreased the muscle activity of both the Erector Spinae and Biceps Femoris. Functionally, the mobilisations resulted in an increase of lumbar and hamstring range of motion compared to a control. As part of a multifactorial approach to hamstring management lumbar mobilisations, as a conservative treatment technique, have the capacity to influence the hamstring complex.

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Table 1 – Description statistics for intervention and control groups

	Intervention Group (n = 20)	Control Group (n = 18)
	Mean ± SD	Mean ± SD
Age (years)	3 ± 11	27.1 ± 4.09
Height (cm)	172 ± 13	173.1 ± 9.9
Body Mass (kg)	71 ± 15	72 ± 18

Table 2 - Outcome measures at baseline with effect statistics and inferences for within- and between-group comparisons

Outcome Measure	Within-Group Changes						Between-Group (intervention-control) Differences	
	Mobilization (n=20)			Control (n=18)			Change score (% mean; ±90% CL)	Qualitative inference
	Baseline values (mean ± SD)	Change score (% mean; ±90% CL)	Qualitative inference	Baseline values (mean ± SD)	Change score (% mean; ±90% CL)	Qualitative inference		
ALF ROM	5.69 ± 1.31	18.3 ± 6	Small Effect; Mostly likely Beneficial	6.01 ± 1.79	0.3 ± 1.1	Small effect; Most Likely Trivial	18.6 (11.8 ± 25.8)	Large Effect; Likely Beneficial
ALF EMG Erector Spinae	5.56 ± 1.12	-5.3 ± 0.8	Small Effect; Likely Beneficial	6.76 ± 2.55	-0.6 ± 0.3	Small effect; Most likely Trivial	-4.7(-10.5 ± 1.4)	Moderate Effect; Possible Beneficial
ALF EMG Bicep Femoris	5.82 ± 1.52	-4.3 ± 7.9	Large Effect; Likely Beneficial	5.69 ± 2.1	1.9 ± 1.7	Small Effect; Most Likely trivial	-6.1 (-13.1 1.6)	Small Effect; Possible Beneficial
AKE ROM	30.9 ± 10.41	23.2 ± 9.6	Large Effect; Likely Beneficial	33.85 ± 10.93	-0.6 ± 1.4	Small Effect; Most Likely Trivial	22.8 (-29.6 ± 15.2)	Large Effect; Likely Beneficial
AKE EMG Erector Spinae	7.30 ± 5.16	16.2 ± 12.9	Small Effect; Very Likely Beneficial	8.47 ± 4.44	2.6 ± 2.3	Small Effect Most Likely Trivial	-18.3 (-27.7 ± 7.6)	Small Effect; Likely Beneficial-
AKE EMG Bicep Femoris	11.8 ± 8.21	-21 ± 14.7	Small Effect; Likely Beneficial	11.54 ± 5.67	-0.3 ± 0.6	Small Effect Most Likely Trivial	-20.8 (-30.9 ± -9.2)	Small Effect; Likely Beneficial

