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# Does the choice of spinal level treated during posteroanterior (PA) mobilisation affect treatment outcome?

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The purpose of this study was to establish whether posteroanterior (PA) mobilisation is more effective in relieving low back pain (LBP) when the treatment is delivered to the level identified by the therapist as responsible for the LBP, than when delivered to a randomly selected level. One physiotherapist and 120 subjects suffering LBP participated. Prior to treatment allocation, baseline measurements were taken. The therapist then assessed subjects and nominated the preferred treatment grade and spinal level to be treated. The subjects were then randomly allocated to one of two groups; Group 1 received the treatment at the level identified by the therapist as responsible for the symptoms, whereas Group 2 received treatment at a random lumbar level. In both groups the originally nominated treatment grade was used and all subjects received one treatment session with follow-up measures taken immediately after intervention. Two-way analysis of variance (ANOVA) was used to analyse the data; the first factor was treatment group and the second factor was the direction of the patient's worst movement. There was greater reduction in pain intensity when the mobilisation was applied to the symptomatic level rather than to a randomly assigned level ($F_{1,114} = 4.504$, $p = 0.036$). There was also an interaction effect on pain reduction between the two factors ($F_{2,114} = 3.301$, $p = 0.04$). The results of this study confirm that the level treated is a determinant of the immediate analgesic effect of PA mobilisation treatment for LBP. Other parameters of treatment dose such as the direction, peak force, and frequency of PA mobilisation await formal investigation.

**Keywords:** Low back pain, spiral manipulation, physical therapy

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## INTRODUCTION

Approximately 70% of people experience low back pain (LBP) during their lifetime (Frymoyer, 1988). In most cases the origin of the LBP symptoms remains unknown and the condition is described as LBP of unknown origin or nonspecific LBP (NSLBP) (Frymoyer, 1988; Riddle, 1998; Waddell, 1998). Between 10 and 50% of patients with LBP are referred to physiotherapists (Van Der Valk, Dekker, and Van Baar, 1995). There are a number of physiotherapy treatments offered to LBP patients including exercise therapy, massage, ergonomic advice, electrotherapy, and spinal manipulative therapy (SMT). SMT includes both manipulation and mobilisation (Shekelle et al, 1992; Maitland, Hengeveld, Banks, and English, 2001). One of the most frequently used mobilisation techniques for patients with NSLBP is the central posteroanterior (PA) pressure (Maitland et al, 2001). During the application of this technique, a therapist manually applies a force to the skin overlying a patient's spinous process while the patient lies prone.

Although the effects of PA mobilisation have been examined, most studies have used cadaveric specimens or subjects without LBP (Lee and Evans, 1991, 1992a; 1992b, 1994; McCollam and Benson, 1993; Petty, 1995). Previous studies by Lee and Evans (1991, 1992a, 1992b, 1994) investigating the biomechanical effects of SMT have found that PA mobilisation produces extension moments and shear forces to lumbar motion segments. An in vivo study by Lee and Evans (1997) noted that a 150 N static force applied to the $L_4$ spinous process caused the upper motion segments to extend whereas $L_5/S_1$ tended to flex.

A number of randomised controlled trials in subjects with LBP have demonstrated the efficacy of SMT in reducing pain (Triano, McGregor, Hondras, and Brennan, 1995; Goodsell, Lee, and Latimer, 2000; Sanders, Reinert, Tepe, and Maloney, 1990), and increasing range of motion and improving disability (Farrell and Twomey, 1982; Koes et al, 1992; Nwuga, 1982). Only one study has investigated the efficacy of PA mobilisation in subjects with LBP (Goodsell, Lee, and Latimer, 2000) concluding that PA mobilisation was effective in reducing pain on the patients' worst movement. However, the manner in which PA mobilisation or SMT produces these effects is not well understood.

It has been suggested that in order to produce the best outcome for patients with NSLBP therapists should deliver SMT to the most symptomatic spinal level (Maitland et al, 2001). Therefore, it is recommended that therapists perform passive accessory motion testing to identify the most symptomatic level and then apply manual treatment to this level (Maitland et al, 2001). Applying treatment to this level is thought to produce better results than when treatment is applied to an adjacent or more remote spinal level, although there is no scientific evidence supporting this empirical recommendation. The aim of this study therefore, was to establish whether PA mobilisation is more effective in relieving LBP when the treatment is delivered to the level identified by the therapist as the most symptomatic spinal level, than when delivered to a randomly selected level.

## METHOD

A randomised controlled trial with blind outcome assessment was undertaken where one manipulative physiotherapist treated 120 subjects with NSLBP. The immediate effect of central PA mobilisation on pain and range of motion was investigated using a factorial design with two independent variables (group intervention [2 levels] and the patient's worst movement direction [3 levels; lumbar flexion, extension, and lateral flexion]). Patients suffering LBP were randomly assigned, using concealed allocation, to either receive central PA mobilisation at the most symptomatic spinal level or to receive central PA mobilisation to a randomly selected lumbar spinal level. All measures of outcome were performed by an investigator who was blind to group allocation.

## Subjects

### *Physiotherapist*

A qualified manipulative physiotherapist with 21 years clinical experience working in private and private hospital physiotherapy practices in Sydney and remote NSW, Australia, performed the treatments in this study.

### *Patients*

One hundred and twenty NSLBP patients (71 males, 49 females) with a mean age of 41.2 years (*SD* 14.3, range 12–72 years) were recruited for the study. In this group of patients, the median duration of symptoms was 45.5 days (interquartile range = 5.5 months [$P_{25}$ = 14 days, $P_{75}$ = 6 months]). Patients were excluded from the study if they had any contraindication to lumbar mobilisation (Maitland et al, 2001). All patients agreeing to participate gave consent in writing after the procedures had been fully explained. Ethical approval to conduct the study was obtained from The University of Sydney Human Ethics Committee, Sydney, NSW, Australia.

## Outcome measures

### *Pain intensity*

A numerical rating scale (NRS) was used to measure pain intensity. In this study, the NRS was presented to patients as an 11-point box scale (0–10): where "0" was defined as no pain and "10" was defined as the worst pain imaginable. The NRS was used to rate current pain intensity before and after the intervention, and the amount of pain experienced on movement tests including flexion, extension, and lateral flexion to the left and right. Also, the measure of pain on the patient's worst movement was obtained by recording the NRS score corresponding to the patient' most painful movement.

### *Range of movement*

The range of movement was measured using two methods: the modified fingertip-to-floor method and the double inclinometer method. The modified fingertip-to-floor method measures total forward bending movement (ie, movement of the spine, hips, and pelvis) and has been shown to have high intrarater and interrater reliability with $ICC_{(2,1)}$ values being 0.98 and 0.95, respectively (Gauvin, Riddle, and Rothstein, 1990).

In the current study, the dualer inclinometer system (Dualer Plus$^{TM}$, JTech, 324 W. 1120 N., American Fork, UT 84003) was used to measure the lumbar spinal movements of flexion, extension, and lateral flexion to the left and right sides. The double inclinometer method has a similarly high interrater reliability with Pearson's *r* ranging from 0.96 to 0.99 in measuring all sagittal movements of the lumbar spine (Reynolds et al, 1991). However, the test is intended to measure movement at the lumbar spine rather than total forward bending. The dualer system consists of two electronic inclinometers called master and slave. The master inclinometer is 91 mm high, 53 mm long and 18 mm wide while the slave inclinometer is 53 mm high, 53 mm long and 18 mm wide. The accuracy and repeatability of this system in measuring range of movement has been reported to be within ±1 degree (Livingston T. Instruction manual. Published by Jtech. 324 W. 1120N, American Fork, Utah 84003). Saur and colleagues (1996) have reported a correlation of 0.8 and 0.75 between functional radiography and double inclinometer measures of lumbar flexion and extension range of movement, respectively. Although the correlation between the radiography and lateral flexion measures made using the double inclinometer is not known, the reliability is high, similar to that obtained for flexion and extension measures (Newton and Waddell, 1991).

### *Global perceived effect*

A global perceived effect scale was used to compare patient's symptoms before and after the intervention. An 11-point box scale (−5 to 5) was shown to the patients immediately after receiving the intervention, and the patient was asked to rate any change in their symptoms on the scale: −5 = "vastly worse," 0 = "unchanunchanged" and 5 = "completely recovered."

## Procedures

Subjects with NSLBP deemed suitable for central PA mobilisation treatment by the participating physiotherapist were interviewed regarding the area, duration, and bothersomeness of LBP symptoms. Data also were collected regarding the amount of time off work, interruption to activities of daily living, and previous episodes of back pain that the subject had experienced. The physiotherapist then assessed the subject and recorded the most appropriate treatment for the subject including the grade of treatment to be used and the "correct" level to be treated (the most symptomatic or dysfunctional level). Judgments about whether a level was dysfunctional were made by the treating physiotherapist based upon manual examination. The therapist then drew a sealed envelope that allocated the subject to receive treatment at either the correct or a random level. Subjects in the correct group received central PA mobilisation to the most symptomatic level as determined by the physiotherapist, while those in the random level group received mobilisation to a randomly assigned level. The grade of mobilisation used in both groups was that determined appropriate by the physiotherapist prior to treatment allocation. The subject characteristics for each group are summarised in Table 1.

An investigator blind to group intervention marked the $T_{12}$-$L_1$ interspinous space and $S_1$ spinal level using permanent ink to ensure that the electronic inclinometers were placed on the same spinal level. This investigator then performed measures of pain and range of movement at baseline and immediately following intervention. The subject was asked to rate their current pain intensity. Range of movement measures were performed using both the modified fingertip-to-floor method and the double inclinometer method. For the modified fingertip-to-floor method, the subject was asked to stand on a 13 cm high platform with their toes close to the edge of the platform. A firm sheet of cardboard was attached to the platform. In order to record the maximal forward bending range of every subject, consistent verbal instructions were given to all subjects. The subject was asked to slide their hands down the front of the cardboard towards the floor moving as far as possible while keeping their knees straight. The distance from the middle fingertip to the floor was then measured using a metal ruler to the nearest 5 mm. The measurement was calculated by subtracting the height of the platform (13 cm) from the total distance.

Inclinometer measurements of lumbar spinal movements were then obtained in a similar manner to that described by Waddell and colleagues (1992). The master was placed on the mark at the level of the $T_{12}$-$L_1$ interspinous space, and the slave placed on the mark at the level of the $S_1$ spinal level. For measuring lumbar flexion, the subject was

**Table 1**
**Subject characteristics for both groups**

| Variables | Correct Level | Random Level |
|---|---|---|
| Age (years) | 41.1 ± 14.5 | 41.3 ± 14.3 |
| Height (m) | 1.74 ± 0.1 | 1.68 ± 0.2 |
| Mass (kg) | 79.3 ± 17.8 | 81.5 ± 27.9 |
| Duration of symptoms (days) | 220.7 ± 442.7 | 247.5 ± 616.2 |
| Restricted activities of daily living (days) | 6.5 ± 8.3 | 7.2 ± 8.1 |
| Work loss (days) | 3.4 ± 7 | 2.8 ± 6.1 |
| Number of patients with past history of LBP | 47/60 | 50/60 |
| Number of patients with leg numbness | 9/60 | 6/60 |
| Number of patients where "correct level" decision was based upon symptoms produced with manual examination | 29/60 | 25/60 |

Continuous variables are means ± SD.

instructed to bend forward as far as possible keeping both knees straight, avoiding rotation, and bearing weight equally on both feet. An inclinometer reading was taken in full flexion and recorded on the second trial. The subject also was asked to note the maximum pain produced on flexion. A similar procedure was followed for lumbar extension range, but the subject was instructed to bend backwards as far as possible keeping both knees straight, avoiding any rotation, and bearing weight equally. For the lateral flexion test, the patient was instructed to slide one hand down the leg as far as possible avoiding any rotation and bearing weight equally. Again, inclinometer measurements and the maximum pain intensity experienced during the movement were recorded.

After completing the baseline measurements, the investigator left the treatment area to ensure that he remained blind to the treatment administered. The subject then received two 1-minute repetitions of central PA mobilisation applied to either the correct level determined by the physiotherapist, or to a randomly selected level using the nominated treatment grade identified by the physiotherapist. On completion of the treatment, the investigator was recalled to the treatment area in order to perform the postintervention measurements. The global perceived effect scale was then given to the subject to rate the change in their symptoms after the intervention compared to prior to the intervention. The pain and range of movement measurements described earlier were then repeated in the same manner.

## DATA ANALYSIS

A total of nine dependent variables were used for statistical analysis: current pain intensity, pain on worst movement, global perceived effect, forward bending range, lumbar flexion range, lumbar extension range, right lumbar lateral flexion range, left lumbar lateral flexion range, and range on worst lumbar movement. A difference score, calculated by subtracting the preintervention score from the postintervention score, was obtained for each variable except global perceived effect. The mean and standard deviation of the difference scores for all variables were then calculated. The effect size of each variable was also calculated by dividing the mean difference between correct group and random group by the pooled standard deviation.

Two-way analysis of variance (ANOVA) was used to investigate the effect of central PA mobilisation between the group intervention and the subject's worst movement direction on the nine dependent variables with the significance level set at alpha $= 0.05$. A Paired $t$-test also was performed to compare the preintervention and postintervention scores within groups (both groups) and within this sample group to investigate the effect of PA mobilisation on each variable.

## RESULTS

The mean values ± standard deviation of the difference scores for both groups for all variables are given in Table 2. The effect sizes for all variables are shown in Table 3. Although mean difference scores for each variable were small, significant differences were found between preintervention and postintervention measures for all variables within both groups using a Paired $t$-test ($p < 0.05$). These results demonstrate that manual therapy has an immediate effect on treatment outcomes for subjects suffering LBP.

The results of two-way ANOVA are given in Table 4. It was found that only one variable, the current pain intensity, was reduced significantly more, when the mobilisation was applied to the correct level, rather than to a randomly assigned level ($F_{1,114} = 4.504$, $p = 0.036$). Figure 1 shows the change in current pain intensity between two groups by plotting the difference in the pain scores against the subjects ($N = 60$ each group). Figure 2 shows the mean change in the current pain intensity between two groups, the error bars represent a 95% confidence interval (CI). The means 95% CI of the difference

**Table 2**
**Mean difference scores (*SD*) between preintervention and postintervention measures for each variable**

| Variables | Correct Group | Random Group |
|---|---|---|
| Pain (11-point scale) | | |
| Current pain intensity | 1.34 (1.27) | 0.88 (1.43) |
| Worst movement | 1.51 (1.61) | 1.13 (1.41) |
| Range of movements | | |
| Modified fingertip-to-floor (cm) | 1.50 (3.77) | 1.04 (2.49) |
| Flexion (degree) | −1.80 (4.03) | −1.30 (3.36) |
| Extension (degree) | −2.48 (2.80) | −2.02 (2.85) |
| Right lateral flexion (degree) | −2.57 (2.92) | −2.37 (2.59) |
| Left lateral flexion (degree) | −2.75 (2.85) | −2.08 (2.39) |
| Worst movement (degree) | −2.83 (3.94) | −2.95 (2.99) |
| Global perceived effect (11-point scale) | 1.28 (1.36) | 1.09 (1.93) |

A positive sign for the difference scores of the modified fingertip-to-floor and a negative sign for the difference scores of the other movement tests indicate an increase in range of movement.

**Table 3**
**Effect sizes of the change score found in this study**

| Variables | Effect Size |
|---|---|
| Current pain intensity (11-point scale) | 0.34 |
| Left lateral flexion (degree) | 0.25 |
| Pain on worst movement (11-point scale) | 0.25 |
| Extension (degree) | 0.16 |
| Flexion (degree) | 0.14 |
| Modified fingertip-to-floor (cm) | 0.14 |
| Global perceived effect (11-point scale) | 0.11 |
| Right lateral flexion (degree) | 0.07 |
| Range of movement on worst movement (degree) | 0.03 |

scores for current pain intensity on the 11-point scale for subjects treated at the correct level versus a randomly assigned level were 1.34 (1.02–1.66) and 0.88 (0.52–1.24), respectively. These two figures illustrate that the current pain intensity had a greater reduction when subjects were treated at the correct level than when subjects were treated at a randomly assigned level.

Due to the small amount of change in the current pain intensity scores, the percentage of improvement of the current pain intensity was compared to the subjects' initial scores prior to intervention. It was found that the current pain intensity of all subjects decreased by an average of 31% between preintervention and postintervention. In the correct group the current pain intensity decreased by an average of 36% (median 33%) which was greater than that of the randomly assigned level group which had an average decrease in pain intensity of 25% (median 6%).

An interaction effect also was found between the group intervention and the direction of the subject's most painful movement on the current pain intensity ($F_{2,114} = 3.301$, $p = 0.04$). This interaction effect is illustrated in Figure 3 where it can be seen that the magnitude of the between group difference (correct versus random) varied depending upon whether the worst movement was flexion, extension, or lateral flexion. For subjects whose most painful movement was flexion, there was a much greater reduction in pain when mobilised at the most symptomatic level (1.81; 95% CI = 1.16–2.46) compared to when mobilised at a randomly assigned level (0.43; 95% CI = − 0.28–1.12).

## DISCUSSION

The results of this study indicate that PA mobilisation treatment significantly affects pain and range of movement in subjects suffering LBP. In particular, PA mobilisation applied to the correct or most symptomatic level of the lumbar spine produces a greater reduction in the current pain intensity than when applied to a randomly selected level. One possible

**Table 4**
**Two-way ANOVA results testing for differences between group intervention and the subject's worst movement direction, and interactions between these 2 effects**

| | Group Intervention | | Direction of Worst Movement | | Interaction | |
|---|---|---|---|---|---|---|
| Variables[a] | $F_{1,114}$ | *p* Value | $F_{2,114}$ | *p* Value | $F_{2,114}$ | *p* Value |
| Pain | | | | | | |
| Current pain intensity | 4.504 | 0.036* | 0.058 | 0.944 | 3.301 | 0.040* |
| Pain on worst movement | 2.688 | 0.104 | 3.625 | 0.03* | 0.974 | 0.381 |
| Range of movements | | | | | | |
| Modified fingertip-to-floor | 0.792 | 0.375 | 3.629 | 0.03* | 0.474 | 0.624 |
| Flexion | 0.536 | 0.466 | 0.404 | 0.669 | 1.304 | 0.275 |
| Extension | 1.655 | 0.201 | 6.588 | 0.002* | 0.441 | 0.644 |
| Right lateral flexion | 0.475 | 0.492 | 0.953 | 0.389 | 0.542 | 0.583 |
| Left lateral flexion | 2.598 | 0.11 | 2.756 | 0.068 | 0.029 | 0.972 |
| Worst movement | 0.007 | 0.931 | 4.562 | 0.012* | 0.186 | 0.83 |
| Global perceived effect | 1.362 | 0.246 | 1.09 | 0.34 | 2.231 | 0.112 |

[a]Difference score between pre-intervention and post-intervention.
*Significant, $p < 0.05$.

reason for the greater pain relieving effect of PA mobilisation when applied to the correct level could be that the force is applied directly to the spinal level responsible for LBP causing more mechanical effect than when applied to a randomly selected level (Lee and Evans, 1991, 1994). Additionally, our results support the findings of the study by Goodsell and colleagues (2000) that PA mobilisation has an effect on pain reduction in patients suffering LBP. However, Goodsell and colleagues' research differs from ours in that it demonstrated that PA mobilisation produced a greater reduction in pain intensity during functional activities while ours demonstrated a greater reduction in current pain intensity.

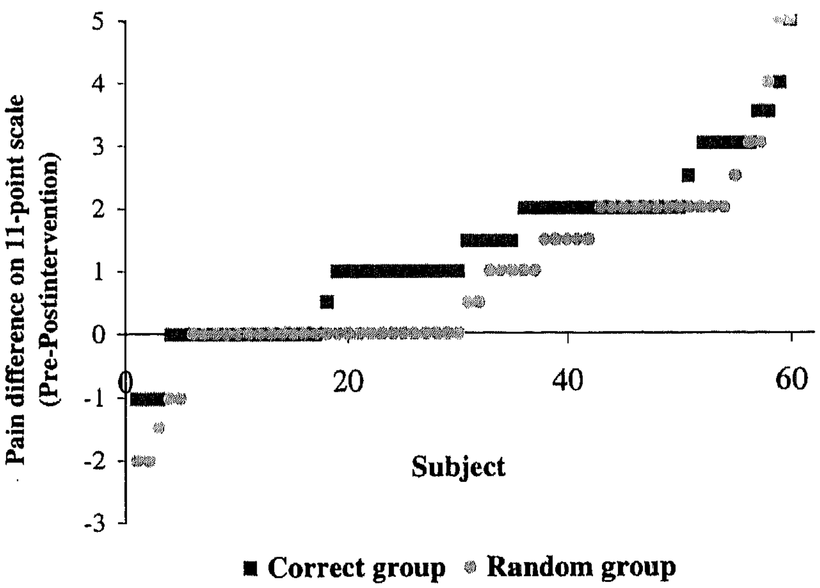


**Fig. 1** Change in pain intensity following PA mobilisation for subjects receiving "correct" versus "random" level of mobilisation. A positive sign indicates a decrease in subject's current pain intensity.

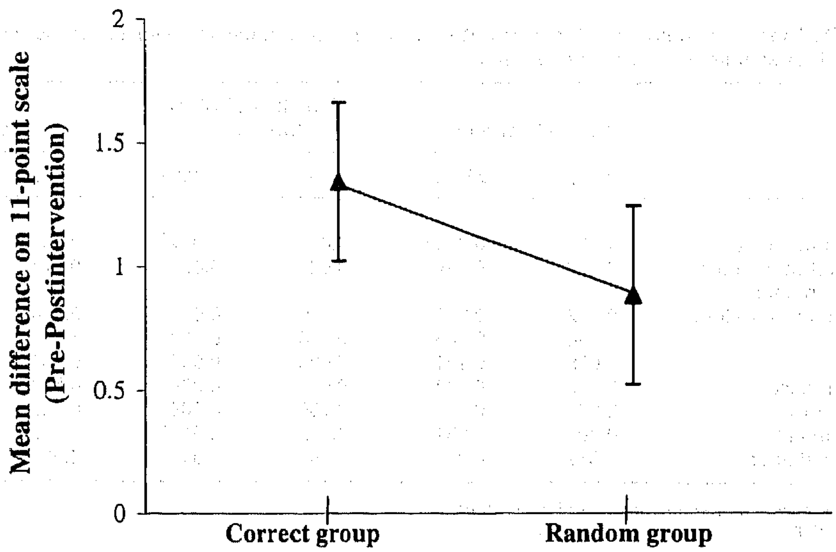


**Fig. 2** Mean difference in current pain intensity following mobilisation treatment. Error bars represent 95% CI.

An interaction effect between the level at which the mobilisation was applied (correct or random level) and the direction of the subject's most painful movement, on the current pain intensity, was demonstrated in this study. It can be clearly seen that subjects whose worst movement was lumbar flexion or extension have greater pain relief when PA mobilisation treatment is delivered to the correct level than when it is delivered to a randomly selected level (Figure 3). Three post hoc tests were performed to interpret the effect of the direction of worst movement on the current pain intensity. We found a significant difference on current pain intensity between treatment delivered to the correct level, and that delivered to a randomly selected level when subjects worst movement was lumbar flexion

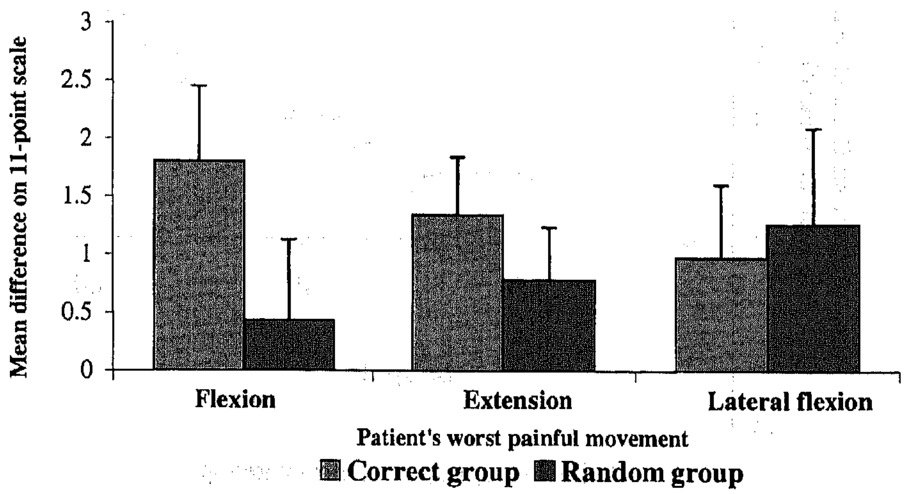


**Fig. 3** Interaction effect between group intervention and subject's most painful direction. Error bars represent 95% CI.

($F_{1,114} = 7.756$, $p = 0.006$). There was no significant difference for subjects whose worst movements were lumbar extension and lumbar lateral flexion (either to the right or left side) ($F_{1,114} = 1.769$, $p = 0.186$ and $F_{1,114} = 0.462$, $p = 0.498$, respectively). These results suggest that PA mobilisation treatment is more effective in reducing pain in subjects whose worst movement is lumbar flexion compared to subjects whose worst movements are lumbar extension and lateral flexion.

It has been proposed by Maitland and colleagues (2001) that PA mobilisation is best used for patients whose LBP is either localised centrally or distributed to both sides of the patients' body. Unfortunately these authors have not clearly recommended whether PA mobilisation is more effective in patients with particular physical examination findings. Our study provides information about this. For example, our results suggest that patients whose worst movement is flexion would have greater improvement in pain reduction than patients whose worst movement is lateral flexion.

Although PA mobilisation is frequently used to relieve patients' LBP symptoms, little is known about the mechanism whereby it achieves these effects. It has been proposed that mobilisation may alter the mechanical properties of the spine (Maitland et al, 2001). Our study and others (Goodsell, Lee, and Latimer, 2000; Petty, 1995), however, did not demonstrate a change in the mechanical response of the spine as characterised by changes in range of motion. The lack of change in active lumbar movements in our study may reflect the fact that the subjects evaluated had low current pain intensities. The average current pain intensity measured on the 11-point scale found in our study was 3.7 scale points (median = 3 scale points, $SD = 2.1$). Another plausible explanation for the lack of change in range of movement is that in our study subjects were measured immediately after a short duration of manual therapy. It is possible that following a course of manual therapy (eg, two or three weeks of manual therapy), increased range of movement may be demonstrated. Further research needs to address whether there is a link between LBP and range of movement. Repeating the study using subjects with either higher initial pain values or following a course of manual treatment may demonstrate that PA mobilisation does change range of motion.

Another theory for relieving pain, SMT-induced hypolagesia, has been proposed by Vicenzino and colleagues (1998). This theory suggests that SMT produces an immediate hypoalgesia by activating descending mechanical pain inhibitory systems in the dorsal periaqueductal gray region (Vicenzino et al, 1998). The immediate analgesic effect we noted in our study could be explained by this theory.

In conclusion, this study indicates that, in order to best reduce current pain intensity, mobilisation treatment should be delivered to the most symptomatic spinal level rather than a randomly selected level. It also suggests that PA mobilisation treatment may be a useful approach to relieve pain in patients suffering LBP where lumbar flexion is the worst movement. The results confirm that the level treated is a determinant of the immediate analgesic effect of PA mobilisation treatment of LBP. Other parameters of treatment dose such as the direction, peak force, and frequency of PA mobilisation await formal investigation.

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