
# Short-Term Effect of Spinal Manipulation on Pain Perception, Spinal Mobility, and Full Height Recovery in Male Subjects with Degenerative Disc Disease: A Randomized Controlled Trial

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No reprints are avaible for this study.

The study protocol was approved by the Ethical and Research Committee of Faculty of Dom Bosco, Curitiba, Paraná, Brasil, with registration number CAAE 0002.0.301.000-11. The study has been registered in the Australian and New Zealand Clinical Trial Registry with registration number ACTRN12613000430730.

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## Abstract

**Objective:** To evaluate the short-term effect on spinal mobility, pain perception, neural mechanosensitivity, and full height recovery after high-velocity low-amplitude (HVLA) spinal manipulation (SM) in the lumbosacral joint (L5-S1)

**Study Design:** Randomized, double-blind, controlled clinical trial with evaluations at baseline and after intervention

**Setting:** University-based physical therapy research clinic

**Participants:** Forty male subjects (N=40) (mean age± SD; 38 ± 9.14 years) diagnosed with degenerative lumbar disease at L5-S1 were randomly divided into two groups: the treatment group (TG) (n = 20) (39 ± 9.12 years) and control group (CG) (n = 20) (37 ± 9.31 years). All participants completed the intervention and follow-up evaluations

**Interventions:** A single L5-S1 SM technique (pull-move) was performed in the TG, whereas the CG received a single placebo intervention

**Main Outcome Measures**: Measures included assessing the subject's height using a stadiometer. The secondary outcome measures included perceived low back pain, evaluated using a visual analogue scale; neural mechanosensitivity, as assessed using the passive straight leg raise test (SLR); and amount of spinal mobility in flexion, as measured using the finger to floor distance test (FFD)

**Results:** The intra-group comparison indicated a significant improvement in all variables in the TG (p<.001). There were no changes in the CG, except for the FFD (p=.008). In the between-group comparison of the mean differences from pre- to post-intervention, there was statistical significance for all cases (p<.001)

**Conclusions:** An HVLA SM in the lumbosacral joint performed on male subjects with degenerative disc disease immediately improves self-perceived pain, spinal mobility in flexion, hip flexion during the passive SLR, and subject's full height. Future studies should include female subjects and should evaluate the long-term results

**Keywords***:* Intervertebral disc degeneration; Lumbar disc disease; Spinal manipulation.

***List of abbreviations***

IVD intervertebral disc

LBP low back pain

DD disc degeneration

SM spinal manipulation

HVLA high-velocity low-amplitude

ROM range of motion

CG control group

TG treatment group

VAS visual analogue scale

SLR passive straight leg raise test

FFD finger to floor distance test

L5 fifth lumbar vertebra

Lumbar intervertebral disc (IVD) disease is one of the main causes for low-back pain (LBP) among individuals with spinal disorders, affecting approximately 16% of patients.[1] A total of 80% of the population of industrialized countries experience episodes of severe LBP during their lives,[2] with disc degeneration (DD) being the most common pathology in the adult spine and accounting for approximately 90% of surgery cases.[3] Subjects suffering from symptomatic disc disorders incur the highest health care expenditure among those with other LBP diagnoses.[4] Nevertheless, the etiology of LBP appears to be multifactorial, which makes its diagnosis and management still controversial.[5]

Even though spinal manipulation (SM) has been linked with positive changes in pain central processing mechanisms,[6] there are conflicting reports with regard to the impact of SM on pain perception in LBP patients.[7,8] However, conclusions are limited by the scarce number of studies.[8] There appears to be some evidence of the effectiveness of high-velocity low-amplitude (HVLA) SM in lumbar IVD disorders.[9] SM has been demonstrated to decrease pain and improve function in symptomatic lumbar DD.[10] On the contrary, little is known about the neural mechanosensitivity response of the lower extremities after manipulative treament.[11,12]

The structural disruption of the IVD (loss of the hydrostatic capacity of the nucleus) during DD may end up leading to a loss of IVD height and a possible reduction of spinal range of motion.[13] DD, however, has also been positively correlated with segmental flexibility of the lumbar spine.[14] An IVD height narrowing has been associated with a history of LBP problems,[15] although no relation between LBP and IVD height has been concluded in other studies.[16] The cumulative effect of the IVD loss of fluid in response to mechanical stress may change the subject's measured height (spinal shrinkage).[17] In addition, limitations in hip range of motion (ROM) in subjects with DD appears to be specially important because hip mobility influences the loads upon the lower back,[13] and reduced hip ROM may also be related to LBP.[18]

Conservative approaches appear to be among the best options for DD associated with LBP.[13] Therefore, the purpose of the study was to evaluate, in subjects with lumbar DD, the immediate effect of a lumbosacral HVLA SM on: (a) the subject's height, (b) self-perceived LBP, (c) neural mechanosensitivity, and (d) spinal mobility in flexion.

## Methods

### Design

This was a controlled, randomized and double-blind clinical trial. All participants signed an informed consent form, as established by the institutional review board. The study protocol was conducted according to the Declaration of Helsinki.

### Randomization Process

The random sequence was obtained using the website www.randomization.com,[19] and an outside collaborator prevented access to the sequence for those participating in the research.

**Blinding**

Before randomization, the participants received general information about the study and were informed that there would be different techniques compared. Subjects and evaluators who collected or analyzed data remained unaware of the treatment allocation group.

**Sample Size**

The sample size was calculated using Granmo version 7.12 software.[a] For a two-sided contrast and accepting an α value of .05 and a beta risk of .01, eighteen subjects were required per study group to detect a difference equal to or greater than 17.5% in the between-groups comparison of the stadiometry values. A 15% SD was assumed together with an estimated 10% rate of loss to follow-up.

**Study Subjects**

Fifty-six (N=56) male subjects were evaluated for possible participation. Based on a non-probabilistic convenience sampling, the participants were consecutively recruited from the principal investigator's clinical consultancy. The research protocol was implemented at an university-based physical therapy research clinic from March to October 2012. Of the total number of subjects enrolled, 16 were excluded for several reasons (figure 1).The final sample included 40 male subjects (38 ± 9.14 years) with a diagnosis of DD in the lumbosacral joint. The participants were randomized into two study groups: the Control Group (CG) (n=20) and the Treatment Group (TG) (n=20). No loss to follow-up was recorded during the data collection or analysis phases.

**Inclusion/Exclusion Criteria**

The inclusion criteria were as follows: (a) males between 18-55 years; (b) standardized body mass index (between 20-25 kg/m$^2$); (c) imaging evidence ($T_2$-weighted MRI) to ensure clinical diagnosis of DD, based upon the presence or absence of degeneration in the lumbosacral IVD;[13,20] and (d) LBP (no minimum intensity of pain was specified),[21] with or without pain radiating to the lower extremities above the knee, according to categories 1 and 2 of the Quebec Task

Force classification system.[22] The exclusion factors were: (a) smoking; (b) history of alcoholism or alcohol consumption within 24 hours prior to data collection; (c) professional sportsmen (changes in the IVD response mechanical parameters have been found in these subjects);[23,24] (d) diagnosis of median, fragmented or migrating herniation ($T_2$-weighted MRI);[13,23] (e) cauda equina syndrome;[25] (f) general contraindications to SM;[26] (g) surgery for DD; (h) radicular pain and/or radiculopathy with presence of neurologic signs;[22] and (i) SM treatment within three months before data collection.

**Data Collection Protocol**

Participants were subjected to the evaluation and intervention protocol together in one session that lasted approximately an hour. The intervention was conducted three minutes after the assessment, and the re-evaluation process began three minutes after the intervention. The therapist in charge of the intervention had over 8 years of clinical experience in the field of manual therapy. The pre-intervention data collection protocol was conducted in the order stated below. This order was maintained after the intervention, apart from the stadiometer measurement, which was performed first in the post-intervention assessment.

**Outcome Measures**

**Evaluation of Self-Perceived LBP**

LBP was measured with a visual analogue scale (VAS). The VAS consists of a horizontal 100-mm line, which ranges from 0 mm (no pain) to 100 mm (severe pain), where the subjects mark their perceived pain.[27] The VAS is an effective, sensitive and appropriate tool to measure acute and chronic pain.[27] The subjects were asked about the current intensity of pain.[28,29]

**Passive Straight Leg Raise Range of Motion**

Neural mechanosensitivity was observed by means of the passive straight leg raise test (SLR).[30] The initial appearance of pain or discomfort was the test end point.[31] In this position, a goniometer[b] was used to measure the hip flexion ROM. The lower limb that presented radiating pain was chosen to be assessed. In cases where there was only midline LBP or equally radicular pain, the SLR ROM from the lower limb with a worse performance was taken as the reference value. Among other considerations, the SLR is "positive" when there is identified asymmetry between lower extremities.[30] The SLR is considered an easy-to use tool, with a reliability (ICC) of 0.87 (95% CI: 0.69 - 0.95).[30]

**Spine Mobility in Flexion (Finger to Floor Distance Test)**

Spinal mobility was assessed using the finger to floor distance test (FFD). The FFD evaluates the maximum spinal mobility in flexion, and it is a possible indicator of functional limitation.[32] The FFD was conducted according to the established methodology.[33] This test is considered easy to conduct and has a high degree of interexaminer reliability (r = 0.96 to 0.98).[34]

## Stadiometer

The stadiometer measures height variations and the amount of IVD compression caused by pressure on the spinal column.[17] The protocol described by Rodacki et al[24] was followed. The participants were considered sufficiently trained when after five consecutive evaluations, the measurements displayed a SD of less than 0.5 mm.[17,24] The person's height was measured after 90 seconds standing upright in the stadiometer[c] to allow body structures to reach their equilibrium.[24] To prevent postural adjustments, fixing metal bars were placed on different anatomical points. The subject also wore safety glasses with a leveling system to stop head movements. The measuring stick of the digital transducer[d] was positioned on the center of gravity above the head. The subject remained in the stadiometer at all times during measurements, instead of using the "in-out" method.[35] The stadiometer is a noninvasive method that has proven validity [36] and is easier to use and less costly than MRI.[37]

## Interventions

## SM in the Treatment Group

The SM technique (pull-move) was performed following previous research reports.[38,39] The participant was in a side-lying position. The upper body was turned to introduce rotation and lateral flexion into the lumbosacral spine. Then, the therapist moved the area of counter-rotation to the segment to be manipulated (figure 2). The thrust was performed very fast within a short ROM.[38,39]

**Placebo Manoeuver (sham) in the Control Group**

In the CG, after placing the subject in side-lying position with hip and knee flexion, no mechanical tension was added, as no turning of the upper body nor manipulative thrust were delivered. The position was maintained during the same time as estimated for the TG.

**Data Analysis**

The descriptive and inferential analysis of the results was performed using the BioEstat 5 free software program.[e] The mean, SD and 95% confidence interval were calculated for the different variables. The statistical analysis was conducted considering significant at a p value < .05. The D'Agostino test evaluated the normality of the study variables. Only the self-perceived LBP followed a non-normal distribution (p>.05). The comparison between-groups used the Student t-test for the quantitative variables, and the Chi-square (X2) for the categorical variables. In the intra-group comparison, the Student t-test was used to analyze the parametric dependent variables, whereas the Mann-Whitney U test was used for the nonparametric variable. The analysis of variance for repeated measures (ANOVA test) with the group allowed the inter-group differences to be observed. The correlation test (Pearson or Spearman) was used to assess the association between extraneous variables and the dependent variables.

## Results

The baseline results in regard to the clinical aspects and the outcome measures are included in table 1. No significant differences in the inter-group comparison were found (p>.05), except in the case of the SLR (p=.004).

Table 2 lists the pre- and post-intervention values and the analysis of the intra-group changes. All the study variables displayed a significant improvement in the TG (p<.001). On the contrary, there were no intra-group differences in the CG (p>.05) except for the FFD (p=.008).

Table 3 reports the between-groups comparison of the mean score changes after intervention (p<.001 in all cases). The between-group analysis indicated significance in the case of LBP (p<.001; $F_{1,38}$=21.03; $R^2$=0.35), hip flexion ROM during the SLR (p<.001; $F_{1,38}$=50.05; $R^2$=0.56), flexion mobility in the FFD (p<.001; $F_{1,38}$=47.63; $R^2$=0.55) and in the stadiometry (p<.001; $F_{1,38}$=145.05; $R^2$=0.79).

In the correlation analysis, a negative correlation was found between the stature recovery and the increase in mobility during the FFD (p<.001; r=0.656), as well as between the height gained and the perceived pain relief (p=.001; r=-0.499). Similarly, the changes in the stadiometry positively correlated with improvements in the SLR (p<.001; r=0.537).

## Discussion

The lumbosacral SM achieved an immediate reduction in self-perceived LBP. The minimum important difference is defined as the smallest variation in the outcome in the domain of interest, indicating meaningful change in clinical status.[40] For VAS, it has been reported to vary from 20 mm in chronic LBP [41,42] to 35 mm in acute or subacute LBP.[42] Licciardone et al[43] concluded that a substantial LBP improvement after SM needs to represent a change ≥ 50% in regard to VAS score at baseline. Pain perception decreased by 17 ± 16.57 mm in the TG, which represents a 45.94% improvement in relation to baseline (table 3). Although the results were close to clinical significance, they must be cautiously interpreted because subjects were most likely at different stages of LBP.

The SM was delivered to the lumbosacral spine to “open” (gap) the targeted joint. The side-lying position combined with SM appears to be beneficial, both for pain reduction and zygapophyseal joint gapping, in subjects with acute LBP.[44] Nonetheless, although SM has been related to a short-term pain relief in LBP,[43] there is still controversy regarding this aspect. On the one hand, SM has demonstrated an impact on the central control mechanism and pain regulation.[45] On the other hand, a recent systematic review concluded that there is low-quality evidence to support that SM is more effective than sham treatment concerning pain relief.[46] This lack of evidence is linked to poor quality methodology in many cases.[47] Most studies on SM lack previous estimates of sample size and a control group.[47] This clinical trial has taken into account these aspects to increase internal validity.

In regards to the SLR, the hip flexion ROM significantly increased in the TG, compared with the sham intervention. Szlezak et al[48] assessed the immediate effect of lumbar mobilizations in healthy subjects and found a significant improvement in the SLR (mean increase of 8.50º). They explained their findings as a consequence of a possible change in the neurodynamics of lower extremity posterior muscles and neural structures. The results of the present study in subjects with DD were better after SM at L5-S1 (13.65° ± 8.62°) (table 3) and surpassed the minimal detectable change reported for the SLR in LBP patients (5.7º-6.6º).[49] Therefore, an improvement in the mechanosensitivity of the nervous system appears to be a plausible reason to understand the observed phenomenon.[30] In this sense, SM has been linked to short-term inhibitory effects on the human motor system.[50] Sensitizing maneuvers (ankle dorsiflexion and/or neck flexion) are needed to elucidate that the limitation during SLR is certainly related to the neural system.[51] In the present study, SLR was performed with pelvis supported at rest and the ankle and neck in neutral position with no sensitizing movements added. Another possible explanation for the findings is a change of distal muscle tone and activity, which has been perceived as a protective reflexive mechanism to prevent strain of the nerves.[30] Even though it remains controversial, it has also been concluded that HVLA lumbosacral SM displays a short-term impact on the attenuation of alpha motoneuronal activity. [50] This seems to be linked to a reduction of muscle tone and pain perception.[50] However, these aspects (tone and muscle activation) were not measured and controlled in the study. Though the SLR response was positive in the evaluated lower limb, future studies should extend the observations to both lower limbs.

The spinal mobility during FFD was also increased in the TG. SM modulates the somatosensory system, which inhibits the paravertebral muscle hyperactivity and improves spine functionality, among other effects.[52] As stated before, the SM contributed to enhanced hip flexion mobility with a possible impact on FFD. Previous studies concluded that the mean difference in the FFD after intervention should be greater than 4.5 cm[49] or 10 cm[53] for the result to have clinical significance and predict improvement in disability. The FFD increased an average of 3.67 ± 2.09 cm in the TG (table 3), and only one of the TG subjects improved above 10 cm. Therefore, the results cannot be considered as clinically relevant. Other factors that may influence the FFD have not been taken into account, such as hip ROM, pelvic alignment at the hip and hamstring and/or calf muscles tension.[32]

FFD also improved in the intra-group analysis in the CG (p=.008) (table 2), which underwent a sham intervention with the subject placed in a side-lying position. As suggested, paraspinal muscles may relax during maintained side-posture positioning,[44] with the results previously referred to the FFD. However, only the mechanical effect from the thrust appears to be a key element to the effectiveness of the SM.[38,45] There were only a few minutes between pre- and post-intervention measurements. Therefore, it is also possible that the post-intervention evaluation could have just improved as a consequence of the learning process from the pre-intervention assessment. To increase the internal validity and predictive value of studies, the combination of FFD and SLR has been suggested as the best option in evaluating subjects with acute/subacute LBP.[49]

A significant height change was found in the TG, even though the mean absolute amount of increase was very small (3.98 ± 1.46 mm, table 3). Similar height recovery was observed after superficial heat treatment in LBP patients (4.2 ± 2.4 mm)[54] but also after sustained lumbar flexion and extension postures in pain-free participants (between 3.15 mm – 5.84 mm).[37,55] In the latter studies, measurements were made with the subject in the seated position. In addition, age, which seems to be linked to DD progression,[5,13] and may influence the stadiometry results,[24] was different among study samples. Thus, it is difficult to compare between studies.

The increase in paravertebral muscle activity in chronic LBP has been associated with greater compressive loads and a lower possibility of height recovery,[56] although this correlation remains just as an hypothesis.[57] Nevertheless, the inverse process may be inferred. The impact of SM on "gapping"[44] and on diminishing paravertebral hyperactivity[52] may produce changes in stadiometry. It remains uncertain if a single SM in a single spinal joint (L5/S1) is sufficient to explain the immediate height recovery. SM effects are not isolated to the targeted level, as lumbar SM is just specific and accurate half the time.[58] Likewise, standing posture is also dependent on other factors, such as pelvic alignment at the hip and hamstring tension, among others, which were not controlled.

## Study Limitations

The subjects were not evaluated for LBP duration. Thus, they might be at different stages of LBP. The research only included male subjects and assessed short-term effects. It would be of great interest to determine whether there are gender-related effects. Future studies should include males and females and medium- to long-term results. Furthermore, fear-avoidance beliefs, which have been correlated with lumbar flexion in LBP, have not been evaluated.[59]

## Conclusions

A side-lying SM technique in the lumbosacral region decreases self-perceived LBP in the short term and produces an immediate improvement in spinal mobility in flexion, the subject's height and hip flexion mobility during the SLR in male subjects with DD.

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## Figure Legends

**Figure 1.** Flowchart Diagram According to CONSORT Statement for the Report of Randomized Controlled Trials.

**Figure 2.** Pull-move technique in the Treatment Group.

**Table 1.** Physical and clinical baseline characteristics of the sample*

| | Control Group (n=20) | Treatment Group (n=20) | P value |
|---|---|---|---|
| Age (yrs) | 37 ± 9.31 | 39 ± 9.12 | .541 |
| Weight (kg) | 76.65 ± 3.77 | 80.1 ± 8.88 | .118 |
| Height (m) | 1.76 ± 0.04 | 1.79 ± 0.05 | .159 |
| LBP (VAS) (mm) | 29.0 ± 26.33 | 37.1 ± 36.14 | .429 |
| SLR (degrees) | 48.05 ± 11.19 | 39.10 ± 7.01 | .004 |
| FFD (cm) | 9.9 ± 4.37 | 14.02 ± 9.58 | .091 |
| Stadiometry (mm) | - 0.0 ± 0.13 | - 0.0 ± 0.13 | 1.00 |

Abbreviations: LBP, self-perceived low back pain; VAS, visual analogue scale; SLR, straight leg raise test, degrees of hip flexion; FFD, finger to floor distance test.

* Data are reported as mean ± SD

**Table 2.** Pre and post-intervention values and intra-group differences in each study group *

| | Control Group | | | Treatment Group | | |
|---|---|---|---|---|---|---|
| | Pre - Int | Post - Int | p | Pre - Int | Post – Int | p |
| LBP (VAS) (mm) | 29.0 ± 26.33 | 29.10 ± 26.37 | 1.00 | 37.1 ± 36.14 | 20.01 ± 22.47 | <.001 |
| SLR (degrees) | 48.05 ± 11.19 | 47.59 ± 10.19 | 1.00 | 39.10 ± 7.01 | 52.75 ± 9.53 | <.001 |
| FFD (cm) | 9.9 ± 4.37 | 9.55 ± 4.54 | .008 | 14.02 ± 9.58 | 10.35 ± 8.35 | <.001 |
| Stadiometry (mm) | - 0.0 ± 0.13 | + 0.02 ± 0.13 | .142 | - 0.0 ± 0.13 | 3.98 ± 1.46 | <.001 |

Abbreviations: Pre – Int, Pre-Intervention; Post – Int, Post-Intervention; LBP, low back pain; VAS, visual analogue scale; SLR, straight leg raise test, degrees of hip flexion; FFD, finger to floor distance test; p value, intra-group comparison between pre- and post- intervention results

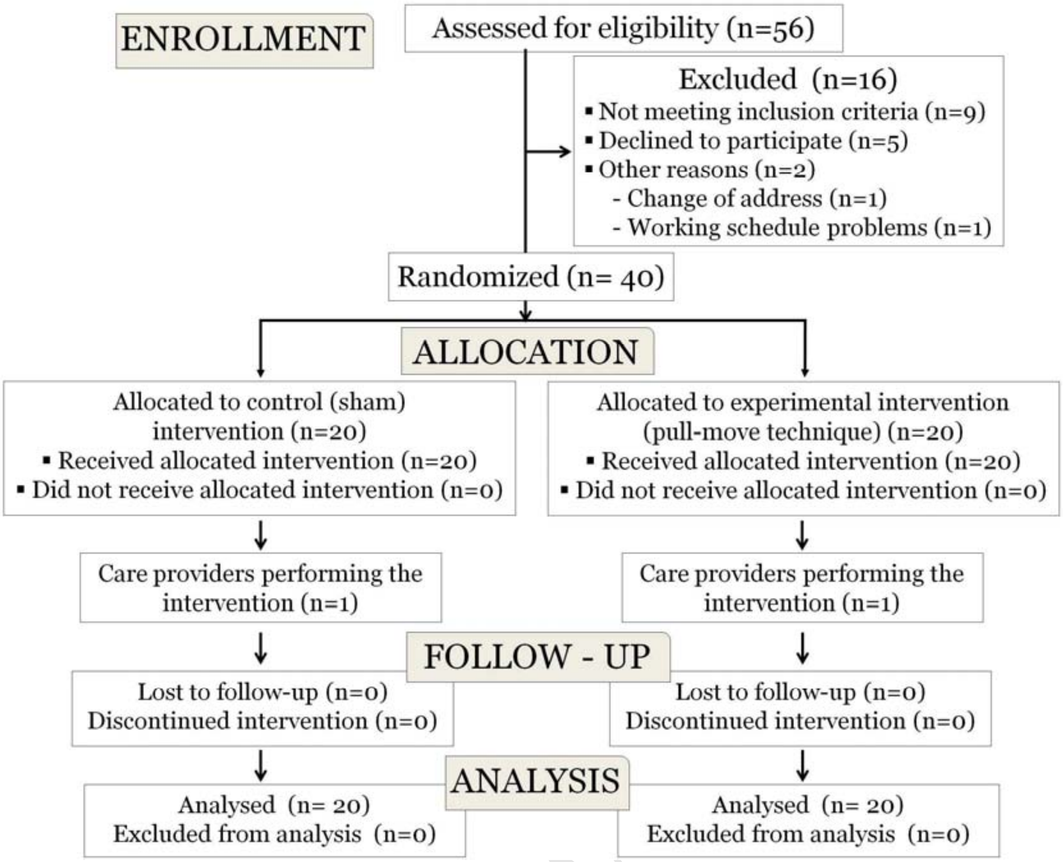
*Values are reported as mean ± SD

**Table 3.** Between – group comparison of the mean differences from pre to post-intervention*

| | Control Group | Treatment Group | p |
|---|---|---|---|
| LBP (VAS) (mm) | 0.10 ± 0.04 (0.01 / 0.08) | 17.0 ± 16.57 (9.24 / 24.75) | <.001 |
| SLR (degrees) | 0.46 ± 0.39 (0.13 / .60) | -13.65 ± 8.62 (-17.68 / -9.61) | <.001 |
| FFD (cm) | 0.35 ± 0.48 (.12 /.57) | 3.67 ± 2.09 (2.69 / 4.65) | <.001 |
| Stadiometry (mm) | -0.03 ± 0.09 (-.07 / .01) | -3.98 ± 1.46 (-4.67 / -3.30) | <.001 |

Abbreviations: LBP, self-perceived low back pain; VAS, visual analogue scale; SLR, straight leg raise test, degrees of hip flexion; FFD, finger to floor distance test; p value, intergroup comparison of the mean values between pre and post-intervention

* Values are reported as mean ± standard deviation (95% confidence interval)


ENROLLMENT
Assessed for eligibility (n=56)
Excluded (n=16)
▪ Not meeting inclusion criteria (n=9)
▪ Declined to participate (n=5)
▪ Other reasons (n=2)
- Change of address (n=1)
- Working schedule problems (n=1)
Randomized (n= 40)
ALLOCATION
Allocated to control (sham) intervention (n=20)
▪ Received allocated intervention (n=20)
▪ Did not receive allocated intervention (n=0)
Allocated to experimental intervention (pull-move technique) (n=20)
▪ Received allocated intervention (n=20)
▪ Did not receive allocated intervention (n=0)
Care providers performing the intervention (n=1)
Care providers performing the intervention (n=1)
FOLLOW - UP
Lost to follow-up (n=0)
Discontinued intervention (n=0)
Lost to follow-up (n=0)
Discontinued intervention (n=0)
ANALYSIS
Analysed (n= 20)
Excluded from analysis (n=0)
Analysed (n= 20)
Excluded from analysis (n=0)