OBJECTIVE: The purpose of this clinical study was to compare the immediate- and short-term effects of lumbar Mulligan sustained natural apophyseal glides (SNAGs) on patients with nonspecific low back pain with respect to 2 new kinematic algorithms (KA) for range of motion and speed as well as pain, functional disability, and kinesiophobia. METHODS: This was a 2-armed randomized placebo-controlled trial. Subjects, blinded to allocation, were randomized to either a real-SNAG group (n = 16) or a sham-SNAG group (n = 16). All patients were treated during a single session of real/sham SNAG (3 × 6 repetitions) to the lumbar spine from a sitting position in a flexion direction. Two new KA from a validated kinematic spine model were used and recorded with an optoelectronic device. Pain at rest and during flexion as well as functional disability and kinesiophobia was recorded by self-reported measures. These outcomes were blindly evaluated before, after treatment, and at 2-week follow-up in ...

Référence bibliographique


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SHORT-TERM EFFECTS OF MULLIGAN MOBILIZATION WITH MOVEMENT ON PAIN, DISABILITY, AND KINEMATIC SPINAL MOVEMENTS IN PATIENTS WITH NONSPECIFIC LOW BACK PAIN: A RANDOMIZED PLACEBO-CONTROLLED TRIAL

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ABSTRACT

Objective: The purpose of this clinical study was to compare the immediate- and short-term effects of lumbar Mulligan sustained natural apophyseal glides (SNAGs) on patients with nonspecific low back pain with respect to 2 new kinematic algorithms (KA) for range of motion and speed as well as pain, functional disability, and kinesiophobia.

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Results: Of 6 variables, 4 demonstrated significant improvement with moderate-to-large effect sizes (ES) in favor of the real-SNAG group: KA-R (P = .014, between-groups ES cliff δ = −.52), pain at rest and during flexion (visual analog scale, P < .001; ES = −.73/−.75), and functional-disability (Oswestry Disability Index, P = .003 and ES = −.61). Kinesiophobia was not considered to be significant (Tampa scale, P = .03) but presented moderate ES = −.46. Kinematic algorithms for speed was not significantly different between groups (P = .118) with a small ES = −.33. All 6 outcome measures were significantly different (P ≤ .008) during within-group analysis (before and after treatment) only in the real-SNAG group. No serious or moderate adverse events were reported.

Conclusion: This study showed evidence that lumbar spine SNAGs had a short-term favorable effect on KA-R, pain, and function in patients with nonspecific low back pain. (J Manipulative Physiol Ther 2015;38:365-374)

Key Indexing Terms: Low Back Pain; Musculoskeletal Manipulations; Randomized Controlled Trial

LOW BACK PAIN (LBP) is one of the most common musculoskeletal disorders for which patients consult medical care. It is also the most important cause of disability and absenteeism with increasing prevalence leading to a major socioeconomic impact on society. These facts highlight the importance of finding effective and validated treatments for this disabling condition.
Two broad categories of LBP are recognized. When a specific pathoanatomic origin is identified such as a tumor or fracture, it is labeled as specific and requires appropriate medical care such as specific medication or surgery. On the other hand and more commonly, in up to 90% of cases, no precise specific origin for pain can be identified; such LBP is consequently described as nonspecific LBP. 1

Low back pain is managed by a variety of treatment modalities 5,6 including Orthopedic Manual Therapy (OMT). This form of treatment has been recommended in national guidelines, for example, in the United States 7 and is also frequently used in clinical practice in various countries. 8,9 As demonstrated by recent systematic reviews, OMT management combined with usual medical care provides better results as compared with usual medical care alone for all stages (acute/subacute or chronic) of LBP. 7,10

A novel growing concept in the field of OMT and clinical practice, which remains sparsely studied in the literature, is “mobilization with movement (MWM),”11-13 originally developed by Mulligan. 11 The main indication for MWM is movement impairment due to pain and/or stiffness. The therapeutic goal is to rapidly reduce pain and to increase range of motion (ROM). The principle of this treatment is simple, in that the manual therapist performs a sustained passive segmental glide of the involved joint, whereas the patient actively moves in the impaired direction. 11-13 Mulligan 11,12 purported a biomechanical basis for the efficacy of MWM in reducing pain and improving ROM, but there may be other explanations for their effects including neurophysiologic mechanisms. Mulligan MWM techniques can be applied to both peripheral and spinal joints. When applied to the spine, MWM are called sustained natural apophyseal glides (SNAGs). 11-13 The current study focuses on SNAGs and their effects on the lumbar spine.

It has been reported that many physical therapists in the United Kingdom manage their patients with LBP by using SNAGs as a part of their physical intervention. 14 This is despite the poor level of evidence, through lack of clinical studies, for the efficacy of lumbar SNAGs for LBP. 15 Indeed, only 3 studies reported on the effects of lumbar SNAGs, 16-18 with only 2 investigating the biomechanical effects. 16,17 The first, a placebo-controlled trial, 16 was carried out on 49 asymptomatic subjects. Sustained natural apophyseal glides were applied during flexion in sitting at 2 lumbar levels by an experienced examiner in a single session and failed to demonstrate an increase in lumbar ROM measured by a 3-dimensional electrogoniometer. In contrast, the second placebo-controlled trial 17 investigated 26 people with LBP during flexion and who were suitable for SNAGs, recording ROM using double inclinometry. A single session of SNAGs demonstrated a significant increase of 7° lumbar flexion ROM greater than placebo but no change in pain scores. Obviously, in view of the paucity of literature regarding lumbar SNAGs and in comparison with its widespread clinical use, further investigations are necessary to study lumbar SNAGs’ efficacy as well as indications when used for people with LBP.

Recent studies from our research team 3,19,20 have investigated spine kinematics in people with LBP using an optoelectronic measurement system. A kinematic spine model was developed where the shoulder girdle and spine were divided into 6 segments: shoulder girdle, upper thoracic and lower thoracic spine, upper and lower lumbar spine, and as the last segment the total lumbar spine (ie, combination of upper and lower lumbar spine segments). Each segment was considered to be rigid and homogenous. Kinematic variables speed and ROM were evaluated during movement in all planes. Range of motion and speed variables showed a highly significant difference (P < .001) between healthy subjects and those with chronic nonspecific LBP in all spinal segments during flexion and combined movements. These studies provided evidence for the validity of the kinematic spine model in distinguishing people with LBP.

From our previous studies, 2 new kinematic algorithms (KA) ROM (KA-R) and speed (KA-S) were identified as having a potential interest in future clinical studies addressing the effectiveness of OMT interventions applied to the spine in ways other than simply looking at the effects on pain and disability. 19,20 Moreover, it has been proposed that future clinical studies should target their interventions on a more homogeneous subgroup of patients with LBP to improve clinical outcomes as well as effect sizes (ES) for outcome measures. 10

Based on these findings, we used the kinematic spine model to assess whether lumbar SNAGs were able to improve the kinematic features of trunk movement in a targeted group of subjects with LBP. The main purpose of this clinical study was to compare the immediate- and short-term effects of a single session of SNAG to a sham SNAG (placebo) treatment applied to the lumbar region, on primary outcome measures, that is, kinematic variables (KA-R and KA-S) and on the following secondary outcome measures: pain, function, and on kinesiophobia in a subgroup of people with LBP. The hypothesis was in favor of the real SNAG intervention for primary and secondary outcome measures for between-group analyses, even if improvements were expected in both groups for within-group analyses as well.

METHOD

Design

This study was a single-center (Cliniques Universitaires Saint-Luc, Brussels, Belgium), prospective, randomized and placebo-controlled trial with 2 arms and with blinded patients and evaluator. The design of this clinical trial followed the recommendations of the CONSORT (Consolidated Standards of Reporting Trials) statement. 21 The study was approved by the local Ethic Committee Board of the University of Louvain and was registered in ClinicalTrials.gov NCT02128607.
Subjects

Eighty-seven people with LBP were initially recruited from “Cliniques Universitaires Saint-Luc.” Of these, 32 were included in the study based on specific criteria and provided consent. Stratification based on pain mechanisms has been previously recommended.22 These criteria were combined with indications for the application of lumbar SNAGs.11,12 The inclusion criteria were subjects aged between 20 and 55 years and who complained of LBP mostly provoked by trunk flexion at any stage (acute to chronic), which did not radiate lower than the knee. The subjects were selected where lumbar flexion was the most provocative movement using a standardized physical examination method aimed to identify lumbar pain provocative movement patterns using active and passive accessory movement tests.23 Finally, the pain associated with trunk flexion had to be reduced by the application of a central lumbar SNAG applied through the spinous process. Patients were excluded if they presented with any known contraindication to OMT (eg tumor, fracture, osteoporosis, infection, rheumatic diseases, or herniated disk).

Thirty-two people with LBP were included in the trial and were randomly distributed in 2 arms: 1 group receiving the lumbar SNAG treatment (n = 16) and the other receiving a sham lumbar SNAG (n = 16). Randomization was performed by stratified randomization with blocks of random numbers under sealed opaque envelopes previously prepared, in a fashion of 4 subsets, each subset containing 8 envelopes, and aimed to balance the stages of LBP for each group during the process of the study.

Material and Outcome Measures

The outcome measures were trunk ROM and speed as well as pain at rest and during trunk flexion just before and just after a single session of treatment. The impact of the intervention at very short term (2 weeks) on functional disability and kinesiophobia was also evaluated. Six variables were assessed before (T0) and after treatment (T1) (Fig 1). All the following outcome measures were blindly assessed by the same examiner.

Kinematic Measures. Kinematic variables were the primary outcome measures and were evaluated using an optoelectronic device (Elite-BTS) composed of 8 infrared cameras capable of recording the 3-dimensional positions of 9 reflective markers placed on bony landmarks on the trunk according to a validated kinematic spine model,19,20 at a frequency of 200 Hz and accuracy of 0.1 mm. This model (Fig 2A and B) subdivides the shoulder girdle, spine, and pelvic girdle into various segments. The test procedure and recording conditions have been described previously.19,20 Briefly, trunk movements were assessed in a sitting position, trunk flexion, left and right rotation, and combined movement of trunk flexion associated with left and right rotation of the pelvis (Fig 3). Each trunk movement was performed and recorded 10 times.

A binary logistic regression analysis had previously determined segments and trunk movements of the kinematic spine model that were the most discriminant for LBP.19,20 The final results were 2 KA, 1 KA-R and 1 KA-S according to the following equations (see19,20 for more information):

\[
\text{KA-R} = 17.77 - (0.074 \times \text{LTS}^\circ) - (0.11 \times \text{SS}^\circ) - (0.059 \times \text{TLS}^\circ)
\]

\[
\text{KA-S} = 6.19 - (0.063 \times \text{TLS}^\circ) / \text{s}
\]

Where LTS\(^\circ\), lower thoracic spine ROM in flexion; SS\(^\circ\), shoulder segment ROM in right rotation; TLS\(^\circ\), total lumbar spine ROM in flexion with left rotation; and TLS\(^\circ\)/s, total lumbar spine speed in flexion with right rotation.

Self-Reported Measures. Self-reported measures were the secondary outcome measures. Pain at rest (present pain) as well as pain during trunk forward bending from a standing position was recorded using a 10-cm visual analog scale (VAS) just before and just after the intervention. Functional disability was assessed with the use of the Oswestry Disability Index (ODI) before intervention and 2 weeks after. The score are expressed in percentage. Kinesiophobia was assessed with the Tampa scale.

Intervention

First, through a standardized clinical examination incorporating combined movements evaluation,23 the examiner determined if the patient had greater pain during active trunk flexion than extension as well as the most painful vertebral level (with passive accessory intervertebral movements). This combined movements’ examination procedure has previously been described and validated to identify the most painful pattern of trunk movement as well as the lumbar segmental level(s) involved.23 Secondly, the evaluator determined whether the patient responded positively to a seated lumbar SNAG applied through the spinous process of the involved vertebra.13 To do this, the examiner had 4 attempts to increase ROM and reduce pain by at least 2/10 on the VAS. As recommended,13 the evaluator applied the SNAG on the spinous process of the vertebra that was the most painful during combined movements examination. Glide force was applied parallel to the apophyseal articular surface (cranial direction). If the effect obtained was not sufficient, the examiner was allowed to vary the intensity and/or direction (vector of applied force) of the SNAG. In addition, the evaluator could change the central vertebral level of lumbar SNAG application.12 If, after 4 trials, the SNAG application did not provide the desired effect, the patient was excluded from the study (Fig 1).

In both groups, during the treatment, the patient was placed in a standardized seated position (hips and knees in 90° flexion) on a table with feet supported, stabilized with a belt around the waist (Fig 4).11,16 Three sets of 6 repetitions were performed in the real-SNAG and sham (placebo) intervention. A single inexperienced physiotherapist (novice in use of SNAGs) applied the treatment procedure in both groups and was therefore not blind to the patient’s group allocation. Both the treating therapist and evaluator
were trained to 16 hours to correctly apply the study protocol by 2 experienced manual therapists.

In the real-SNAG group, the therapist followed published guidelines for SNAG application. The therapist applied a gliding force with the hypothenar eminence placed on the spinous process of appropriate lumbar vertebral level, whereas the patient performed the limited trunk flexion movement until onset of pain before returning to the starting position (Fig 4). The cranial glide force was maintained throughout all the movement in both direction (forward bending and back from bending) and with each repetition. Communication was maintained with the patient to ensure that no pain was felt during the treatment.

In the placebo group, the sham-SNAG intervention replicated the same procedure used in a previous study. The technique mimicked the real-SNAG, only with 2
estimation indicating differences: the therapist placed his hypothenar eminence on the spinous process of the above vertebral level and applied minimal glide force in a caudal direction.

**Statistical Analysis**

Statistical analysis was carried out using SigmaStat 3.5. Estimation of the required sample size was calculated on the basis of the minimal detectable change 95% of the primary outcome measure (KA-R and KA-S) with a desired power of 0.80 and an α level of .05; we have obtained an estimation of the sample size in each group from 16 patients. Similarity of baseline measures between groups (T0) was assessed using a Student t test. Our main hypothesis was the comparison between the groups for primary kinematic outcome measures and for self-reported outcome measures. We used Mann-Whitney rank sum test on the means of difference (T0-T1) of the sham and real group for statistical evaluation, as most of the variables failed to demonstrate a normal distribution. We performed a specific α correction for inflated type-1 error with null hypothesis rejection using a Bonferroni correction. For primary outcome kinematic measures (KA-R and KA-S), this correction was 0.05/2, indicating P < .025 was the required level for significance. For the secondary self-reported measures (VAS rest, VAS pain (VAS) at rest and during lumbar spine flexion demonstrated a significant difference (P < .025) in favor of the real-SNAG group following the same statistical method described above but with a Wilcoxon signed rank test.

**RESULTS**

The number of patients included and excluded as well as the reasons of exclusion during the process of the study is reported in Figure 1. Anthropometric data and variable outcomes at baseline of included patients are described in Table 1. The period of participants’ enrollment was from February 2014 until June 2014; the end of follow-up was July 2014. The trial was ended in July 2014 because the required sample size was reached.

Subjects with nonspecific LBP included in this study had a mixed pain history: 63% were chronic, 21% acute, and 16% subacute. No significant differences on outcome measures were present at baseline between groups (Table 1). Between-group analysis on primary kinematic and secondary self-reported outcome measures is shown in Table 2, and within-group analysis before and after treatment is shown in Table 3. No serious or moderate adverse events were reported in both groups during all the process of the study.

A graph of speed curves (°/s) of the lower lumbar spine segment during trunk forward bending in 1 typical acute LBP patient and 1 typical chronic LBP patient from the real-SNAG (Fig 5A) and sham-SNAG (Fig 5B) group is presented in Figure 5.

**Between-Group Comparison**

**Primary Kinematic Outcome Measures.** Kinematic algorithms for ROM demonstrated a significant difference (P < .025) in favor of the real-SNAG group with large clinical ES (P = .014 and ES = −.52). In contrast, KA-S demonstrated no significant difference (P > .025) with only small clinical ES (P = .118 and ES = −.33).

**Secondary Self-Reported Outcome Measures**

Pain (VAS) at rest and during lumbar spine flexion demonstrated a significant difference (P < .0125) in favor of the real-SNAG group with large clinical ES (P = .001 and ES = −.73, −.75). Functional disability (ODI) also demonstrated a significant difference (P < .0125) in favor of the real-SNAG group with large clinical ES (P = .003 and ES = −.61). In contrast, there was no significant difference between groups for kinesiophobia (Tampa scale) (P > .0125), with only a moderate clinical ES favoring the real-SNAG group (P = .03 and ES = −.46).

**Within-Group Comparison (Secondary Explanatory Hypothesis)**

**Primary Kinematic Outcome Measures.** Kinematic algorithms for ROM and KA-S before and after the intervention improved significantly in the real-SNAG group (P = .01 and P = .008,
respectively) but not in the sham-SNAG group ($P = .86$ and $P = .63$, respectively).

**Secondary Self-Reported Outcome Measures.** There were significant improvements in the real-SNAG group for all secondary outcome measures after the intervention. Pain (VAS) at rest and during lumbar spine flexion before and after intervention improved significantly in the real-SNAG group ($P < .001$) but not in the sham-SNAG group ($P = .56$ and $P = .15$, respectively). Functional disability (ODI) before and after (2 weeks) intervention improved significantly in the real-SNAG group ($P = .002$) but not in the sham-SNAG group ($P = .84$). Kinesiophobia (Tampa scale) before and after (2 weeks) intervention improved significantly in the real-SNAG group ($P = .004$) but not in the sham-SNAG group ($P = .23$).

**DISCUSSION**

Our results suggest substantial improvements favoring lumbar SNAG’s as compared with placebo for KA-R, pain at rest and during trunk flexion as well as for functional disability. In contrast, KA-S and kinesiophobia showed no significant difference between groups. Despite this, within-group explanatory analysis demonstrated highly significant

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**Table 1. Anthropometric Data and Outcome Variables at Baseline**

<table>
<thead>
<tr>
<th></th>
<th>Sham SNAG (n = 16)</th>
<th>Real SNAG (n = 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male/female</td>
<td>7/9</td>
<td>9/7</td>
</tr>
<tr>
<td>Age (y)</td>
<td>Means (SD)</td>
<td>Means (SD)</td>
</tr>
<tr>
<td>40.7 (10.2)</td>
<td>40.7 (10.2)</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.1 (3.3)</td>
<td>24.1 (2.6)</td>
</tr>
<tr>
<td>LBP duration (mo)</td>
<td>19.7 (19.4)</td>
<td>21.0 (21.2)</td>
</tr>
<tr>
<td>KA-R (T0)</td>
<td>3.5 (2.9)</td>
<td>4.9 (3.2)</td>
</tr>
<tr>
<td>KA-S (T0)</td>
<td>2.1 (1.4)</td>
<td>2.4 (1.9)</td>
</tr>
<tr>
<td>VAS at rest (present pain) T0</td>
<td>2.5 (1.7)</td>
<td>3.0 (1.8)</td>
</tr>
<tr>
<td>VAS flexion (pain in trunk flexion) T0</td>
<td>5.1 (1.6)</td>
<td>5.6 (1.8)</td>
</tr>
<tr>
<td>ODI (T0)</td>
<td>22.9 (10.7)</td>
<td>22.4 (12.2)</td>
</tr>
<tr>
<td>Tampa scale (T0)</td>
<td>42.1 (6.2)</td>
<td>43.7 (6.3)</td>
</tr>
</tbody>
</table>

BMI, body mass index; KA-R, kinematic algorithm ROM; KA-S, kinematic algorithm speed; LBP, low back pain; ODI, Oswestry Disability Index; SNAG, sustained natural apophyseal glides; T0, baseline; VAS, visual analogue scale.

* nonsignificant difference between groups with Student t test.
differences in all outcome measures before and after intervention only in the real-SNAG group.

It may be hypothesized that a larger sample size may have resulted in significant differences between groups for KA-S also. However, our prospective calculation of sample size provided an estimate of 16 patients within each group for kinematic outcome measures. With such a small sample, the statistical effect of possible atypical responses is greater. Indeed, almost all patients from our sample (80%) improved their speed (KA-S) in both groups after the intervention. However, a small percentage (20%) of subjects demonstrated the opposite response and decreased speed during trunk movements after lumbar real and sham SNAG therapy. Moreover, the mix of different stages of LBP included in our sample, from acute to chronic, is another factor that may explain a no significant effect on KA-S between the groups that was observed.

When comparing the current results to previous studies reporting on the effects of Mulligan techniques, most of them have investigated the effects of MWM on peripheral joints25-30 or on the cervical spine.31-33 However, there are few published reports investigating effects with respect to the lumbar spine. Indeed, only 2 studies have addressed the effects of lumbar SNAGs on ROM and pain. The first study,16 a placebo-controlled trial, showed no significant improvement in active trunk flexion ROM after lumbar SNAGs in asymptomatic people. However, it is problematic to compare those results in asymptomatic people (where the SNAG technique could not be applied according to the technique guidelines11-13) with the present study on people with LBP. The second study17 investigated patients with LBP and showed a significant increase in trunk flexion ROM but no significant reduction in pain after the application of lumbar SNAGs. Our results show that lumbar SNAGs reduced pain at both rest and during active trunk flexion and also increased trunk ROM. The effectiveness of SNAGs was not limited to just pain reduction and improved ROM but also to improved functional disability and kinesiophobia in people with LBP. However, long-term effects were not analyzed in this study. It would be interesting to analyze long-term effects of lumbar SNAGs in future studies.

In the study of Konstantinou et al.,17 the placebo was a passive modality (patient lying on the table). The authors made this choice to avoid the influence of an active placebo on the quality of trunk movement probably because repeated active spinal movements could be considered as a self-treatment for LBP.34,35 However, the authors could not distinguish the possibility that patients in the SNAG group have improved only through repetition of movements rather than SNAG technique

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**Table 2. Between-Groups Analysis on Primary Kinematic and Secondary Self-Reported Outcome Measures**

<table>
<thead>
<tr>
<th>Outcome Measures</th>
<th>Sham SNAG (n = 16), Median (Interquartile Range)</th>
<th>Real SNAG (n = 16), Median (Interquartile Range)</th>
<th>P</th>
<th>ES (Cliff δ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KA-R</td>
<td>0.05 (−0.73: 0.59)</td>
<td>−0.88 (−2.91: −0.44)</td>
<td>.014^a</td>
<td>−.52 (−.77: −.12)</td>
</tr>
<tr>
<td>KA-S</td>
<td>−0.05 (−0.88: 0.63)</td>
<td>−0.65 (−1.45: −0.03)</td>
<td>.118</td>
<td>−.33 (−.65: .09)</td>
</tr>
<tr>
<td>VAS rest</td>
<td>0 (0: 0.5)</td>
<td>−1 (−2: −1)</td>
<td>&lt;.001^b</td>
<td>−.73 (−.91: −.35)</td>
</tr>
<tr>
<td>VAS flexion</td>
<td>0 (−1.5: 0)</td>
<td>−3 (−3: −1.5)</td>
<td>&lt;.001^b</td>
<td>−.75 (−.90: −.44)</td>
</tr>
<tr>
<td>ODI</td>
<td>0 (−2: 2)</td>
<td>−5 (−8: −1)</td>
<td>.003^b</td>
<td>−.61 (−.83: −.23)</td>
</tr>
<tr>
<td>Tampa</td>
<td>0 (−2: 1)</td>
<td>−6 (−9.5: −0.5)</td>
<td>.03</td>
<td>−.46 (−.76: .01)</td>
</tr>
</tbody>
</table>

CI, confidence interval; ES, effect size; KA-R, kinematic algorithm for range of motion; KA-S, kinematic algorithm for speed; ODI, Oswestry Disability Index; SNAG, sustained natural apophyseal glides; Tampa, Tampa scale for kinesiophobia.; VAS flexion, VAS (pain) during trunk flexion; VAS rest, VAS (pain) at rest.

^a Significant difference between groups, corrected level of P < .025 for primary kinematic outcome measures (KA-R and KA-S).

^b Significant difference between groups, corrected level of P < .0125 for secondary self-reported outcome measures.

**Table 3. Within-Group Analysis Before and After Treatment**

<table>
<thead>
<tr>
<th>Outcome Measures</th>
<th>Sham SNAG (n = 16)</th>
<th>Real SNAG (n = 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (Interquartile Range) at T0</td>
<td>Median (Interquartile Range) at T1</td>
</tr>
<tr>
<td>KA-R</td>
<td>3.28 (1.36−6.41)</td>
<td>3.69 (0.82−5.81)</td>
</tr>
<tr>
<td>KA-S</td>
<td>2.27 (0.65−3.42)</td>
<td>1.68 (0.87−2.72)</td>
</tr>
<tr>
<td>VAS rest</td>
<td>2 (1.5−3.5)</td>
<td>2 (1.5−4)</td>
</tr>
<tr>
<td>VAS flexion</td>
<td>5 (4−6)</td>
<td>4 (3.5−5)</td>
</tr>
<tr>
<td>ODI</td>
<td>20 (16−27)</td>
<td>20 (17−27)</td>
</tr>
<tr>
<td>Tampa</td>
<td>41 (38−45)</td>
<td>41.5 (36.5−45)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome Measures</th>
<th>Sham SNAG (n = 16)</th>
<th>Real SNAG (n = 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (Interquartile Range) at T1</td>
<td>Median (Interquartile Range) at T1</td>
</tr>
<tr>
<td>KA-R</td>
<td>4.85 (2.56−7.23)</td>
<td>2.44 (0.57−5.32)</td>
</tr>
<tr>
<td>KA-S</td>
<td>2.59 (0.66−4.14)</td>
<td>1.09 (−0.12−2.63)</td>
</tr>
<tr>
<td>VAS rest</td>
<td>3 (4)</td>
<td>1.5 (0.5−3)</td>
</tr>
<tr>
<td>VAS flexion</td>
<td>5.5 (4−6.5)</td>
<td>3 (2−4)</td>
</tr>
<tr>
<td>ODI</td>
<td>21 (13−34)</td>
<td>14 (12−25)</td>
</tr>
<tr>
<td>Tampa</td>
<td>44 (40−50)</td>
<td>38.5 (34.5−42.5)</td>
</tr>
</tbody>
</table>

KA-R, kinematic algorithm for range of motion; KA-S, kinematic algorithm for speed; ODI, Oswestry Disability Index; SNAG, sustained natural apophyseal glides; Tampa, Tampa scale for kinesiophobia.; VAS flexion, VAS (pain) during trunk flexion; VAS rest, VAS (pain) at rest.

^a Significant difference between baseline and final evaluation within groups, corrected level of P < .025 for primary kinematic outcome measures (KA-R and KA-S).

^b Significant difference between baseline and final evaluation within groups, corrected level of P < .0125 for secondary self-reported outcome measures.
Moreover, an active placebo as in our study mimicked as closely as possible a real treatment. In our protocol, the same total number of active trunk movements was performed in both groups, to distinguish the effect of real and sham SNAGs from the simple effect of repeated active trunk movements.

The exact mechanism of potential action for lumbar SNAGs is not known, as no studies have yet investigated this. However, there are proposed biomechanical and neurophysiologic mechanisms. Biomechanically, there are some similarities between posteroanterior mobilization undertaken in prone lying and a SNAG. Lee and Evans reported that a posteroanterior on the L5 spinous process induced anterior translation of the L5 vertebra and flexion at the L5-S1 segment. The biomechanical effects of a lumbar SNAG may be enhanced by the cranial direction of the glide along the facet joint plane, together with the active trunk movement. Another proposed mechanism of action may be through correction of a positional fault. Mulligan hypothesized that lack of normal facet gliding in flexion may distort the disc and provoke pain. Hence, improving facet gliding may normalize forces on the disc, relieving pain.

Zusman has described a rationale for the pain relief provided by manual therapy based on the theory of extinction and habituation. Pain may be considered as a form of aversive memory that once present could be more and more easily recalled. Behaviorally, a conditioned fear response may be reduced in intensity through extinction, a form of learning characterized by a decrease in a conditioned response when the conditioned stimulus that elicits it is repeatedly nonreinforced such as might occur during SNAGs. In our sample of people with LBP, trunk flexion was the most painful movement. The real SNAG intervention provided exposure to the painful movement in the absence of any overt danger, which is fundamental to interventions used in the extinction of aversive memories, but this was not the case for the sham SNAG intervention. Progressive mobilization may also desensitize the nervous system through habituation. The mechanism involves a progressive decline in the ability of the presynaptic nerve terminal to transmit impulses. In the subjects from this study, nonnoxious sensory input from the repeated real lumbar SNAG may have competed with and replaced pain sensitization, returning the nervous system to a normal state.

There may be various mechanisms of action for lumbar SNAGs at different stages of LBP. In our sample, there was a mix of stages, with the majority being chronic in nature. As we have discussed, SNAGs may have neurophysiologic as well as mechanical effects, which may have implications for acute and chronic LBP. However, it is beyond the scope of this study to identify the mechanisms underscoring the positive changes seen from SNAGs.

These proposed mechanisms of action described here might explain the significant difference observed on outcome measures in favor of real SNAG interventions. However, for kinesiophobia, there was no significant difference for between-group analysis after Bonferroni correction despite significant improvement in the real-SNAG group for within-group analysis. This might be explained by the nature of the sham intervention in which the subjects were still exposed to the painful stimulus during trunk flexion and, thus, may maintain a conditioned fear response. Moreover, another often debated issue is the quality of the placebo procedure used in physical therapy trials because that might explain the results in favor of the real intervention. Placebo in manual therapy and in nonpharmacologic trials is still a very complex issue to address because a good-quality placebo needs to mimic as closely as possible the real intervention without its

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**Fig 5.** A, Speed curves of the lower lumbar spine segment (S2-L3) during trunk forward bending before (baseline) and after (final evaluation) real SNAG for 1 typical (best responder) acute LBP patient (red curve) and 1 typical chronic LBP patient. B, Speed curves of the lower lumbar spine segment (S2-L3) during trunk forward bending before (baseline) and after (final evaluation) sham SNAG for 1 typical (best no responder) acute LBP patient (red curve) and 1 typical chronic LBP patient.
specific effect with patients still believing that they have received the real treatment.  

**LIMITATIONS**

There are several potential limitations to this study’s findings. One is the limited clinical experience of the treating therapist in the use of SNAGs that may have influenced the effectiveness of the intervention. However, SNAGs are simple techniques that require minimal training, so this is not believed to be a substantial factor in the outcome of the technique. Moreover, some caution is required when interpreting the outcome measures in favor of the real SNAG group, as the 95% CI covers a wide range of possibilities in terms of ES. Finally, a potential bias could be present during the initial selection of patients, as they need to respond positively to the SNAG application before inclusion and randomization in one of the groups. This procedure has the potential to unconsciously inform the included patients on the real SNAG effects during the selection. However, this procedure is consistent with the widespread recommendations of stratification of care for LBP patients as well as the integration of the clinical reasoning in manual therapy trials.

To corroborate the positive changes of lumbar SNAGs seen in this study, future studies should further investigate the effects on speed of trunk movements and kinesiophobia, long-term efficacy, and possible mechanisms of action. Moreover, correlations between primary kinematic outcomes measures and secondary self-reported outcome measures could be investigated. Finally, more studies are required to identify potential responders to validate the clinical application of this form of manual therapy.

**CONCLUSION**

This is the first randomized, placebo-controlled trial that has investigated the short-term effects of lumbar SNAGs on 2 new KA of trunk movements (KA-R and KA-S) as well as pain, functional disability, and kinesiophobia in patients with nonspecific LBP. Although the results show a significant improvement in KA-R, pain, and functional disability in favor of lumbar SNAGs, some caution is required when interpreting these data, as the 95% CI covers a wide range of possibilities in terms of clinical ES. Hence, this study provides preliminary evidence that lumbar SNAGs have immediate- and short-term efficacy in the treatment of a targeted group of patients with nonspecific LBP.

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