

Immediate effect of mobilization with movement (MWM) in patients with low back pain: a randomized controlled trial

Efeito imediato da mobilização com movimento (MWM) em pacientes com dor lombar: um estudo randomizado controlado

Joyce Maria Fraga¹, Tayla Maria Fraga Camargo¹, Thayane Gomes de Mendonça¹, Simone Ribeiro da Costa Soares¹, Júlia Helena Silva¹, Bruna Leonel Carlos¹, Ricardo da Silva Alves¹

ABSTRACT

Objective: To analyze the effect of the Mobilization With Movement (MWM) of the Mulligan's concept in the perception of nociceptive and neuropathic pain, range of motion (ROM) and joint mobility of individuals with low back pain. **Method:** This is a randomized and controlled clinical trial, with 30 volunteers with nonspecific low back pain, divided into: Intervention Group (INTG), that received sustained natural apophyseal glides (SNAG) type MWM of the Mulligan's concept; Control Group (CONTG), which received a similar intervention to INTG. Volunteers were assessed using the Numeric Rating Scale for Pain (NRS Pain); the Modified Schober Test (MST) and ROM by goniometry for lumbar spine mobility and Douleur Neuropathique 4 (DN4) questionnaire for assessment of neuropathic and nociceptive pain. **Results:** INTG showed an increase in lumbar flexion (pre-intervention= 81.21±15.23°; post-intervention= 90.00±19.62°, p< 0.05), mobility of the lumbar spine in MST (pre= 15.33±1.05 post= 16.08±1.02, p< 0.05) and reduction of pain perception by NRS Pain (pre= 5.33±2.26; post= 1.47±2.61 p< 0.05) and in CONTG (pre= 4.07±2.34; post= 2.20±1.93, p< 0.05). **Conclusion:** The intervention with MWM - SNAGs promoted improved ROM and mobility in flexion of the lumbar spine, associated with reduction from the nociceptive pain in INTG and CONTG.

Keywords: Low Back Pain, Nociceptive Pain, Musculoskeletal Manipulations, Rehabilitation

RESUMO

Objetivo: Analisar o efeito da Mobilization With Movement (MWM) do conceito Mulligan na percepção de dor nociceptiva e neuropática, na amplitude e na mobilidade articular de indivíduos com dor lombar. **Método:** Trata-se de um ensaio clínico randomizado e controlado, de 30 voluntários com dor lombar inespecífica, divididos em: Grupo Intervenção (GINT) que recebeu a mobilização articular com deslizamentos apofisários naturais mantidos (MWM - SNAGs); Grupo Controle (GCONT), que recebeu uma mobilização articular placebo. Os voluntários foram avaliados pela escala numérica de dor (EVN); pelo teste modificado de Schober (TMS) para a mobilidade da coluna lombar e pelo DN4 para avaliação da dor neuropática e nociceptiva. **Resultados:** GINT apresentou aumento da flexão lombar (pré intervenção= 81,21±15,23°; pós-intervenção= 90,00±19,62°, p= <0,05), da mobilidade da coluna lombar no TMS (pré= 15,33±1,05 pós= 16,08±1,02, p= <0,05) e redução da percepção de dor pela EVN (pré= 5,33±2,26; pós= 1,47±2,61= p< 0,05) e no GCONT (pré= 4,07±2,34; pós= 2,20±1,93, p< 0,05). **Conclusão:** A intervenção com MWM - SNAGs promoveu melhora da ADM e da mobilidade na flexão da coluna lombar, associada com redução da dor nociceptiva no GINT e no GCONT.

Palavras-chaves: Dor Lombar, Dor Nociceptiva, Manipulações Musculoesqueléticas, Reabilitação

¹Universidade do Vale do Sapucaí – Univás

Corresponding Author

Ricardo da Silva Alves
E-mail: ricardofisio31@gmail.com

Conflict of Interests

Nothing to declare

Submitted: June 16, 2023

Accepted: September 12, 2023

How to cite

Fraga JM, Camargo TMF, Mendonça TG, Soares SRC, Silva JH, Carlos BL, Alves RS. Immediate effect of mobilization with movement (MWM) in patients with low back pain: a randomized controlled trial. Acta Fisiátr. 2023;30(3):173-179.

DOI: 10.11606/issn.23170190.v30i3a214325

ISSN 2317-0190 | Copyright © 2023 | Acta Fisiátrica
Instituto de Medicina Física e Reabilitação – HCFMUSP



This work is licensed under a Creative Commons - Attribution 4.0 International

INTRODUCTION

Low back pain is one of the main symptoms of musculoskeletal dysfunction.¹ It is estimated that 80% of individuals experience an episode of low back pain at some point in their lives,² leading to dysfunction and work absenteeism, affecting socioeconomic aspects, increasing healthcare costs, and straining social support systems.³ Therefore, these conditions highlighted the importance of effective treatments for lower back pain.⁴

Low back pain can be divided in two categories: specific and nonspecific. Only 10% of the cases have a specific underlying condition,⁵ that requires medical interventions.¹ Nonspecific causes represent 90% of the complaints,³ they are imprecise and can be triggered by various biopsychosocial factors.⁶ The pain can be classified as nociceptive or neuropathic. Nociceptive pain is a response to nociceptor activation in the peripheral receptors of primary afferent neurons.⁷ Neuropathic pain is caused by injury or disease of somatosensory nervous system,⁸ and it is characterized by neurological symptoms and pain the lower rib margins and buttock folds, accompanied by radiating pain in one or both legs.^{1,3} Understanding these characteristics helps in diagnosing and proposing more effective treatment strategies for individuals with lower back pain.

The therapeutic strategies for low back pain include manual therapy, which reduces pain and increases range of motion.^{9,10} Among these strategies, joint mobilization from the Mulligan concept are included, based on restoring the alignment of the accessory component of the physiological movement.^{11,12} It is believed that the occurrence of pain inhibition is associated with modifications in neurophysiological responses in the central and peripheral nervous systems, resulting from the application of manual therapy techniques.^{13,14} The execution of these techniques without pain and their role in correcting positional faults are advantages because they resolve muscular protection around the joint, restore normal functions and alleviate the pain-generating mechanism.^{15,16} Therefore, assessing range of motion can help identify low back pain and contribute to the management and treatment response.

Several randomized controlled trials have observed minimal changes in lumbar spine after the application of the Mulligan's technique, using optoelectronic video systems,^{17,18} inclinometers¹⁹ and three-dimensional electrogoniometers.²⁰ Although these methods are considered the gold standard for assessing range of motion, they are impractical in clinical practice due to their high cost, operational requirements, and interpretation complexity.²¹ Therefore, the use of specific tests for the lumbar region that are reliable, simple, quick and cost-effective is extremely useful.²¹

OBJECTIVE

This study aims to analyze the effects of Mulligan concept MWM on the perception of nociceptive and neuropathic pain, as well as on the range of motion and joint mobility of individuals with low back pain.

METHOD

This study was randomized, controlled placebo clinical trial, conducted from May to July 2021. The volunteers were submitted to simple randomization through a mobile application Random

Number Draw (Code2Apps, Rio de Janeiro, Brazil) for choose sealed and sequentially numbered envelopes to determine the respective groups: Intervention Group (INTG) and Control Group (CONTG). This study was approved by the Research Ethics Committee of the University of Vale do Sapucaí (CEP – Protocol: 4.390.917). It is registered in the Brazilian Clinical Trails Registry (REBEC n°: RBR-9mq5r8k) and adheres to the principals stated in the Declaration of Helsinki (2000).

A total of 37 volunteers with low back pain were eligible for the study, coming from the waiting list of the physiotherapy sector at the University of Vale do Sapucaí, as well as invitations and social media, but 7 were excluded. Inclusion criteria considered volunteers of both sexes, aged between 18 to 60 years, who had episodes of nonspecific low back pain and/or pain in the lower limbs.

Volunteers who had difficulties in understanding the assessment and intervention instruments to which they would be submitted were excluded; those with specific low back pain; injuries that prevented movement in the lower and/or upper limbs; those who had undergone spinal or any lower body region surgery within the past six months; the volunteers with infectious diseases; those with myopathies and recognized collagen disorders, neurological injuries and rheumatologic diseases; and those that, for personal reasons, refuse to sign the informed consent form (ICF), as shown in Figure 1.

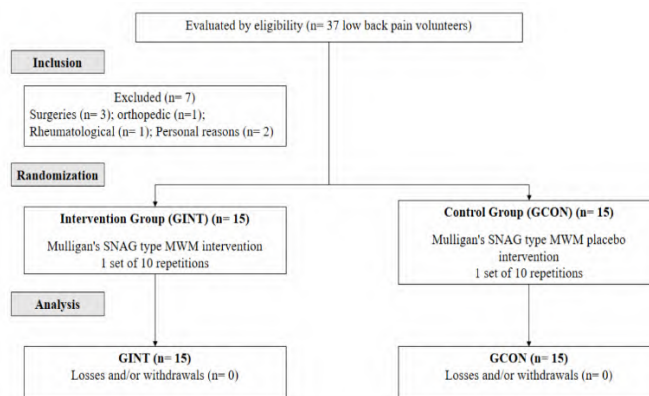


Figure 1. CONSORT flowchart

All volunteers were submitted by the same trained examiner at two time points: pre-intervention and post-intervention. The assessment included goniometry, the modified Schober test (MST), the Numerical Rating Scale for Pain (NRS Pain) and the Douleur Neuropathique 4 (DN4) questionnaire.

For goniometry assessment, the movements of lumbar spine flexion were performed with the volunteer in an upright position, with the feet position 10cm apart and a ruler placed between the feet. The fixed arm of the goniometer was positioned on the lateral surface of the thigh towards the lateral femoral condyle, perpendicular to the ground. The movable arm was positioned along the mid-axillary line of the trunk, with its axis over the anterosuperior iliac spine. The range of motion for lumbar spine flexion was measured from 0° to 95°.²²

For the assessment of lumbar spine extension, the positioning of the goniometer and the volunteer followed the same protocol as flexion. The range of motion for lumbar spine extension is from 0° to 35°.²² For lateral flexion of the lumbar spine, the volunteer stood in an upright position, the fixed arm of the goniometer was positioned on the line between the posterosuperior iliac

spines, and the movable arm of the goniometer was placed vertically towards the spinous process of the seventh cervical vertebra. The axis of the goniometer was positioned between the posterolateral iliac spines on the sacral crest. The range of motion for lateral flexion of the lumbar spine was measured from 0° to 40°. ²²

For lumbar spine rotation, the volunteer was positioned comfortably in a seated position, with an upright posture, knees flexed at 90° and the ankles in a neutral position. The fixed arm of the goniometer was positioned at the center of the head, on the sagittal suture, and the movable arm, which followed the movement, remained parallel to the ground on the sagittal suture. The participant was instructed to avoid rotation of the cervical and pelvic spine. The range of motion for this movement is from 0° to 35°. ²²

For the assessment of lumbar mobility in the volunteers, the MST was used (Figure 2 A and B), which has an intra-examiner reliability index (ICC= 0.87) and an inter-examiner reliability index (ICC= 0.79). ²³ In this test, the volunteer was positioned in an upright posture, and a horizontal line corresponding to the spinous process of the fifth lumbar vertebra was marked.

Another mark was made 10cm above the first mark using a measuring tape. Then, the volunteer was asked to perform maximum forward flexion of the trunk with knees extended. If the knee flexion occurred during the test, it would be disregarded. After the forward flexion of the trunk, lumbar spine mobility was considered present when the distance between the marks was greater than 5cm, with a distance of more than 15cm between the marks. Lower values indicated limitation and decreased mobility of the lumbar spine. ^{21,23}

The participants were assessed for pain perception using the NRS Pain, where "0" indicates no pain and "10" represents maximum pain intensity. The volunteers were instructed to assign a score corresponding to their pain before and after the intervention.

The DN4 questionnaire was used to classify pain as either nociceptive or neuropathic and it has a sensitivity of 100% and specificity of 93.2% for identifying neuropathic pain. ²⁴ It consists of seven items related to the symptoms and three related to the physical examination. For each item, a negative response receives a score of zero, while a positive response receives a score of one. The total score ranges from zero to ten points. A score lower than three classifies the pain as nociceptive, while a score of four or higher classifies the pain as neuropathic. ^{24,25}

The interventions were performed in the Human Motricity Laboratory at the University of Vale do Sapucaí, Pouso Alegre, Minas Gerais. The volunteers underwent a standardized physical examination involving combined movements to identify the painful range of motion and the most painful vertebral level. ^{4,26} To identify painful vertebral level, the maneuver consisted positioned the hypothenar eminence region of the right hand in the spinous process of the lumbar vertebra and performed a slip (cranial direction) in the treatment plan of the joints while the volunteer performed the maximal possible active movement of flexion and extension of the spine lumbar. In the INTG, to identify the affected lumbar vertebrae, after applying the maneuver, an increase in range of motion and a reduction in pain of at least 2/10 in the NRS Pain was expected. ²⁶

To ensure the same protocol, for the CONTG, the painful lumbar vertebra was located and the maneuver was applied to the unaffected upper vertebra, with no change in range of motion and pain being expected.



Figure 2: A: Schober test – initial procedure of the test; B: Schober test – final procedure of the test

The Intervention Group (INTG) received the application of SNAG-type MWM from the Mulligan's concept following the recommended guidelines. ^{27,28} For this, volunteers were instructed to sit with their hips and knees at 90°, feet supported and ankles in neutral position.

A joint mobilization belt was positioned over the volunteer's anterior superior iliac spines. A glide force was applied with the right hand's hypothenar eminence region in the spinous process of the lumbar vertebra positioned over the correct level of the lumbar vertebral spinous process, while the volunteer performed the limited trunk movement until the onset of pain, before returning to the initial position (Figure 2). A sustained cranial glide force was applied in the flexion and extension end movement of the spine (cranial direction) throughout the movement, with varying intensity and/or direction of SNAG application. ²⁶ Communication was maintained with the volunteer to ensure that no pain was felt during the treatment.

For the Control Group (CONTG), a placebo intervention similar to SNAG-type MWM of the Mulligan's concept was performed, following the same procedure, but the mobilization performed at the site had no therapeutic effect. ²⁷

For this group, techniques imitated SNAG-type MWM. With the volunteer and examiner properly positioned, the same intervention protocol used in the INTG was adopted, however, the hypothenar eminence of the examiner's hand was positioned on the lumbar spinous process at a level above the identified painful vertebra and a minimum cranial sliding force was applied (Figure 3).



Figure 3. The standard procedure and implementation of the MWM technique of the Mulligan Concept carried out in INTG and CGON

In both groups, an attendance session was performed for one series of 10 repetitions of the Mulligan's concept MWM technique. At the end of the last repetition, the natural epiphyseal glide in the cranial direction was sustained for 10 seconds in trunk flexion. The average time of each session was 15 minutes.

The examiners received 16 hours of practical training, conducted by the experienced professionals in SNAG-type MWM from the Mulligan's concept⁴ before the start of the study. This condition aimed to reduce the risk of possible information and researcher bias that could distort the estimation of the effect measure.

The sample size and power were previously calculated using a pilot study. The calculation (G*Power 3.1.7; Franz Paul, Universität Kiel, Germany) sampling power and effect size was obtained by means of the fatigue subscale scores, using the following parameters: Test family: F tests > Statistical test: ANOVA: repeated measures, between factors > type of power analysis: a priori: compute required sample size—given α , power, and effect size. To obtain the sample size, the scores of the NRS was used, presenting the following results: (INTG= 1.46± 2.52; CONTG= 2.20± 1.87; d= 0.370; power= 0.807), requiring a minimum of 22 volunteers.

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS, IBM Corp., Chicago, IL, USA), version 22.0 for Windows. To test the normality of the data, the Shapiro-Wilk test was used, with results of $p > 0.05$ for all the variables that were considered to have a normal distribution. To assess the interaction between the groups for clinical and anthropometric variables (age, body mass, height, body mass index and duration of low back pain), the analysis of variance test (ANOVA one-way) was used. To assess the interaction between the groups for categorical variables, such as sex, movement limitation and medication use, the Chi-square test was conducted on the data.

The effect of the intervention was compared between the groups by means of an analysis of variance (ANOVA) two-way repeated measures model, when the criterion of normality was met. The analysis of variance were submitted to Mauchly's sphericity test to measure the equality of variances of the differences between time evaluations. When normality and sphericity was met, the corresponding parametric alternative, ANOVA two-way test with a post hoc Bonferroni test, with a significance level of 5% for all the variables.

RESULTS

For the quantitative variables: age, body mass, height, body mass index (BMI) and duration of the low back pain, no significant differences were found between the groups. For the categorical variables: sex, duration of the low back pain and medication, significant differences were observed between the groups, specifically, 76.67% of the participants were women, while 23.33% were men.

It can be observed that after the mobilization, there was a reduction in pain perspective in both groups. In the INTG, there was a significant increase in the ROM of flexion and the trunk mobility through MST. A significant difference in the ROM of right lateral flexion of the lumbar spine was observed at the pre-intervention moment. No significant differences were found for the other variables.

Table 1. Sociodemographic and clinical data of the study participants

Variables	Intervention group (n= 15)	Control group (n= 15)	p value
Sex - n (%)			
Female	13 (86.66)	10 (66.66)	<0.001
Male	2 (13.34)	5 (33.34)	
Age (years)	25.7±5.46	28.33±8.73	0.258
Body mass (Kg)	66.20±17.23	73.33±16.99	0.263
Height (m)	1.66±0.07	1.69±0.10	0.273
BMI (Kg/m ²)	23.96±4.92	25.40±3.73	0.374
Duration of low back pain (months)	64.93±61.99	83.53±90.89	0.518
ROM limitation - n (%)			
Yes	6 (40)	9 (60)	0,645
No	9 (60)	6 (40)	
Medications - n (%)			
Yes	3 (20)	3 (20)	<0.001
No	12 (80)	12 (80)	

* $p < 0.05$ difference between pre and post intervention; β $p < 0.05$ intergroups differences. Legend: n = sample number; % = percentage; Kg = kilograms; m = meters; BMI: Body Mass Index; Kg/m² = kilograms per square meter

DISCUSSION

The results showed a significant increase in the trunk flexion range of motion ($p = 0.003$), reduction in pain perception to the NRS ($p = 0.001$) and an increase in trunk mobility scale (TMS) ($p = 0.001$) after the SNAG-type MWM. The SNAG-type MWM technique resulted in immediate and substantial reduction in pain perception, followed by an improvement in function in musculoskeletal conditions.^{16,19,29}

In previous studies, reports of the effects of using the Mulligan technique on peripheral joints,^{12,30-32} and cervical vertebrae³³ can be found. However, there are few clinical trials investigating the effects of MWM on the lumbar spine^{4,12,16} and many of them compared symptomatic individuals to asymptomatic. One placebo controlled clinical study did not show differences in trunk flexion range of motion after the application of SNAG-type MWM in the lumbar spine between symptomatic and asymptomatic individuals.²⁰

The findings in the literature differ from this study, which demonstrates an increase in the ROM and increased lumbar spine mobility following the application of the Mulligan technique.

Clinical trials in manual therapy require a placebo intervention that closely resembles the real intervention.^{4,18} The CONTG reduced pain without altering range of motion. This study is similar to the study conducted by Hidalgo et al.⁴ where an active placebo intervention was performed. This allowed to observe the effects of SNAG-type MWM compared to simple active trunk movement. Further studies are needed to corroborate these findings and provide more evidence in this area.

Both INTG and CONTG reduced pain reported on the NRS Pain, which was classified as nociceptive according to the DN4. This can be explained by the touch in the lumbar region, which has low-threshold mechanosensitive cutaneous nerves,³⁴ resulting in the inhibition of central nociceptive responses³⁵ and assisting in the relief of musculoskeletal pain.^{36,37}

Table 2. Comparative analysis of numeric pain rating scale (NRS), lumbar range of motion and mobility, and neuropathic pain questionnaire (DN4) between groups at pre and post intervention moments

Variables	Groups	Pre	Post	P value		
				G*T	T	G
Flexion (°)	Intervention	81.21±15.23	90.00±19.62*	0.38	0.003	0.503
	Control	89.33±20.43	93.86±19.27			
Extension (°)	Intervention	37.21±12.05	34.60±10.66	0.145	0.6	0.413
	Control	37.21±5.06	40.50±6.02			
Right rotation (°)	Intervention	38.38±12.08	41.21±13.71	0.167	0.584	0.909
	Control	42.27±12.89	39.86±6.96			
Left rotation (°)	Intervention	38.13±12.24	42.80±8.58	0.065	0.923	0.312
	Control	40.53±7.77	35.64±8.39			
Right lateral flexion (°)	Intervention	34.33±11.57 β	33.86±7.91	0.312	0.727	0.008
	Control	43.87±11.83	40.29±8.15			
Left lateral flexion(°)	Intervention	36.20±10.92	38.07±11.98	0.708	0.151	0.465
	Control	40.13±11.94	39.36±7.17			
Schober (cm)	Intervention	15.33±1.05	16.08±1.02*	0.801	<0.001	0.061
	Control	16.07±1.08	16.67±1.03			
DN4	Intervention	1.80±0.86	0.53±0.83	1	1	0.153
	Control	2.07±0.70	1.40±1.12			
NRS Pain	Intervention	5.33±2.26	1.47±2.61*	0.05	<0.001	0.7
	Control	4.07±2.34	2.20±1.93*			

G*T: groups* Times interaction; G: groups; T: times; °: degree; cm: centimeter; DN: douleur neuropathique; NRS: Numeric Rating Scale for Pain; * p< 0.05 difference between pre and post intervention; β p< 0.05 intergroups differences

The use of pain classification criteria in manual therapy is a strategy for better out-comes. This allowed observing the effects of SNAG-type MWM compared to simple active trunk movement. Further studies are needed to corroborate these findings and provide more evidence in this area.

The exact mechanism of lumbar SNAGs is still not fully understood. It is believed that biomechanical effects of lumbar SNAG-type MWM may be enhanced by superior sliding along the facet joint plane, correcting osteokinematics and arthrokinematics.^{15,16,27,28}

Neurophysiological effects contribute to the understanding of pain inhibition mechanisms at the central and peripheral nervous system levels.¹³ After manual therapy, a reduction in neural impulse transmission has been observed leading to the restoration of normal function in the nervous system.³⁸ Therefore, it is suggested that after SNAG-type MWM intervention in the INTG, sensory and protective tissue responses were modified, contributing to an increase in trunk flexion range of motion.

In the present study, a prolonged duration of low back pain was observed on both groups. The reduced effects of SNAG-type MWM in the lumbar region can be attribute to the different stages of low back pain. The sample included individuals in different stages of low back pain with the majority being of a chronic nature. Neurophysiological and mechanical responses may have implications depending on the stage of the injury.⁴ It is necessary to conduct further studies that observe how the range of motion of the lumbar spine and trunk mobility behave after Mulligan concept intervention in the acute, subacute and chronic stages of low back pain.

Another factor that contributed to the significant increase in trunk flexion may be the adherence to criteria such as direction, force, point of contact and repetitions during the execution of the technique.^{28,39}

When these criteria are met, the range of motion of trunk flexion assessed by goniometry and MST showed significantly higher values compared to the placebo intervention. This study has limitations, such as higher proportion of women and stage of low back pain. It is suggested that that future studies include samples with similar characteristics.

Future studies should apply the SNAG-type MWM of the Mulligan concept to larger samples that encompass other movements of the spine, in order to gain a better understanding of the method's effect on lumbar spine ROM and trunk mobility.

CONCLUSION

After the intervention with MWM of the Mulligan's concept, specifically SNAG, were observed an increase in the trunk flexion range of motion, measured by goniometry, an increase in mobility by the MST in lumbar spine flexion among individuals with low back pain without neuropathic pain, and there was a reduction in the perception of nociceptive pain in both groups.

REFERENES

1. Manek NJ, MacGregor AJ. Epidemiology of back disorders: prevalence, risk factors, and prognosis. *Curr Opin Rheumatol.* 2005;17(2):134-40. Doi: [10.1097/01.bor.0000154215.08986.06](https://doi.org/10.1097/01.bor.0000154215.08986.06)

2. Hoy D, Brooks P, Blyth F, Buchbinder R. The Epidemiology of low back pain. *Best Pract Res Clin Rheumatol*. 2010;24(6):769-81. Doi: [10.1016/j.berh.2010.10.002](https://doi.org/10.1016/j.berh.2010.10.002)
3. Hartvigsen J, Hancock MJ, Kongsted A, Louw Q, Ferreira ML, Genevay S, et al. What low back pain is and why we need to pay attention. *Lancet*. 2018;391(10137):2356-2367. Doi: [10.1016/S0140-6736\(18\)30480-X](https://doi.org/10.1016/S0140-6736(18)30480-X)
4. Hidalgo B, Pitance L, Hall T, Detrembleur C, Nielens H. 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. *J Manipulative Physiol Ther*. 2015;38(6):365-74. Doi: [10.1016/j.jmpt.2015.06.013](https://doi.org/10.1016/j.jmpt.2015.06.013)
5. Lizier DT, Perez MV, Sakata RK. Ejercicios para el tratamiento de la lumbalgia inespecífica. *Rev Bras Anestesiol*. 2012;62:842-6. Doi: [10.1590/S0034-70942012000600008](https://doi.org/10.1590/S0034-70942012000600008)
6. Brazil AV, Ximenes AC, Radu AS, Fernandes AR, Appel C, Maçaneiro CH, et al. Diagnóstico e tratamento das lombalgias e lombociatalgias. *Rev Bras Reumatol*. 2004;44(6):419-25. Doi: [10.1590/s0482-50042004000600005](https://doi.org/10.1590/s0482-50042004000600005)
7. Nijs J, Apeldoorn A, Hallegraef H, Clark J, Smeets R, Malfliet A, et al. Low back pain: guidelines for the clinical classification of predominant neuropathic, nociceptive, or central sensitization pain. *Pain Physician*. 2015;18(3):E333-46. Doi: [10.36076/ppj.2015/18/e333](https://doi.org/10.36076/ppj.2015/18/e333)
8. Arendt-Nielsen L, Morlion B, Perrot S, Dahan A, Dickenson A, Kress HG, Wells C, Bouhassira D, Drewes AM. Assessment and manifestation of central sensitisation across different chronic pain conditions. *Eur J Pain*. 2018;22(2):216-41. Doi: [10.1002/ejp.1140](https://doi.org/10.1002/ejp.1140)
9. Simonelli C, Vitacca M, Vignoni M, Ambrosino N, Paneroni M. Effectiveness of manual therapy in COPD: A systematic review of randomised controlled trials. *Pulmonology*. 2019;25(4):236-47. Doi: [10.1016/j.pulmoe.2018.12.008](https://doi.org/10.1016/j.pulmoe.2018.12.008)
10. Pagé I, Biner É, Descarreaux M. Vertebral displacements and muscle activity during manual therapy: distinct behaviors between spinal manipulation and mobilization. *J Manipulative Physiol Ther*. 2018;41(9):753-61. Doi: [10.1016/j.jmpt.2018.07.004](https://doi.org/10.1016/j.jmpt.2018.07.004)
11. Exelby L. The Mulligan concept: its application in the management of spinal conditions. *Man Ther*. 2002;7(2):64-70. Doi: [10.1054/math.2001.0435](https://doi.org/10.1054/math.2001.0435)
12. Stathopoulos N, Dimitriadis Z, Koumantakis GA. Effectiveness of Mulligan's mobilization with movement techniques on pain and disability of peripheral joints: a systematic review with meta-analysis between 2008-2017. *Physiotherapy*. 2019;105(1):1-9. Doi: [10.1016/j.physio.2018.10.001](https://doi.org/10.1016/j.physio.2018.10.001)
13. Bialosky JE, Beneciuk JM, Bishop MD, Coronado RA, Penza CW, Simon CB, et al. Unraveling the Mechanisms of Manual Therapy: Modeling an Approach. *J Orthop Sports Phys Ther*. 2018;48(1):8-18. Doi: [10.2519/jospt.2018.7476](https://doi.org/10.2519/jospt.2018.7476)
14. Imamura M, Imamura ST, Kaziyama HH, Targino RA, Hsing WT, Souza LP, et al. Impact of nervous system hyperalgesia on pain, disability, and quality of life in patients with knee osteoarthritis: a controlled analysis. *Arthritis Rheum*. 2008;59(10):1424-31. Doi: [10.1002/art.24120](https://doi.org/10.1002/art.24120)
15. Baeske, R. Mobilisation with movement: a step towards understanding the importance of peripheral mechanoreceptors. *Phys Ther Rev*. 2015;20:299-305. Doi: [10.1080/10833196.2015.1121014](https://doi.org/10.1080/10833196.2015.1121014)
16. Pourahmadi MR, Mohsenifar H, Dariush M, Aftabi A, Amiri A. Effectiveness of mobilization with movement (Mulligan concept techniques) on low back pain: a systematic review. *Clin Rehabil*. 2018;32(10):1289-98. Doi: [10.1177/0269215518778321](https://doi.org/10.1177/0269215518778321)
17. Hidalgo B, Gilliaux M, Poncin W, Detrembleur C. Reliability and validity of a kinematic spine model during active trunk movement in healthy subjects and patients with chronic non-specific low back pain. *J Rehabil Med*. 2012;44(9):756-63. Doi: [10.2340/16501977-1015](https://doi.org/10.2340/16501977-1015)
18. Hidalgo B, Detrembleur C, Hall T, Mahaudens P, Nielens H. The efficacy of manual therapy and exercise for different stages of non-specific low back pain: an update of systematic reviews. *J Man Manip Ther*. 2014;22(2):59-74. Doi: [10.1179/2042618613Y.0000000041](https://doi.org/10.1179/2042618613Y.0000000041)
19. Vicenzino B, Paungmali A, Teys P. Mulligan's mobilization-with-movement, positional faults and pain relief: current concepts from a critical review of literature. *Man Ther*. 2007;12(2):98-108. Doi: [10.1016/j.math.2006.07.012](https://doi.org/10.1016/j.math.2006.07.012)
20. Moutzouri M, Billis E, Strimpakos N, Kottika P, Oldham JA. The effects of the Mulligan Sustained Natural Apophyseal Glide (SNAG) mobilisation in the lumbar flexion range of asymptomatic subjects as measured by the Zebris CMS20 3-D motion analysis system. *BMC Musculoskelet Disord*. 2008;9:131. Doi: [10.1186/1471-2474-9-131](https://doi.org/10.1186/1471-2474-9-131)
21. Macedo CDSG, Souza PRD, Alves PM, Cardoso JR. Estudo da validade e confiabilidade intra e interobservador da versão modificada do teste de Schöber modificado em indivíduos com lombalgia. *Fisioter Pesq*. 2009;16:233-8. Doi: [10.1590/S1809-29502009000300008](https://doi.org/10.1590/S1809-29502009000300008)
22. Marques AP. Manual de Goniometria. Barueri: Manole; 1997.
23. Lindell O, Eriksson L, Strender LE. The reliability of a 10-test package for patients with prolonged back and neck pain: could an examiner without formal medical education be used without loss of quality? A methodological study. *BMC Musculoskelet Disord*. 2007;8:31. Doi: [10.1186/1471-2474-8-31](https://doi.org/10.1186/1471-2474-8-31)
24. Santos JG, Brito JO, Andrade DC, Kaziyama VM, Ferreira KA, Souza I, et al. Translation to Portuguese and validation of the Douleur Neuropathique 4 questionnaire. *J Pain*. 2010;11(5):484-90. Doi: [10.1016/j.jpain.2009.09.014](https://doi.org/10.1016/j.jpain.2009.09.014)
25. Eckeli FD, Teixeira RA, Gouvêa AL. Instrumentos de avaliação da dor neuropática. *Rev Dor*. 2016;17(Suppl 1):S20-2. Doi: [10.5935/1806-0013.20160041](https://doi.org/10.5935/1806-0013.20160041)
26. Vicenzino B, Hing W, Rivett D, Hall T. Mobilisation with movement: the art and the science. Chatswood: Churchill Livingstone/Elsevier; 2011.
27. Krekoukias G, Petty NJ, Cheek L. Comparison of surface electromyographic activity of erector spinae before and after the application of central posteroanterior mobilisation on the lumbar spine. *J Electromyogr Kinesiol*. 2009;19(1):39-45. Doi: [10.1016/j.jelekin.2007.06.020](https://doi.org/10.1016/j.jelekin.2007.06.020)

28. Grieve GP, Boyling JD, Jull GA. Grieve's modern manual therapy: the vertebral column. Edinburgh: Churchill Livingstone/Elsevier; 2004.
29. Mulligan BR. Manual therapy: NAGS, SNAGS, MWMS, etc. 5th ed. Wellington: Plane View Services; 2004.
30. Neto F, Pitance L. El enfoque del concepto Mulligan en el tratamiento de los trastornos musculoesqueléticos. EMC-Kinesiterapia - Medicina Física. 2015;36(1):1-8. Doi: [10.1016/S1293-2965\(14\)69732-2](https://doi.org/10.1016/S1293-2965(14)69732-2)
31. Amro A, Diener I, Bdair WO, Hamed A, Shalabi AI, Ilyan DI. The effects of Mulligan mobilisation with movement and taping techniques on pain, grip strength, and function in patients with lateral epicondylitis. Hong Kong Physiother J. 2010;1(28):19-23. Doi: [10.1016/j.hkpj.2010.11.004](https://doi.org/10.1016/j.hkpj.2010.11.004)
32. Gilbreath JP, Gaven SL, Van Lunen L, Hoch MC. The effects of mobilization with movement on dorsiflexion range of motion, dynamic balance, and self-reported function in individuals with chronic ankle instability. Man Ther. 2014;19(2):152-7. Doi: [10.1016/j.math.2013.10.001](https://doi.org/10.1016/j.math.2013.10.001)
33. Marrón-Gómez D, Rodríguez-Fernández ÁL, Martín-Urrialde JA. The effect of two mobilization techniques on dorsiflexion in people with chronic ankle instability. Phys Ther Sport. 2015;16(1):10-5. Doi: [10.1016/j.ptsp.2014.02.001](https://doi.org/10.1016/j.ptsp.2014.02.001)
34. Izquierdo Pérez H, Alonso Perez JL, Gil Martinez A, La Touche R, Lerma-Lara S, Commeaux Gonzalez N, et al. Is one better than another?: A randomized clinical trial of manual therapy for patients with chronic neck pain. Man Ther. 2014;19(3):215-21. Doi: [10.1016/j.math.2013.12.002](https://doi.org/10.1016/j.math.2013.12.002)
35. Zimmerman A, Bai L, Ginty DD. The gentle touch receptors of mammalian skin. Science. 2014;346(6212):950-4. Doi: [10.1126/science.1254229](https://doi.org/10.1126/science.1254229)
36. Mancini F, Beaumont AL, Hu L, Haggard P, Iannetti GDD. Touch inhibits subcortical and cortical nociceptive responses. Pain. 2015;156(10):1936-44. Doi: [10.1097/j.pain.000000000000253](https://doi.org/10.1097/j.pain.000000000000253)
37. Monroe CM. The effects of therapeutic touch on pain. J Holist Nurs. 2009;27(2):85-92. Doi: [10.1177/0898010108327213](https://doi.org/10.1177/0898010108327213)
38. Bialosky JE, Beneciuk JM, Bishop MD, Coronado RA, Penza CW, Simon CB, et al. Unraveling the Mechanisms of Manual Therapy: Modeling an Approach. J Orthop Sports Phys Ther. 2018;48(1):8-18. Doi: [10.2519/jospt.2018.7476](https://doi.org/10.2519/jospt.2018.7476)
39. Zusman M. Forebrain-mediated sensitization of central pain pathways: 'non-specific' pain and a new image for MT. Man Ther. 2002;7(2):80-8. Doi: [10.1054/math.2002.0442](https://doi.org/10.1054/math.2002.0442)