

Effectiveness of classic physical therapy proposals for chronic non-specific low back pain: a literature review

Ferran CUENCA-MARTÍNEZ, Ph, Sara CORTÉS-AMADOR, PhD and Gemma Victoria ESPÍ-LÓPEZ, PhD

Department of Physiotherapy, Faculty of Physiotherapy, University of Valencia, Spain

ABSTRACT. Introduction: Chronic low back pain is a pathological process that compromises the functionality and quality of life worldwide. The objective of the study was to evaluate the effectiveness of classical physiotherapy in the management of non-specific chronic low back pain. Methods: A literature search in English electronic databases was performed from November to December of 2015. Only those studies addressing chronic non-specific low back pain by manual therapy and different types of exercises methods were included, and those, which combined acute or subacute pain with systematic reviews and clinical practice guidelines, were excluded. Studies involving cognitive-behavioral approaches were also excluded. Results: 487 studies were identified, 16 were analyzed and 10 were excluded. Of the 6 studies reviewed, 5 of them achieved a moderate quality and 1 of them was of a low quality. Back School exercises and McKenzie's method were all ineffective. Osteopathic spinal manipulation proved effective when performed on the lower back and the thoracic area but only immediately after it was received, and not in the medium or long term. Massages proved effective in the short term too, as well as the global postural reeducation although ultimately this study can be considered of a low methodological quality. Conclusions: Based on the data obtained, classical physiotherapy proposals show ineffectiveness in the treatment of chronic non-specific low back pain. More multidimensional studies are needed in order to achieve a better treatment of this condition, including the biopsychosocial paradigm.

Key words: lumbar injury, manual therapy, bibliography analysis

(Phys Ther Res 21: 16-22, 2018)

Low back pain is one of the most common health problems and it has a huge impact on adults¹. Worldwide, low back pain is the problem that causes the greater amount of years of disability. It usually leads to a loss of functionality and of participation in society, affecting activities of daily life and quality of life².

Low back pain is defined as pain in the posterior region of the lower back. The limits of the low back are the lower edge of the last rib and the iliac crest³, and only 15% of it has been diagnosed to have a specific cause⁴.

Therefore, the most common type of low back pain has a non-specific origin. It is a kind of pain type wherein

imaging tests do not provide any relevant information for the treatment and for which such tests are not able to determine any accurate patho-anatomical diagnosis⁵.

A great number of studies have demonstrated that absolute rest is inefficient for the chronic non-specific low back pain⁶ as well as taking drugs for the pain, since they only achieve short-term benefits. Although there is no evidence of medium and long-term benefits, it is a well-known fact that drugs cause undesirable effects on the organism^{7,8}. Other therapies such as thermotherapy and electrotherapy with transcutaneous electrical nerve stimulation or interferential stream have proved to be ineffective as well⁹⁻¹¹.

Manual therapy provides an eclectic variety of specific techniques for the treatment of low back tissues with the purpose of obtaining neurophysiological effects. They affect both the central and peripheral nervous system, and have a positive impact on both pain and the motor activity¹²⁻¹⁴.

Peripheral plasma changes that arise after the application of manual therapies produce an increased release of en-

Received: October 24, 2017

Accepted: December 25, 2017

Advance Publication by J-STAGE: March 20, 2018

Correspondence to: Sara Cortés Amador, Department of Physiotherapy, Faculty of Physiotherapy, University of Valencia, 5 Gascó Oliag Street, Valencia, 46010, Spain

e-mail: sara.cortes@uv.es

doi: 10.1298/ptr.E9937

ogenous opioids like β -endorphins. In chronic patients, manual therapy increases the pain threshold in peripheral pain receptors, which have been subjected to neurogenic inflammation or peripheral sensitization¹⁵. There is also a decreased activation of the posterior horn of the medulla¹⁶.

Regarding supraspinal structures, it has been proved that there are a close links between manual therapy and the periaqueductal gray, the amygdala, the rostral ventromedial medulla, and the anterior cingulate cortex, which cause descending pain inhibition after performing manual therapy¹⁵.

On the whole, it has been proved that there is an activation of the autonomic nervous system after applying manual therapy that produces a sympathetic excitatory state. This state leads to pain reduction, an increase of body temperature, and to tachycardia and tachypnea¹⁷.

The objective of this study is to analyze the therapeutic interventions currently being performed for the treatment of nonspecific lumbar pain, with special attention on the management of patients. It is based on the existing high prevalence rates of this pathology and it is intended to evaluate both successes and biases of the current classical physiotherapy proposals.

Finally, the purpose of the study is to collect the state of the art of the field in order to observe the effectiveness of the current mechanistic and classical proposals therapies for chronic non-specific low back pain.

Methods

Studies included

Only randomized controlled trials, published in English, were selected.

Patients over eighteen years old of both sexes and diagnosed with chronic non-specific low back pain were included and only those studies that addressed chronic non-specific low back pain by manual therapy and different exercises methods were included.

The intensity of the pain and the disability were analyzed.

Data sources and searches

The search included articles published from January 2006 to December 2015 was performed using PubMed and PEDro electronic databases, and the final date of this search was November 2015. The terms used were derived from the combination of the following words: “chronic low back pain”, “non-specific”, “spinal manipulation”, “manual therapy”, “mobilization”, “stretching”, “exercises” and “massage”.

Selection criteria and data extraction

Two independent reviewers carried it out one analysis of the data using the full text of the selected articles. A third reviewer resolved discrepancies between the two reviewers.

Articles that combined acute or sub acute pain with systematic reviews, meta-analysis and clinical practice guidelines were excluded. Studies involving cognitive-behavioral approaches were also omitted.

The assessment of the methodological quality of the articles was performed using JADAD list score.

Results

Study selection

The Figure 1 shows the PRISMA¹⁸ flow diagram and search strategies that were used in this review.

Methodological quality analysis

According to the JADAD scale¹⁹, every study²⁰⁻²⁵, except the one by Lawand *et al.*²³, was of a reasonable quality, as they all obtained 4 points. All of them showed that it was impossible to get a double blind, i.e., it was not possible to blind neither the subjects nor the therapists.

However, the randomized control trial of Lawand *et al.*²³ only achieved 2 points in the JADAD score. This was possible because the above mentioned randomized control trial did not describe the method of blinding appropriately, contrarily to the rest of randomized control trials. The Table 1 shows the methodological quality analysis of the study²⁰⁻²⁵.

Description of studies

The Table 2 shows the characteristics and effects of the studies included.

Description of results

Characteristics of the spinal manipulation in patients with chronic non-specific low back pain

There were three studies with spinal manipulation for the treatment. The study conducted by Oliveira *et al.*²⁰, proved that high-velocity spinal manipulation techniques are effective in the short term when performed on the low back region, as well as from a distance on the dorsal region. This research is connected in a linear manner to the one carried out by Senna y Machaly²⁵, given that a substantial reduction in pain was achieved only in the group subjected to a maintained spinal manipulation therapy immediately after finishing the study, and not in the long term or the medium term. The study conducted by Bronfort *et al.*²⁴, determined that there was no pain relief neither with long-term nor with short-term manipulations.

Characteristics of the therapy's massage in patients with chronic non-specific low back pain

The study directed by Cherkin *et al.*²¹, conducted two types therapy's massage: one was rather superficial and soothing and the other was more focused on releasing muscular tension in the lumbar region. The results showed a statistically significant reduction in pain immediately after

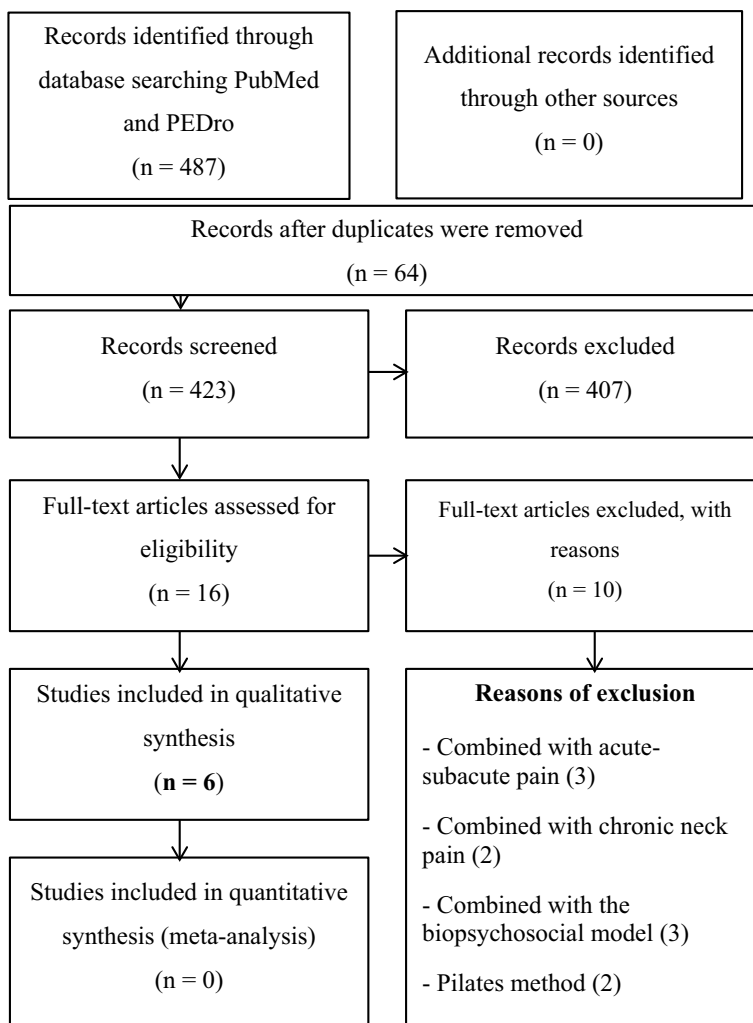


Figure 1. Flowchart of search strategies according to PRISMA.

Table 1. Methodological quality of the studies according to the JADAD scale

ITEMS TRIALS	1	2	3	4	5	SCORE
Oliveira <i>et al.</i> (20)	Yes	Yes	No	Yes	Yes	4
Cherkin <i>et al.</i> (21)	Yes	Yes	No	Yes	Yes	4
García <i>et al.</i> , (22)	Yes	Yes	No	Yes	Yes	4
Lawand <i>et al.</i> , (23)	Yes	Yes	No	No	Yes	2
Bronfort <i>et al.</i> (24)	Yes	Yes	No	Yes	Yes	4
Senna <i>et al.</i> , (25)	Yes	Yes	No	Yes	Yes	4

Note: Was the study described as randomized?, [2] Was the method used to generate the sequence of randomization appropriate and well described?, [3] Was the study described as double blind?, [4] Was the method of double blinding appropriate and well described?, [5] Was there a description of withdrawals and dropouts? Methodological criteria were scored as follows: [1], [3] and [5] were scored as yes (1) and no (0), while [2] and [4] were scored as yes (-1) and no (1).

the conclusion of the study at 10 weeks after intervention, both in pain relief and in increase of functional capacity, although such reduction in pain could not be maintained until

the following 26 or 52 weeks. However, only the relaxation massage group maintained the increase of the functional capacity at 52 weeks post-intervention.

Characteristics of exercises methods in patients with chronic non-specific low back pain

The article by García *et al.*²²⁾, confirmed that neither the exercises of the Back School nor the McKenzie exercises are effective for the treatment of chronic non-specific low back pain. The study of Lawand *et al.*²³⁾ shows the effectiveness of the postural global reeducation in patients with chronic non-specific low back pain accomplishing a reduction in pain that lasted until three months after the study completion.

Finally, the study conducted by Bronfort *et al.*²⁴⁾, determined that there was no pain relief neither with long-term nor with short-term neither in supervised exercises nor in exercises at home.

Discussion

Based on the acquired results, it seems that the application of classical physiotherapy proposals yields results

Table 2. Characteristics of studies and obtained results.

Author	N	Follow-up	Type of study	Treatment	Effects
Oliveira <i>et al.</i> (20)	148	Pre-Int. Post-inter (24 hours)	Trial without control group	G1: Low back spinal manipulation G2: Thoracic spinal manipulation	They all showed statistically significant results at 24 hours post intervention in pain reduction ($p < 0.001$) and PPT increase ($p < 0.001$) but they did not obtain any difference between both groups ($p = 0.1$).
Cherkin <i>et al.</i> (21)	401	52 weeks	Comparative trial	G0: Usual care G1: Specific massage G2: Relaxation massage	Both types of massage showed statistically significant results at 10 weeks after intervention, both in pain relief and in increase of functional capacity (G1- $p < 0.001$ / G2- $p < 0.001$ / G1-G2 $p > 0.05$)., However, they showed inefficacy at 52 weeks post intervention in pain reduction ($p > 0.05$), and only G2 showed effectiveness in the improvement of the functional capacity ($p = 0.049$).
García <i>et al.</i> , (22)	148	6 months	Trial without control group	G1: Back School exercises G2: McKenzie method exercises	6 months after intervention, none of both groups showed statistically significant results neither in pain reduction ($p > 0.05$) nor in disability improvement ($p > 0.05$).
Lawand <i>et al.</i> (23)	61	3 months	Comparative trial	G0: Control group+Drugs G1: Stretching exercises with global postural reeducation (GPR).	At 3 months of follow-up only G1 showed statistically significant results both in pain reduction ($p < 0.001$) and in disability improvement ($p < 0.001$).
Bronfort <i>et al.</i> (24)	301	52 weeks	Trial without control group	G1: Supervised exercises G2: Low back spinal manipulation G3: Exercises at home	None of them obtained statistically significant results in pain relief or in disability improvement, neither in the short ($p > 0.05$) nor in the long term ($p > 0.05$).
Senna <i>et al.</i> , (25)	60	10 months	Comparative trial	G0: Control group (simulation of the spinal manipulation) G1: Low back spinal manipulation during 1 month G2: Low back spinal manipulation during 9 months	There was statistically significant progress in pain reduction, and in the improvement of the disability and the quality of life only while spinal manipulations were being maintained ($p < 0.05$), but not when they ceased ($p > 0.05$).

Note: Pre-Int: pre Intervention. Post-Int: Post-intervention. G: Group.

that are not very effective in the management of chronic non-specific low back pain. Apparently, the ineffectivity of this treatment is the reason behind the current high prevalence rates of chronic non-specific low back pain. Nonetheless, that ineffectivity does not lie in the inefficiency of manual therapy, the physical exercise or on the movement itself when treating non-specific low back pain; on the contrary, they are necessary. Instead, it lies in the misunderstanding of what chronic pain is, along with the disregard of yellow flags such as central sensitization and of the current paradigm shift towards a treatment that follows the biopsychosocial model, in which a person is a unified totality and not merely tissue²⁶.

Comments of results and relationships

The study conducted by Oliveira *et al.*,²⁰ shows that the purpose of spinal manipulation lies in its neurophysiological effects, both local and from a distance, obtained by means of manual therapy, and not in its biomechanical effects, which do not reflect the clinical reality as it is evidenced by Hsieh *et al.*²⁷ and Kanlayanaphotporn *et al.*²⁸.

The study carried out by Senna y Machaly,²⁵ proved that maintaining spinal manipulation techniques are not a good therapeutic option for the treatment of chronic non-specific low back pain given the fact that they are only useful to obtain analgesic effects that solely arise immediately after such techniques have been performed.

The study conducted by Bronfort *et al.*,²⁴ can lead us to consider that the neurophysiological effects, such as the descending inhibitory control or the release of endogenous opioids after spine manipulation, might be affected in underlying pathologies to a process of central sensitization. As a result, conducting this technique of manual therapy would be pointless from a theoretical perspective directed to a therapeutic target. This study²⁴ also involves two additional groups subjected to exercises; the first one was under supervision whereas the second one was not. Nevertheless, both groups rendered ineffective and this could be due to two possible reasons.

Firstly, exercise is paramount in any therapeutic target, since it provides with analgesic effects based on neuroplasticity changes on a central nervous system level^{29,30}. People

with pathologies who experience chronic algeias are susceptible to fear of movement (kinesiophobia) as it is shown in the fear-avoidance model³¹⁾, an aspect completely disregarded in the study. Secondly, the article does not provide with any information concerning how patients performed their exercises or why such a significant amount of leaves took place in those two groups. The current physiotherapeutic methods that aid to guarantee that a patient correctly performs the exercises that he or she fears opt for the gradual exposition to them, as it is shown in the study by Trost *et al.*,³²⁾.

Thus, the explanation for the therapeutic failure can be found in the fact that the technique of gradual exposition was not used, and also in an alteration in the descending inhibitory control systems and other neurophysiological pain regulatory systems present in processes that involve peripheral neuropathic pain, as it was previously mentioned.

Comparison with other studies

Studies with the same type of approach

Now, let us observe the results obtained in the systematic review and meta-analysis in Franke *et al.*,²⁾, which evaluates the effect of spine manipulation in chronic non-specific low back pain. Its conclusions are in accordance with the results of such revision wherein there are relevant effects with regard to pain reduction or to the improvement of the functional status in patients with chronic non-specific low back pain in short-term only getting analgesic local effects less than three months but not in the medium and long term.

The study of Lin *et al.*³³⁾ showed that only a massage treatment for patients with chronic low back pain was less effective than general practice care but the same treatment with exercises and behavioral approach were more effective than the general practice care.

Other study, Kumar *et al.*³⁴⁾, obtained that exists a low evidence than massage therapy is better than usual care and placebo in short term in patients with chronic non-specific low back pain but there are contradictory findings for the effectiveness if it is compared with physical therapy such mobilization, standard medical care and acupuncture.

Finally, the review of van Middelkoop *et al.*³⁵⁾ proved that exercises therapy does not show statistically significant differences in pain reduction and disability in comparison with no treatment, spinal manipulation, medical usual care and back school exercises.

Studies with other type of approach: Biopsychosocial paradigm

Theoretically, the effects of manual therapy, both local and from a distance activate the descending inhibitory control system via the reticulospinal tract. However, in the case of chronic pain, this neurophysiological phenomenon is affected and manual therapy cannot accomplish the same effect as in the acute and subacute dysfunctions³⁶⁾.

Treatments grounded on the biopsychosocial model for addressing the psychosocial processes related to chronic pain appear to show more positive results than the mechanistic proposals³⁷⁾. The systematic review and meta-analysis directed by Kamper *et al.*³⁸⁾ observed the inefficacy of a multidimensional treatment in patients with chronic non-specific low back pain and the conclusions were that multidisciplinary intervention carried out through an intervention that follows the biopsychosocial model was more effective than the usual attention received by a specialized doctor and by physical therapies alone, both in pain and disability reduction.

The research study conducted by Bialosky *et al.*, 2008³⁹⁾ refers to the influence of expectation on spinal manipulation induced hypoalgesia in asymptomatic subjects. Subjects were divided into three groups and all of them received a high-velocity spine manipulation technique. The most relevant aspect is that each group was informed differently about the technique used. One of the groups received positive expectations, another group received negative expectations, and the third group received neutral expectations.

The results were that subjects who were given positive and neutral expectations experienced a reduction of pain perception after the spinal manipulation whereas the group that was exposed to negative expectations felt a statistically significant increase in pain perception after the manipulation and, additionally, received primary hyperalgesia in the lower back region. Consequently, it was demonstrated the significant correlation between expectations and pain perception.

In the systematic review and meta-analysis performed by López de Uralde *et al.*⁴⁰⁾ the effectiveness of gradual exposition was observed in comparison with graded activity in patients with CNLBP. The study revealed that gradual exposition showed moderate evidence in the reduction of catastrophizing and kinesiophobia in relation to graded activity. Improvement in fear of movement and catastrophizing seems to be an essential aspect for the recovery of patients with chronic low back pain, and none of the previous studies analyzed in the present review mention these concepts.

Furthermore, in the research work undertaken by Moseley *et al.*⁴¹⁾, pain neurophysiology education spurs changes in pain perception and physical performance and, even though as a therapeutic target it does not seem to be enough to achieve clinical changes, it is statistically significant. Results suggest, therefore, that pain neurophysiology education should be included in any approach to chronic pain management.

Finally, in the review carried out by Dupeyron *et al.*⁴²⁾, therapeutic education appears to show significant progress in the reduction of negative aspects of fear-avoidance behavior and, hence, it improves and increases the patient's

adherence to treatment.

Conclusions

In the first place, based on the acquired results, it seems that the application of classical physiotherapy proposals yields results that are not very effective in the management of chronic non-specific low back pain.

In the second place, the misconceptions regarding chronic pain, along with the lack of a diagnosis in the process of central sensitization, and the need of an effective system of sub-classification for chronic low back pain seem to have a high influence in the inefficient treatment of subject with nonspecific chronic lumbar algias.

In the third place, the bio behavioral treatment addresses the human person as a whole, as opposed to the mechanistic proposals that separate body and mind and focus only on the tissues.

In the fourth place, the management of affective-emotional factors like anxiety and stress, as well as gradual exposition and therapeutic education, seem to be the key to control kinesiophobia and catastrophism, and to achieve self-efficacy and a good adherence to the treatment.

Conflict of Interest: No funding institution. The authors declare that there is no conflict of interest.

References

- 1) Vos T, Flaxman D, *et al.*: Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012; 2163-2196.
- 2) Franke H, Franke JD, *et al.*: Osteopathic manipulative treatment for nonspecific low back pain: a systematic review and meta-analysis. *BMC Musculoskelet Disord*. 2014; 15: 286.
- 3) Vora AJ, Doerr KD, *et al.*: Functional anatomy and pathophysiology of axial low back pain: disc, posterior elements, sacroiliac joint, and associated pain generators. *Phys Med Rehabil Clin N Am*. 2010; 21: 679-709.
- 4) Lizier DT, Perez MV, *et al.*: Exercises for treatment of nonspecific low back pain. *Rev Bras Anesthesiol. Sociedade Brasileira de Anesthesiologia*. 2012; 62: 838-846.
- 5) Bigorda-Sague A: Estudio sobre la eficacia de la escuela de espalda en la lumbalgia inespecífica. *Rehabilitación*. 2012; 46: 222-226.
- 6) Armijo OS, Aqueveque AA, *et al.*: Estudio de Casos: Efectividad de un Protocolo Kinésico en Pacientes con Dolor Lumbar Crónico. *Experiencia Clínica. Rev Of del Col Kinesiólogos Chile*. 2002; 41-46.
- 7) Shen FH, Samartzis D, *et al.*: Nonsurgical management of acute and chronic low back pain. *J Am Acad Orthop Surg*. 2006; 14: 477-487.
- 8) Ibraimi Z, Murtezani A, *et al.*: Prevalence and pharmacologic treatment of patients with low back pain treated at kosovo energetic corporation. *Med Arch*. 2013; 67: 410-413.
- 9) Calle-Fuentes P, Fuentes-Hervías MT, *et al.*: J. Efectos de la hidroterapia en el dolor lumbar crónico: Fisioterapia basada en la evidencia. *Rev Iberoam Fisioter y Kinesiol*. 2007; 10: 97-102.
- 10) Facci LM, Nowotny JP, *et al.*: Effects of transcutaneous electrical nerve stimulation and interferential currents in patients with nonspecific chronic low back pain: randomized clinical trial. *Sao Paulo Med J*. 2011; 129: 206-216.
- 11) Maya-Martín J, Albornoz-Cabello M, *et al.*: Estudio piloto del dolor lumbar tratado con corrientes interferenciales. *Fisioterapia*. 2011; 33: 243-247.
- 12) Hidalgo B, Detrembleur C, *et al.*: 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: 59-74.
- 13) Childs JD, Fritz JM, *et al.*: A clinical prediction rule to identify patients with low back pain most likely to benefit from spinal manipulation: a validation study. *Ann Intern Med*. 2004; 141: 920-928.
- 14) Licciardone JC, Stoll ST, *et al.*: Osteopathic manipulative treatment for chronic low back pain: a randomized controlled trial. *Spine (Phila Pa 1976)*. 2003; 28: 1355-1362.
- 15) Bialosky JE, Bishop MD, *et al.*: The mechanisms of manual therapy in the treatment of musculoskeletal pain: A comprehensive model. *Man Ther*. 2009; 14: 531-538.
- 16) Malisza KL, Gregorash L, *et al.*: Functional MRI involving painful stimulation of the ankle and the effect of physiotherapy joint mobilization. *Magn Reson Imaging*. 2003; 21: 489-496.
- 17) Vicenzino B, Paungmali A, *et al.*: Specific manipulative therapy treatment for chronic lateral epicondylalgia produces uniquely characteristic hypoalgesia. *Man Ther*. 2001; 6: 205-212.
- 18) Moher D, Liberati A, *et al.*: PRISMA 2009 Flow Diagram. The PRISMA statement. 2009.
- 19) Clark HD, Wells GA, *et al.*: Assessing the quality of randomized trials: Reliability of the Jadad scale. *Control Clin Trials*. 1999; 20: 448-452.
- 20) Oliveira RF, Liebano RE, *et al.*: Immediate effects of region-specific and non-region-specific spinal manipulative therapy in patients with chronic low back pain: a randomized controlled trial. *Phys Ther*. 2013; 93: 748-756.
- 21) Cherkin DC, Sherman KJ, *et al.*: A Comparison of the Effects of 2 Types of Massage and Usual Care on Chronic Low Back Pain. *Ann Intern Med*. 2011; 155: 1-9.
- 22) García AN, Costa-Lda C, *et al.*: Effectiveness of back school versus McKenzie exercises in patients with chronic nonspecific low back pain: a randomized controlled trial. *Phys Ther*. 2013; 93: 729-747.
- 23) Lawand P, Lombardi-Júnior I, *et al.*: Effect of a muscle stretching program using the global postural reeducation method for patients with chronic low back pain: A randomized controlled trial. *Jt Bone Spine*. 2015; 82: 272-277.
- 24) Bronfort G, Maiers MJ, *et al.*: Supervised exercise, spinal manipulation, and home exercise for chronic low back pain: A randomized clinical trial. *Spine J*. 2011; 11: 585-598.
- 25) Senna MK and Machaly S: Does maintained spinal manipulation

- therapy for chronic nonspecific low back pain result in better long-term outcome? *Spine (Phila Pa 1976)*. 2011; 36: 1427-1437.
- 26) Flor H: New developments in the understanding and management of persistent pain. *Curr Opin Psychiatry*. 2012; 25: 109-113.
 - 27) Hsieh CY, Vicenzino B, *et al.*: Mulligan's mobilization with movement for the thumb: a single case report using magnetic resonance imaging to evaluate the positional fault hypothesis. *Man Ther*. 2002; 7: 44-49.
 - 28) Kanlayanaphotporn R, Chiradejnant A, *et al.*: The Immediate Effects of Mobilization Technique on Pain and Range of Motion in Patients Presenting With Unilateral Neck Pain: A Randomized Controlled Trial. *Arch Phys Med Rehabil*. 2009; 90: 187-192.
 - 29) Swain R, Berggren K, *et al.*: On aerobic exercise and behavioral and neural plasticity. *Brain sciences*. 2012; 2: 709-744.
 - 30) Voss MW, Vivar C, *et al.*: Bridging animal and human models of exercise-induced brain plasticity. *Trends in Cognitive Sciences*. 2013; 525-544.
 - 31) Zusman M: Cognitive-behavioural components of musculoskeletal physiotherapy - the role of control. *Phys Ther Rev*. 2005; 10: 89-98.
 - 32) Trost Z, Zielke M, *et al.*: The promise and challenge of virtual gaming technologies for chronic pain: the case of graded exposure for low back pain. *Pain Manag*. 2015; 5: 197-206.
 - 33) Lin C-WC, Haas M, *et al.*: Cost-effectiveness of guideline-endorsed treatments for low back pain: a systematic review. *Eur Spine J*. 2011; 20: 1024-1038.
 - 34) Kumar S, Beaton K, *et al.*: The effectiveness of massage therapy for the treatment of nonspecific low back pain: a systematic review of systematic reviews. *Int J Gen Med*. 2013; 6: 733-741.
 - 35) van Middelkoop M, Rubinstein SM, *et al.*: A systematic review on the effectiveness of physical and rehabilitation interventions for chronic non-specific low back pain. *Eur Spine J*. 2011; 20: 19-39.
 - 36) Woolf CJ and Salter MW: Neuronal plasticity: increasing the gain in pain. *Science*. 2000; 288: 1765-1769.
 - 37) Ramond-Roquin A, Bouton C, *et al.*: Psychosocial Risk Factors, Interventions, and Comorbidity in Patients with Non-Specific Low Back Pain in Primary Care: Need for Comprehensive and Patient-Centered Care. *Front Med*. 2015; 2: 73.
 - 38) Kamper SJ, Apeldoorn AT, *et al.*: Multidisciplinary biopsychosocial rehabilitation for chronic low back pain: Cochrane systematic review and meta-analysis. *BMJ*. 2015; 350: h444.
 - 39) Bialosky JE, Bishop MD, *et al.*: The influence of expectation on spinal manipulation induced hypoalgesia: an experimental study in normal subjects. *BMC Musculoskelet Disord*. 2008; 9: 19.
 - 40) López-de-Uralde-Villanueva I, Muñoz-García D, *et al.*: Review A Systematic Review and Meta-Analysis on the Effectiveness of Graded Activity and Graded Exposure for Chronic Nonspecific Low Back Pain.
 - 41) Moseley GL, Nicholas MK, *et al.*: A randomized controlled trial of intensive neurophysiology education in chronic low back pain. *Clin J Pain*. 2004; 20: 324-330.
 - 42) Dupeyron A, Ribinik P, *et al.*: Education in the management of low back pain: literature review and recall of key recommendations for practice. *Ann Phys Rehabil Med*. 2011; 54: 319-335.