EFFECTS OF PHYSICAL THERAPY TREATMENTS WITH AND WITHOUT SPINAL MOBILIZATION IN INDIVIDUALS WITH ACUTE NONSPECIFIC LOW BACK PAIN: A RANDOMIZED TRIAL

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ABSTRACT

This study aimed to investigate the effects of physical therapy treatments combined with spinal mobilization in individuals with acute nonspecific low back pain (LBP). Fifty subjects 30–50 years old were recruited into this study as long as they met the inclusion criteria. After taking their history and giving them a physical examination, all subjects were measured according to the visual analog scale (VAS) for pain intensity, active range of motion (AROM) in flexion, extension, right, and left lateral flexion, and the Thai version of the modified Oswestry Disability Questionnaire (ODQ) before and after the treatments. The patients' perception of change (PPC) was also measured after the treatments. All subjects were then randomly assigned into a control group receiving physical therapy treatments, or an experimental group receiving physical therapy treatments and spinal mobilization. The subjects and the research assistant were blinded to random assignments and the therapists were blinded to all measurements. The program of treatment lasted 6 weeks maximum. The termination of the treatment program was determined by the physical therapists and the subjects. Two-way Repeated Measures Analysis of Variance with Bonferroni post-hoc analysis were used for comparisons. Pearson and Spearman were used for correlation studies between PPC and change scores of VAS, AROM, and ODQ.

The subjects in both groups showed significant improvement in VAS, AROM, ODQ, and PPC ($p<0.05$). However, there was no significant difference between the two groups in any parameters. The experimental group took less treatment trials and had a lower recurrence rate than the control group. For the correlation study, a significant correlation was found between PPC and ODQ ($p<0.05$).

The individuals in the experimental group who received both physical therapy and spinal mobilization showed no significant increase in spinal mobility as compared to the control group. In terms of measurements, ODQ proved to be sensitive in measuring changes in the disability score over certain periods of time. It is interesting to study the effects of spinal mobilization in individuals with LBP and significant stiffness. The affirmation of the effectiveness awaits further formal investigation.

KEYWORD: LOW BACK PAIN/ ACUTE/ MOBILIZATION/ MANUAL THERAPY/ FOLLOW-UP

179 pp.

ผลของการรักษาทางกายภาพบำบัดโดยมีและไม่มีการขยับเคลื่อนข้อต่อกระดูกสันหลังในผู้ที่มีอาการปวดหลังส่วนล่างเฉียบพลัน: การศึกษาแบบสุ่ม
(EFFECTS OF PHYSICAL THERAPY TREATMENTS WITH AND WITHOUT SPINAL MOBILIZATION IN INDIVIDUALS WITH ACUTE NONSPECIFIC LOW BACK PAIN: A RANDOMIZED TRIAL)

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาผลของการรักษาทางกายภาพบำบัดร่วมกับการขยับเคลื่อนข้อต่อกระดูกสันหลังในผู้ที่มีอาการปวดหลังส่วนล่างเฉียบพลัน ผู้เข้าร่วมการศึกษาอายุระหว่าง 30-50 ปี ที่ผ่านเกณฑ์การคัดเลือก จะได้รับการสัมภาษณ์ประวัติ การตรวจร่างกาย และการตรวจวัดระดับความเจ็บปวด ช่วงการเคลื่อนไหวของหลังในท่าก้ม แอ่น และเอียงขวาและซ้าย ประเมินด้วยแบบประเมินออสเวสทรีก่อนและหลังการรักษา และตรวจประเมินระดับความเปลี่ยนแปลงภายหลังการรักษา ผู้เข้าร่วมการรักษาทั้งหมดจะถูกสุ่มแบ่งออกเป็นกลุ่มควบคุมซึ่งได้รับการรักษาทางกายภาพบำบัด หรือกลุ่มทดลองซึ่งได้รับการรักษาทางกายภาพบำบัดร่วมกับการขยับเคลื่อนข้อต่อกระดูกสันหลัง ผู้เข้าร่วมการรักษาและผู้ช่วยวิจัยไม่ทราบผลของการสุ่มแบ่งกลุ่ม และนักกายภาพบำบัดไม่ทราบผลการประเมินในทุกตัวแปร ทั้งสองกลุ่มใช้ระยะเวลาในการรักษาไม่เกิน 6 สัปดาห์ การยุติการรักษาจะถูกกำหนดโดยนักกายภาพบำบัดร่วมกับผู้เข้าร่วมการรักษา สถิติ Two-way Repeated Measures Analysis of Variance ร่วมกับ Bonferroni post-hoc นำมาใช้ในการเปรียบเทียบ Pearson และ Spearman นำมาใช้เพื่อศึกษาความสัมพันธ์ระหว่างระดับความเปลี่ยนแปลงและผลต่างของระดับความเจ็บปวด ช่วงการเคลื่อนไหวของหลังและแบบประเมินออสเวสทรี

ผู้เข้าร่วมการศึกษาทั้งสองกลุ่มมีอาการดีขึ้นภายหลังการรักษาอย่างมีนัยสำคัญทางสถิติในทุกตัวแปร อย่างไรก็ตามไม่พบความแตกต่างระหว่างผู้เข้าร่วมการศึกษาสองกลุ่ม จำนวนครั้งในการรักษาและอัตราการเป็นซ้ำในกลุ่มทดลองน้อยกว่ากลุ่มควบคุม

การศึกษานี้พบว่าผลของการขยับเคลื่อนข้อต่อกระดูกสันหลังร่วมกับการรักษาทางกายภาพบำบัดให้ผลไม่ชัดเจนในผู้ที่มีอาการปวดหลังส่วนล่างเฉียบพลันเมื่อเทียบกับกลุ่มควบคุม และพบว่าแบบประเมินออสเวสทรีมีความไวต่อการวัดการเปลี่ยนแปลงภายหลังการรักษา เป็นที่น่าสนใจในการศึกษาผลของการขยับเคลื่อนข้อต่อกระดูกสันหลังในผู้ที่มีอาการปวดหลังร่วมกับการยึดติดอย่างชัดเจนซึ่งรอการศึกษาต่อไป

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LIST OF ABBREVIATIONS

ANOVA	=	Analysis of Variance
AROM	=	Active Range of Motion
cm	=	centimeter
EMG	=	Electromyography
GPE	=	Global Perceived Effect Scale
kg	=	kilogram
LBP	=	Low Back Pain
Lt.	=	Left, Left side
MOB	=	Mobilization
MPS	=	Myofascial pain syndrome
MT	=	Manual Therapy
m	=	meter
mm	=	millimeter
mo	=	month
MWD	=	Microwave Diathermy
NRS	=	Numerical Rating Scale
ODQ	=	Oswestry Disability Questionnaire
PA	=	Posteroanterior
PFPS	=	Patient-Specific Functional Scale
PPC	=	Patient's Perception of Change
PT	=	Physical Therapy, Physical Therapist
RCT	=	Randomized Controlled Trial, Randomized Clinical Trial
RMQ	=	Roland-Morris Disability Questionnaire
Rt.	=	Right, Right side
SMT	=	Spinal Manipulative Therapy
ST	=	Stabilizing Training
SWD	=	Shortwave Diathermy
VAS	=	Visual Analog Scale

CHAPTER I
INTRODUCTION

Low back pain (LBP) is one of the most prevalent and costly problems in contemporary industrialized countries. It has been estimated that 60–80% of all adults experience LBP at some periods in their lives, but not all seek medical attention nor do they have significant disability (1, 2). However, LBP is one of the primary causes of disability in persons under the age of 45 years (1, 2). Between 10 and 50% of LBP patients receive physical therapy. Patients with a relatively long duration of back pain suffer more frequently, and physical modalities and manual therapy are more often used (3). Prevalence rates for women and men seem to be similar, whereas Caucasians generally have higher prevalence than non-Caucasian people do (3).

Physical therapists play an important role in managing patients with LBP (3). Physical therapists offer three general approaches in addition to education and information: 1) Therapeutic exercises: the procedures can be active or passive in flexion, extension, stretching, and stabilizing training that is reportedly effective in the management of LBP (4, 5). 2) Electrotherapy, various pieces of equipment have been introduced to the physical therapists' approach to low back pain, for example, trans-cutaneous electrical nerve stimulation (TENS), ultrasound, etc. (6) 3) Manual therapy such as massage, mobilization, and manipulation: some physical therapists apply manual therapy to restore function of the spine and also to reduce pain (7). From the study done by van der Valk (3), the authors found that all types of physical therapy modalities including manual therapy, electrophysical agents, and therapeutic exercise were frequently used in patients with both acute and chronic LBP. Moreover, the suggestion from the study done by Hagen (8) revealed that early gentle mobilization with recommendations to stay active had significant benefits in reducing sick leave periods for patients with LBP.

Mobilization is defined as a repetitive passive movement of varying amplitudes of low velocity applied at different parts of the range of motion depending on the effect desired, while manipulation involves a high velocity thrust of small amplitude performed at the limit of available movement (9). The term manipulative therapy includes both mobilization and manipulation techniques. However, as compared to mobilization, manipulation technique has more precautions and contraindications to application, and the therapists who apply this technique should be skillful. (10, 11). In addition, mobilization technique is claimed as an effective intervention when the objectives of treatment are to reduce pain and to improve joint mobility (6, 12-16).

Although individual therapists emphasize the importance of tailoring treatment to the individual patient, overviews of studies of 'hands-on' approaches to manipulation or mobilization of the spine have tended to be different among various therapists, and it also reflects in their efficacy (17). To date, there are many studies investigating about the efficacy of mobilization. (18-20) From literature reviews, the results were inconclusive when the objectives of mobilization were to decrease pain and increase active range of motion (AROM), especially in patients with acute LBP (12).

According to the study done by Koes (21), the international clinical guidelines for the management of LBP in primary care were compared. In this comparison, clinical guidelines from 11 different countries published from 1994 to 2000 were included. It was found that the recommendations regarding spinal manipulation differed more obviously. Australian, Dutch, and Israeli clinical guidelines do not recommend spinal manipulation for acute LBP, while the national clinical guidelines from 8 other countries recommend differently. For example, Danish guideline suggests manipulation after 2 to 3 days, US guideline within 4 weeks, and New Zealander guideline between 4 and 6 weeks. UK guideline suggests that considering manipulative treatment for patients who need additional help with pain relief or who fail to return to normal activities. In general, the type of manipulative therapy or discipline is not well specified.

From recent meta-analysis studied by Assendelft et al (22), thirty-nine high-quality randomized controlled trials (RCT) were selected. The results revealed that use of manipulative therapy alone had no statistically significant advantage over general practitioner care, analgesics, physical therapy, exercises, or back school in both acute and chronic low back pain patients. Most of these titles tried to study the effects of manipulative therapy alone compared to other therapy. But for clinically, physical therapists use manipulative therapy as an adjunctive therapy with traditional physical therapy modalities rather than manipulative therapy alone (3). According to the meta-analysis of 39 evidences, most of the studies pertained to spinal manipulation, while a few of mobilization research were included into the analysis. In addition, some of these mobilization studies were not clinically based, for example, the experiment done by Petty in 2002 pertained to the effect of posteroanterior mobilization on sagittal mobility of the lumbar spine. The author only measured lumbar spine flexion and extension before and after the mobilization in asymptomatic subjects. So, the results could not be generalized to LBP patients when the objectives of mobilization were to decrease pain and limitation (23).

The meta-analysis done by Ottenbacher et al (24) selected nine out of 57 titles which potentially relevant to manipulation and mobilization and met prespecified criteria for inclusion. The analysis revealed that the effects of manipulation or mobilization were greater when it was combined with other treatments. The treatment effects were measured immediately following therapy. In addition, in journals published in the United States revealed manipulation/mobilization to be less effective in comparison with results showing in English language journals published outside the United States. From the conclusion of the study, however, it was claimed that the number of spinal manipulation and mobilization studies was limited to support that spinal manipulation/mobilization was effective when used to treat pain, flexibility limitations, and impairment in physical activity.

From the meta-analysis study in 2004 studied by Bronfort et al (12), the study engaged in efficacy of spinal manipulation and mobilization for LBP using a technique of systematic review and best evidence synthesis. The researchers claimed that despite

many published randomized clinical trials (RCTs), a great number of reviews and several national clinical guidelines, much controversy still remained regarding the evidence for or against efficacy of spinal manipulation and mobilization for LBP. So, the study aimed to analyze the efficacy of spinal manipulation and mobilization in LBP from published articles in English, Danish, Swedish, Norwegian, and Dutch reporting in randomized trials. Sixty-nine RCTs met the selection criteria but 43 out of 69 met the admissibility criteria determined by the validity assignment. The results showed that spinal manipulation and mobilization are effective in the short term when compared with placebo and general practitioner care, and in long term compared to physical therapy. In addition, spinal manipulation and mobilization provided either similar or better pain outcomes in the short and long term when compared with placebo and with other treatments such as medication, McKenzie approach, physical therapy, and back school. From the results, it was suggested that spinal manipulation or mobilization could be recommended to LBP patients with some confidence because there was limited evidence. In addition, the researchers suggested that future studies should address the value of spinal manipulation or mobilization for acute patients, determine optimal number of treatment visits and consider the cost-effectiveness of care.

From the review of meta-analysis, it has been found that there is limited support of effectiveness for physical therapy combined with spinal mobilization when used to treat pain, flexibility limitations, and impairment in physical activity in patients with LBP, especially in acute cases. Despite the limited evidences, the benefits of application of spinal mobilization in acute LBP were noted in published articles (3, 6). It was hypothesized that the cause of pain is from metabolites produced by static muscle contractions, which stimulate group III and IV muscle afferents, which activate gamma motor neurons. The gamma motor neurons affect the stretch sensitivity and discharges of secondary and primary spindle afferents. Increased activity in the primary muscle spindle afferents enhances muscle stiffness, which causes hypomobility of the affected segments. Muscle stiffness also causes further production of metabolites in muscle (25). When this cycle continues, the pain and muscle stiffness tend to increase. So, it could be possible that spinal mobilization is

beneficial in managing pain and muscle stiffness by breaking the cycle because spinal mobilization provides intersegmental movement that could help prevent the formation of muscle stiffness and then promote the mobilization of the metabolites.

When it is expected that the subjects in the present study will improve over time, the correlations between patient's perception of change and change scores in parameters of the study could be interesting because the correlations can represent the relevance of each parameter in detecting the changes over time. Although, there is no gold standard for measurement of clinically relevant change, it can be accepted that the patient's perception of change provides a reliable assessment whether clinically important change has occurred (26). However, there was a study (26) indicating low correlations between the patient's perception of change and the change scores in other outcome measures. Another purpose of this study is to investigate the correlations between patient's perception of change and each parameter again because of the difference of the settings, outcome measures, and then, effect sizes.

From the literature review, the evidence of benefits of spinal mobilization in managing pain and hypomobility in LBP could be found with the limited number of supportive studies, especially in acute LBP. Therefore, this study aims to investigate the effects of physical therapy combined with spinal mobilization in patients with acute LBP in clinical settings, and to study the correlations between patient's perception of change with change scores in subjective, objective, and outcome assessment. The purposes of the study are as follows.

Purpose of the Study

General objective

This study aimed to investigate the effects of spinal mobilization in patients with acute low back pain (LBP) who received physical therapy and spinal mobilization compared with acute LBP patients who received physical therapy alone.

Specific objectives

1. To compare pain intensity and patient's perception of change between patients who received physical therapy treatment with and without spinal mobilization.
2. To compare active range of motion (AROM) in flexion, extension, right lateral flexion, and left lateral flexion between patients who received physical therapy treatment with and without spinal mobilization.
3. To compare modified Oswestry Disability Questionnaire (ODQ) between patients who received physical therapy treatment with and without spinal mobilization.
4. To study the correlations between patient's perception of change and change scores in subjective, objective, and total score of outcome assessment.
5. To study the correlations between patient's perception of change and change scores in individual items of outcome assessment.

Parameters in the Study

1. VAS scale for pain assessment and patient's perception of change
2. Active range of motion (AROM) in flexion, extension, right lateral flexion, and left lateral flexion
3. Modified Oswestry Disability Questionnaire (ODQ) score 10 items including pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, traveling, and employment/ home making

Scope of the Study

This study focused on acute LBP patients who regularly received physical therapy treatment with or without spinal mobilization in physical therapy clinics. The duration of the study lasted for 6 weeks with 3-month follow-ups, and number of recurrence and additional treatments were investigated.

Hypotheses of the Study

1. There were significant differences in subjective assessments (pain intensity and patient's perception of change) between patients who received physical therapy treatment with and without spinal mobilization.
2. There were significant differences in objective assessments (lumbar spine AROM) between patients who received physical therapy treatment with and without spinal mobilization.
3. There were significant differences in outcome assessment (modified ODQ) between patients who received physical therapy treatment with and without spinal mobilization.
4. There were significant correlations between patient's perception of change and change scores in subjective and objective assessments, and total score of outcome assessment.
5. There were significant correlations between patient's perception of change and change scores in individual items of outcome assessment.

Advantages of the Study

1. The results of this study could be used as a guideline for management of patients with acute LBP.
2. The results might support the effects of spinal mobilization as an adjunctive therapy to physical therapy program in patients with acute LBP.
3. The results provided the correlations between patient's perception of change and change scores in pain intensity, AROM, modified ODQ both total score and individual items.

CHAPTER II
LITERATURE REVIEW

2.1 Biomechanics of Lumbar Spine

2.1.1 Lumbar Spine and Surrounding Structures

From anatomical reviews, there are evidences suggesting that vertebral bodies resist most of the compressive load pressing down along the axis of the spine. Intervertebral discs also resist compressive load and allow movements between vertebrae. Apophyseal joint surfaces prevent the discs from excessive shear force and axial rotation, while intervertebral ligaments protect excessive spinal bending. This description has been affirmed by many investigations (27-29). The details of the structures of lumbar spine and surroundings are given as follows.

2.1.1.1 Vertebrae

Lumbar vertebral bodies and intervertebral discs resist about 80% of the compressive force acting on the spine in the upright standing position, with about 40% of the vertebral body's resistance coming from the cortical shell. About 20% of the spinal compressive load normally falls on the apophyseal joints but it can increase to 70% if the discs are narrowed by degenerative changes. The apophyseal joints' resistance to compression comes firstly from the articular surfaces, while some resistance comes from extraarticular impingement of the inferior facet on the lamina below, and a small proportion is probably due to the capsular ligaments resisting backwards rotation of the inferior articular processes about the pars interarticularis. The apophyseal joints are best able to resist horizontal forces acting perpendicular to their broad articular surfaces. Therefore they extremely limit the range of axial rotation in the lumbar spine and are capable of resisting forward shearing forces of about 2 kN. If the apophyseal joints are asymmetrical, shear force can induce a small axial rotation. Forward bending movements cause the neural arch of the upper lumbar vertebrae to bend slightly about the pedicles, probably as a result of imbalanced

muscle forces pulling down on the spinous processes. This mechanism may serve to increase the intervertebral shear force resisted by the apophyseal joints (27).

2.1.1.2 Ligaments

Posterior intervertebral ligaments have strengths ranging from about 100 N for the posterior longitudinal ligament to about 1 kN or more for the apophyseal joints capsular ligaments. Fibers of the interspinous and capsular ligaments vary in length and orientation, and appear to be arranged to resist forward bending movements of the spine. Fibers of the interspinous ligament simply reorientate during small flexion movements and provide minimal resistance, but in full flexion, the position far from the center of rotation in the disc causes them to be severely stretched to strongly resist the load produced. Tension generated in the intervertebral ligaments during flexion leads to compress the intervertebral discs, therefore the intradiscal pressure can rise by 100% or more in full flexion. The iliolumbar ligaments also resist bending and axial rotation of the lower lumbar spine (27).

Interspinous and supraspinous ligaments, the fibers of these two ligaments combine in with each other. Mechanically, therefore, they should be considered as a single unit. Together they have a tensile strength of 160 N (30). When considered in isolation, the supraspinous ligament is weak or absent in the lower lumbar spine and its tensile strength was reported as 77 N at L1-L3, falling to 49 N at L3-L5 (31). The anatomy of the interspinous ligament suggests that its fibers re-orientate in the initial stages of flexion. This probably describes why these two ligaments provide minimal resistance at small angles of flexion, but resist 19% of the applied bending moment in full flexion, and are the first structures to be damaged beyond the normal range of motion.

Intertransverse ligament, it is stretched by up to 20% during lateral flexion which is more than any other ligament, and it may mainly play in resisting lateral flexion. However, its strength has not been assessed, and it could probably be weak and slack in neutral position (32).

Ligamentum flavum, this ligament contains a network of un-crimped collagen fibers together with a high amount of elastin that enables the ligament to be stretched by 80% without failure (33). The ligamentum flavum gives 13% of the spine's resistance to full flexion and its tensile strength is about 250-350 N (30, 33).

Posterior longitudinal ligament, this thin band attaches to the posterior surface of the discs, but is only weakly adheres to the vertebral bodies in between. It consists of crimped collagen fibers which elongate when the ligament is stretched by 7-8%, and it applies a small pre-tension to the disc of about 3 N. The tensile strength has been reported from100-180 N which may reflect some difficulty in determining the obvious boundary between disc and ligament (34, 35).

Anterior longitudinal ligament, it resists spinal extension and is thicker and stronger than the posterior longitudinal ligament. The anterior longitudinal ligament attaches to the anterior margins of the vertebrae rather than to the discs. Its crimped collagen fibers elongate at a stretch of 8-10%. Its strength increases with the speed at which it is stretched and is typically 600 N when tested in-situ and 330 N when removed from the underlying bones (34, 35).

2.1.1.3 Intervertebral Discs

From the basic knowledge of applied anatomy, it reveals that nucleus pulposus has high water content and behaves like a pressurized fluid even in slightly degenerated discs. The inner annulus also behaves like a fluid but the outer annulus is a fibrous solid and acts like a tensile skin for the rest of the disc. When a disc is compressed, the hydrostatic pressure in the nucleus pulposus causes the vertebral end-plates to bulge into the vertebral bodies. The inner and middle annulus also resist compression directly and the disc bulges radially outwards. If the volume of the nucleus pulposus is reduced, then the hydrostatic pressure falls and the annulus resists more compression, bulging like a flat tyre. In addition, nuclear volume and pressure would be reduced after sustained creep loading during the course of a day, and also by degenerative changes, or injury to the adjacent vertebrae. The outer

annulus provides most of the disc's resistance to bending and torsion, and the stretched fibers act like internal ligaments, increasing the pressure in the nucleus pulposus. After sustained or repetitive loading, fluid flow within and from the disc reduces its resistance to bending and shear and then makes the tissue more elastic (27).

2.1.1.4 Muscles

Paraspinal muscles, the paraspinals or lumbar extensors comprise 2 major groups: erector spinae and so-called local muscles (rotators, intertransversi, multifidi). The erector spinae in the lumbar region are composed of 2 major muscles: longissimus and iliocostalis. These muscles originate in thoracic region but act on the lumbar via a long tendon attaching to the pelvis. This long moment arm is ideal for lumbar spine extension and for creation of posterior shear with lumbar flexion. Deep and medial to the erector spinae lay the local muscles. The rotators and intertransversi muscles do not have a great moment arm. Possibly, they represent length transducers or position sensors of a spinal segment by means of their rich composition of muscle spindles. While, the multifidi pass along 2 or 3 spinal levels. They are thought to work as segmental stabilizers. Because of their short moment arms, the multifidi do not contribute much in gross movement (36, 37).

Quadratus lumborum, a thin, large, and quadrangular muscle, has direct insertions on the lumbar spine. The quadratus lumborum consists of 3 components: inferior oblique, superior oblique, and longitudinal fascicles. Both the superior oblique and longitudinal fibers have no direct action on the lumbar spine but serve as secondary respiratory muscles, stabilizing the 12^{th} rib during breathing. The inferior oblique fibers are generally considered to be a weak lateral flexor of the lumbar vertebrae. In addition, the quadratus lumborum is claimed to be a major stabilizer of the spine, typically working isometrically (37, 38).

Abdominal muscles, particularly, transversus abdominis muscle, its fibers run horizontally around the abdomen, allowing for hoop-like stresses with its contraction. The transversus abdominis was found to be activated before limb movement in healthy subject to stabilize the lumbar vertebrae. While, LBP patients

have a delayed activation of this muscle (39). The transversus abdominis together with the internal oblique and the external oblique of abdominal muscles increase the intra-abdominal pressure from the hoop created via the thoracolumbar fascia, therefore contributing functional stability of the lumbar spine. The abdominal external oblique is the largest and most superficial. It serves as a check of anterior pelvic tilt. It also acts eccentrically in lumbar extension and lumbar torsion. In addition, rectus abdominis muscle is a paired, strap-like locating on the anterior aspect of abdominal wall. Contraction of this muscle causes flexion of the lumbar spine (37). Additionally, co-contraction of the transversus abdominis, the obliquus internus, and the multifidus muscle was proved to be beneficial in stabilizing lumbar spine. In addition, the lumbar multifidus muscles were found to atrophy in individuals with LBP (36).

2.1.2 Lumbar Spine and Surrounding Structures during Daily Activities and Lifting

Forces acting on lumbar spine are body weight, tension in spinal ligaments, tension in surrounding muscles, intraabdominal pressure, and any applied external loads. When the body is in upright position, the main loading on the spine is axial. In this position, body weight, the external weight carried, and tension in the surrounding ligaments and muscles all contribute to spinal compression. During standing, total body center of gravity is anterior to the spinal column, placing the spine under a constant forward bending moment. To maintain body position, this torque must be counteracted by tension produced by back extensor muscles. If the trunk or arms are flexed, the increasing moment arms of these body segments contribute to increasing flexor torque and increasing compensatory tension in the back extensor muscles. Because the spinal muscles have very small moment arms with respect to the vertebral joints, they must generate large forces to counteract the torques produced by the spine from the weight of body segments and external loads. Consequently, the major force acting on the spine is usually derived from muscle activity. In comparison to the load present during upright standing, compression on the lumbar spine increases with sitting, standing with spinal forward bending, and sitting with spinal forward bending, respectively (40).

Shear is a dominant force on the spine during flexion as well as during activities requiring backward lean of the trunk. During upright standing, body weight also loads the spine in shear, which creates a tendency for vertebrae to displace anteriorly with relative to adjacent inferior vertebrae. Because very few of the fibers of the major spinal extensor muscles lie parallel to the spine, as tension in these muscles increases, both compression and shear forces on the vertebral and facet joints increase. However, the shear forces produced by muscle tension in the lumbar region is directed posteriorly, therefore, it partially counteracts the anteriorly directed shear forces produced by body weight (40). Although the relative significance of compression and shear on the spine is poorly understood, excessive shear stress is believed to contribute to disc herniation (41).

During lateral flexion and axial rotation, a complex pattern of trunk muscle activation is required more than for flexion and extension. Asymmetrical frontal plane loading of the trunk also increases both compressive and shear forces on the spine because of the added lateral flexion moment. Another factor influencing spinal loading is body movement speed. It has been revealed that lifting in a very fast and jerking movement increases compression and shear forces on the spine and tension in the paraspinal muscles. In addition, the smoothness of the movement of the external loads can minimize the compressive force on the lumbosacral joint (40).

Maintaining a normal or slightly flattened lumbar curve enables the active lumbar extensor muscles to partially balance the anterior shear forces produced by body weight, and uniformly loads the lumbar discs rather than placing a tensile load on the posterior annulus of these discs. A lordotic curve of lumbar spine alternatively increases loading of the posterior annulus and facet joints, while full lumbar flexion changes the line of action of the lumbar extensor muscles that they cannot effectively counteract anterior shear force. Anterior shear load on the lumbar spine also related to increased risk of back injury (42).

Other factors believed to minimize compression on the lumbar spine are intraabdominal pressure and internal bracing system or abdominal bracing system.

The intraabdominal pressure works like a balloon inside the abdominal cavity to support the adjacent lumbar spine by creating a tensile force that partially offsets the compressive loads. It now appears that increased intraabdominal pressure may help to stiffen the trunk to prevent the spine from buckling under compression. It has been suggested that increased intraabdominal pressure caused increasing trunk extensor moment. In addition, internal bracing or abdominal bracing system is another factor that can stabilize vertebral column. Internal bracing system is caused by the muscle contraction of abdominal muscles that further stretch lumbar fascia to stabilize the spine and maintain intraabdominal pressure. This is of value in performing a task such as lifting because the back extensor muscles must generate enough extensor moment to overcome the flexion moment generated by the forward lean of the trunk(40, 43).

In addition, co-contraction of deep abdominal muscles such as transversus abdominis muscle, obliquus internus muscle, and lumbar multifidus muscle is proved to be useful in stabilizing lumbar spine. The exercise of these muscles, or stabilizing exercise was suggested to be effective in the management of LBP in both short term and long term (4, 44). In addition, the lumbar multifidus muscles were found to atrophy in individuals with LBP (36).

2.2 Low Back Pain (LBP)

2.2.1 Overview of LBP Problem

LBP is now recognized as an important clinical and public health problem. It has been estimated that 60-80% of all adults experience LBP at some point in their lives, but not all LBP patients seek medical attention nor do they have significant disability. However, LBP is one of the primary causes of disability in persons under the age of 45 years (1, 2).

LBP remains a significant clinical and social-impact issue, and it seems to reach epidemic proportions in most western industrialized countries (17, 45). It is estimated that about 15-20% of the American population experiences LBP annually and that at any given time, 2% of the population is disable because of back problems (1, 46). Historically, LBP symptoms have been the second leading cause of office

visits to primary care physicians and the most common reason for visits to osteopathic physicians (47).

The lifetime prevalence of LBP was reported to be about 60-80% of adult population in Western countries with high socioeconomic status such as United States, United Kingdom, Norway, the Netherlands, Sweden, with a point prevalence of 15-30%, a 1-month prevalence of 19-43%, and a 1-year prevalence of 20-40% (1). Moreover, the total costs pertaining to LBP are great in term of both direct and indirect costs. Direct cost is expenses for medical attention, and indirect costs involve decreased productivity, decreased on-duty efficiency, time lost from work, and disability compensation packages (48).

In the United States, the direct health care costs and the total costs in 1990 approximately reach USD 23 billion and USD 50-100 billion respectively (49). Additionally for the United Kingdom, the direct health care costs pertaining to LBP in 1998 was estimated to be £1.6 billion, of which around 35% pertains to service provided to private sectors, and the indirect costs associated with decreased production and informal cares was approximately estimated to be £5 billion (50).

In Thailand, the size of LBP problem has been reported that 1-year prevalence in patients aged from 15 years and over was 43%, with a female to male ratio of 1.2:1. Of these patients, 35.9% had chronic LBP, defined as pain lasting more than 3 months, regardless of gender. And the highest prevalence (45.6%) was reported in age group of more than 65 years. These findings proposed that the prevalence of LBP increased with age. There were associations between LBP and residence area, educational level, and occupation. For example, the higher prevalence rates of LBP were found in rural populations, especially in the central of Thailand (40-48%), uneducated and low educated (44%), and agricultural labors (40-44%) (51).

2.2.2 Classifications of LBP

Patient with unknown origin of LBP is about 85% (52). Therefore, classification system is more important in order to help physical therapists understand

their patients and then to manage them appropriately. The concept of classification has recently gained interest among researchers and physical therapists (52). From the beginning, International Classification of Diseases (ICD) is the taxonomy of diagnostic labels widely used by physicians and physical therapists for grouping patients. However, the reliability and validity of assigning ICD codes are quite low. Therefore, there were many researchers created classification systems for grouping LBP patients. The purposes of creating classification systems are to 1) determine the pathology (53), 2) determine the appropriate treatment or guide treatment (54, 55), 3) for clinical decision making, establishing a prognosis, quality control, research (56), 4) identify groups of patients (57). However, when the quality of these classification systems were considered, some systems were evaluated as inappropriate because they were not thoroughly described in the literature (57).

Concerning with the aforementioned classification systems, the benefits and disadvantages of each system are found. About Bernard and Kirkaldy-Willis, their system is divided into 23 categories and the details of each are provided clearly but the construct validity is unknown and can not be generalized to other studies. In addition, there is no report of reliability. With 23 categories, that makes the clinicians difficult to categorize their patients because some explanations are overlapped. The system of Delitto et al is divided into 3 levels with 13 subcategories, however, the definitions of terms are confused and not in proper order, which might make the clinicians hard to use it. The system of McKenzie is quite clear in explanations of terms and the order of severity of the problems. In addition, the system pays attention to most of posture and alignment of back, which may be beneficial to manual therapists who give patients manual therapy. Also, this system can be easily generalized to other studies. Finally, the system of QTF is somewhat alike the system of McKenzie. This system is divided LBP patients into 11 categories with severity order. It is also easy to use with simple explanations of each category. In conclusion, one classification system is not recommended to use over another because these classification systems differ in their purposes and structures. Since no single classification system is clearly dominant over the others, it is inappropriate to conclude that one classification system is the best (52).

Currently, there are some countries, for example, United States, the Netherlands, Israel, United Kingdom, Australia, creating their own national clinical guidelines for grouping LBP patients and suggesting the appropriate examinations and treatments. All of these national clinical guidelines use them as the cut-off point to categorize LBP patients. The information about physical examinations and proposed treatment are also provided. The recommendations regarding treatments are different obviously among these national guidelines; for example, Dutch, Australian, and Israeli guidelines do not recommend spinal manipulation for acute LBP, while the others do. These differences may be due to the reason that recommendations in guidelines are based not only on scientific evidence but also on consensus. The national guideline committees may consider various arguments such as potential side effects, magnitude of the effects, current routine practice, cost effectiveness, and available resources in their countries (21). However, it can be expected that over 70% of LBP patients who follow these guidelines can become pain-free with a recurrence rate of less than 25% (58).

Moreover, there are some recommendations for diagnosis of LBP from the summary of aforementioned national clinical guidelines: 1) Duration of onset of LBP, chronic low back pain, by definition, is pain that has persisted for longer than 3 months. In addition to the pain, patients typically suffer from both physical disabilities and psychological distress (58). The subacute LBP is from 1 month to 3 months, and the acute LBP is less than 1 month (21). In this present study, the patients with acute onset, pain less than 1 month, were recruited. 2) Diagnosis triage is composed of nonspecific LBP, radicular LBP, and specific pathologic LBP or red flags, by which this triage was used for the inclusion criteria in this present study when only nonspecific LBP patients were recruited. 3) Physical therapists should perform history taking and physical examination to exclude red flags. 4) Physical examination for neurologic screening such as straight leg raising (SLR) test is important. 5) Psychosocial factors are considered if there is no improvement. And 6) radiographs are not useful for nonspecific LBP (21).

2.3 Pain Mechanism of LBP

Until now, to date, many studies were done in order to find out the underlying mechanisms of LBP (25, 28, 29, 59, 60). However, the underlying mechanisms of LBP are usually unknown but there are many potential causes and sources of pain. From literature review, there seems to be only concepts but little hard evidence for the development of the LBP. The potential causes of the LBP could be as follows: 1) the micro-injury of the muscles, tendons, ligaments, intervertebral disc or endplate. After micro-injury, it is then followed by macrophage and neutrophil accumulation and inflammation. Static lumbar flexion has been indicated to cause the development of creep and micro-injuries of the collageneous structures in the lumbar ligaments. This promotes acute inflammation and hyperexcitability of the multifidus muscle. This reflexive muscular stiffness is thought to protect against further damage of the injured structures and enabling tissue healing (59). 2) Dorsal ramus neuropathy is thought to be another potential cause of LBP. It has been indicated that pain arising from the passive and active structures can lead to activation of the paraspinal muscle at the same and adjacent levels as a protective reflex. This spontaneous mechanism can cause the paraspinal muscle sustain contraction (59).

LBP simultaneously affecting a disc and facet joints are frequently detected by physical therapists. Additionally, to more common disc, synovial joint, and nerve root pathologies, the lumbar spine is also susceptible to facet joint blocking by the meniscoids and to disc joint irritation by the microrupture of annulus. The movement restrictions associated with these conditions both from irritation of free nerve endings within the injured lumbar structures themselves and from pressures and irritation secondary to swelling and inflammation exudates from neighboring injured tissues (10).

Acute low back pain, or lumbago, originating from a lumbar segment, is often diagnosed as a muscle strain or spasm. Because pain can be localized in paravertebral muscles, by which, any spasm or increased tension of back extensor muscles can create or emphasize a lumbar lordosis. In addition, most cases of acute low back pain are associated instead with a flattened or kyphotic lumbar curvature with or without an

antalgic lateral shift. Acute low back pain often recurs and progresses to a chronic lumbar dysfunction associated with degenerative changes of discs and neighboring structures, and nerve root involvement. With nerve root involvement, patients describe varying forms of lower extremity pain and paraesthesia. These symptoms must be differentiated from pseudo-radicular pain of visceral organ. Visceral pain that imitates a nerve root irritation and refers pain into the lower extremities is unlikely to benefit from mobilization treatment (10).

Nonspecific or postural back pain that caused by prolonged sitting or prolonged static work of trunk muscles is a type of back pain that differs from the other types of back pain such as sciatica or radicular back pain, and specific back pain (red flags). In nonspecific back pain, it is believed that the pain is caused by sensitization of nociceptors. Nociceptors are terminal endings of finely myelinated or unmyelinated afferent peripheral nerve fibers. They are selectively sensitive to mechanical, thermal, or chemical stimuli (61). Most of the neuromuscular and articular tissues are innervated, and therefore are possible the source of pain. Only a superficial layer of articular cartilage, intra-articular menisci, nucleus pulposus, inner layers of the annulus fibrosus and synovial tissue have no direct nociceptive innervation (61). The sensitivity of a tissue to noxious stimulus depends on density of nociceptors of the tissue (61). Muscles are reacting to deeper stimuli. Nonetheless, a pathophysiological model for the cause of muscular tension and pain in musculoskeletal pain syndromes states that metabolites produced by static muscle contractions stimulate group III and group IV muscle afferents, which sensitize gamma-motoneurones. The gamma-motoneurones affect the stretch sensitivity and discharges of secondary and primary spindle afferents, to which increased activity in the primary muscle spindle afferents promotes muscle stiffness, which leads to further production of metabolites in muscle. Increased activity in secondary spindle afferents, which project back to the gamma system, continues a build in the second positive feedback loop which may perpetuate the condition with less support from activity in group III and IV muscle afferents. On the other hand, tissue oxygen tension has revealed to be markedly higher in those with tense muscles than those with no increased muscle tension. Hypoxia is not the result of increased muscle tension but results from an oversupply of oxygen demanded by the

muscle, leading to increased capillary perfusion and rising oxygen tension. Acute compression of a normal peripheral nerve usually does not cause pain but numbness, paraesthesia, motor weakness, and related symptoms. Mechanical compression of a normal spinal nerve root also seems to induce the intraneural inflammation in the nerve roots. This may lead to hyperexcitability of nerve tissue and pain. Mechanical lumbar nerve root compression does not seem to be a sole cause of leg pain or neurological disorders. The inflammatory response in the neural and perineural tissues is the most likely explanation of the pain (62).

2.4 Factors Influencing LBP

2.4.1 Physiological factors

2.4.1.1 Aging

The incidence of LBP increases between the age of 20 to 65. There are multiple factors involved, but one of the main factors is the gradual loss of muscle mass. The incidence of LBP exactly goes down after the age of 65 because the majority of LBP is caused by muscle or ligament strain, and individuals in working age are more likely to suffer from overuse injuries or acute injuries from lifting too heavy loads (63-65). Hicks et al (65) in 2005 studied the associations between trunk muscle composition and physical function in older adults. Their study sample consisted of a 739 men and 788 women aged 70–79. Computed tomography was used to measure trunk muscle area (cm^2) and muscle attenuation of the following muscle groups: lumbar paraspinal muscles, lateral abdominal muscles, and rectus abdominis muscle. The Health ABC Physical Performance Battery (PPB) and its individual components (usual and narrow walk, chair stands, and standing balance) were used to measure functional capacity. Their findings suggested a link between trunk muscle composition and history of LBP as well as reduced functional capacity in older adults. Improving trunk muscle quality may lead to reduced LBP severity and improved functional status.

2.4.1.2 Increased Weight

Body composition changes with age. People tend to have increasing weight into elderly. Fat distributes centrally, with increases in waist

circumference thought to reflect increases in visceral fat with age. Even if weight is stable, people tend to become fatter with age as muscle mass diminishes and is replaced by fat (66). Associations between body fat distribution and LBP are not well stated, although it may be postulated that individuals with excessive abdominal fat mass may be at risk of LBP, resulted from altered posture to counterbalance the protruding fat mass (67). Sternfeld et al (64) in 2002 studied relationship between body composition and functional impairment in older adults. The sample consisted of 1,655 older women and men. The data of body composition, physical performance, and functional limitation were collected. Physical performance was assessed by walking speed and grip strength, while global functional limitation, across several domains, was assessed by self-report using standard questions. Lean mass and fat mass were assessed from bioelectric impedance using population-specific prediction equations derived from dual x-ray energy absorptiometry. Higher fat mass was associated with slower walking speed and greater functional limitation, while higher lean mass was generally associated only with increased grip strength. A higher lean mass-to-fat mass ratio, a relative measure of body composition, was related with faster walking speed and less limitation. These findings suggest that fat mass negatively affected some domains of physical performance and overall functioning. In addition, it was suggested that women with a large waist had a significantly increased likelihood of LBP (68).

2.4.1.3 Smoking

The association between smoking and LBP was explained that it may be due to nicotine-induced perivertebral malnutrition, including the vertebral body and the intervertebral disc. The malnutrition of the intervertebral disc might cause the back susceptible to mechanical stress. It was also hypothesized that smoking leads to vasoconstriction, arterial changes, or both. Therefore, decreased blood supply can occur to the perivertebral structures, including muscles, tendons, and ligaments. The chronic lack of vertebral blood supply has been surmised as a primary mechanism contributing to tissue hypoxia and malnutrition. Tissue malnutrition may have a direct effect in LBP (69). Al-Obaidi et al in 2004 (70) studied cross-sectionally comparing isometric lumbar extensor strength in 76 men who smoke and not smoke with and

without LBP. Therefore, the subjects were divided into 4 groups. All subjects were measured at 7 angles of lumbar flexion: 0, 12, 24, 36, 48, 60, and 72 degrees. The results revealed nonsmokers with LBP had less muscle strength than nonsmokers without LBP. The strength of smokers between with and without LBP had no difference. Nonsmokers both with and without LBP had a significantly greater strength comparing to smokers both with and without LBP. The study of Al-Obaidi et al suggested that smoking may have an effect on strength of back extensor muscles.

2.4.2 Biomechanical factors

2.4.2.1 Static work postures

Research has suggested that static work posture is a risk factor of LBP. Previous research found that LBP were associated with postures that required maintaining mild trunk flexion, defined as the trunk flexed forward from 21 – 45 degrees (odds ratio = 4.9), postures involving maintaining severe trunk flexion, defined as the trunk being flexed forward of more than 45 degrees (odds ratio = 5.7), and postures involving trunk twisting or lateral bending of more than 20 degrees (odds ratio = 5.9). Their results revealed that the risk of back injury increased with exposure to these deviated postures and with increased duration of exposure. Deviated postures highly increase low back tissue loading, particularly when they must be held (71).

2.4.2.2 Seated work postures

The association between seated work posture and the risk factor of LBP was found in previous study. Liira and coworkers (72) reported that sedentary workers who have to sit for long periods continually have a higher risk of LBP, 8% increase in odds ratio. This finding suggests that variable work, and not too long of any single activity, may have benefit in reduction of mechanically induced LBP.

2.4.2.3 Frequent bending and twisting

From literature review, the link between frequent bending and twisting and the increased risk of LBP can be found. In addition, it was also noted that the increased risk of LBP was associated with higher torso velocities. However, this study did not investigate a mechanism to explain a link with LBP (57).

2.4.3 Psychosocial factors

The International Association for the Study of Pain (IASP) defined pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage. This definition pronounces the pain as a physiological and psychological experience. It is physiologically within the body that is dependent on subjective recognition, that is, without psychological awareness, pain cannot exist. It also emphasizes several other important aspects of the pain experience. Pain is usually considered as a warning signal of actual or perceived tissue damage. However, pain without tissue damage can occur, even though the experience may be described as if the damage had occurred. The experience of pain depends on individual's perception or awareness of a noxious stimulus as pain (73). The possible effects of psychosocial factors influencing LBP can be listed as follows.

2.4.3.1 Attitudes, beliefs, and coping strategies

These factors can influence on how pain is perceived and the way in which pain is managed by the person with pain. Acute pain is usually perceived as a signal of tissue damage. Exposure to pain and learning encourages individuals with pain to make decisions about when pain reflects detrimentally, or just a little source that can be easily neglected. Therefore, the therapist should give the patient a practical and reasonable knowledge on how to prevent further damage that may cause more pain, and on how to practice properly in daily living.

2.4.3.2 Anxiety and fear

Exposure to repeated acute episodes of unrelieved pain, the uncertainty of pain occurrence, difficulty to manage, and negative childhood experiences may increase anxiety and fear about pain (73). When the patient shows anxiety or fear, careful assessment of physical, psychological, and social factors is very important. In addition, the patient should be given the clear-and-insight knowledge pertains to the impairments and underlying pathologies.

2.4.3.3 Stress

Stress may produce fatigue, and impaired mental and physical performance. Stress management strategies include relaxation technique and modification of psychological, social or physical factors that contribute to stress at home or work (73).

2.4.3.4 Education, social status, and personality factors

Individuals with different educations may also have different aspects of attitudes towards pain and everyday life. Especially, individuals with graduation of medicine or other related science; they have good knowledge about pain and the cause of pain. Due to their knowledge, it might make them ignored to pain or more stressful on that such pain, compared to individual with blank knowledge about that pain. Social status and assigned role are additional factors that pain might be more pronounced if that such pain interfere or inhibit them from doing jobs or engaging their duty. Moreover, their self-confidence and/or self-esteem to doing something may be challenged by that pain and related symptoms. Personality problems such as repressed hostility and aggression, rigid superego, guilt, masked depression, and other personality disorders have all been thought to have a causal relationship to the occurrence of chronic pain (74).

2.5 Physical Therapy Intervention for LBP

Physical therapy is recognized as playing a significant role in the management of musculoskeletal problems, especially in spinal part. Low back pain (LBP) is one of the most prevalent and costly problems in contemporary industrialized countries. It has been estimated that 60–80% of all adults experience LBP at some periods in their lives, but not all seek medical attention nor do they have significant disability. However, LBP is one of the primary causes of disability in persons under the age of 45 years (2). Between 10 and 50% of LBP patients receive physical therapy. Patients with a relatively long duration of back pain suffer more frequently, and physical modalities and manual therapy are more often used (3). Prevalence rates for women and men seem to be similar, whereas Caucasians generally have higher prevalence than that of non-Caucasian people (3).

Physical therapists offer three general approaches in addition to education and information: 1) Back exercises, these exercises can be active or passive such as stretching exercise, strengthening exercise, and relaxation techniques. 2) Electrotherapy, various pieces of equipment have been introduced to the physical therapists' approach to low back pain, for example, trans-cutaneous electrical nerve stimulation (TENS), ultrasound, etc.(6) 3) Manual therapy such as massage, mobilization, manipulation were applied by some physical therapists to restore function of the joints and the spine and also to reduce pain (7). From a previous study, it has been suggested that manual therapy had a positive effect on patients suffering from chronic back pain, which lasting for longer than six weeks (6).

Although individual therapists emphasize the importance of tailoring treatment to the individual patient, overviews of studies of 'hands-on' approaches i.e., manipulation or mobilization of the spine have tended to be different among various therapists, and it also reflects in their efficacy (17). To date, there are many studies investigating the use or the efficacy of manual therapy such as manipulation, mobilization, mobilization with movement (MWM), etc. (18-20)

van der Valk and colleagues in 1995 studied physical therapy for patients with back pain in the Netherlands. Data were from a survey of physical therapy in Dutch primary health care, which lasted from 1989-1992. The participants were 83 physical therapists in 32 physical therapy practices in primary health care. Three thousand and five hundred eighty seven patients registered using a specially designed form are included in the study. The registration form relates to three main categories, i.e., 1) general patient characteristics and complaints, 2) diagnosis, and 3) treatment goals and the interventions used. The patients were divided into three groups: 1) patients with back pain present for less than 1 week at the start of PT treatment (19.9 %), 2) patients with back pain from 1 week to 3 months (55.3%) and 3) patients with back pain which had been present for longer than 3 months (24.8%). It was shown that the physical therapy diagnosis and treatment vary with the duration of back pain. For patients with a relatively brief history of pain, they suffered more often from impairments in muscle

tone, restriction in joint range of movement and sciatica. They also suffered more often from limitations in their daily life. About the treatment goals, pain reduction, recovery of joint range of motion, regulation of muscle tone, improvement of posture, and improvement of muscle strength were more often defined as treatment goals. Patients with a relatively long duration of back pain significantly suffered from decreased muscle strength. In the part of treatments, manual therapy and PT modalities were more frequently selected, which massage, therapeutic exercise, and other manual therapy, were frequently used.

According to the meta-analysis done by Cherkin and coworkers in 2003 (14), only RCTs studies were gathered in order to investigate the effectiveness of therapeutic massage. From their review, at least 3 published RCTs had evaluated the effectiveness of massage for LBP. The first RCT (75) randomly assigned 104 patients with LBP lasting 1 week to 8 months to massage therapy including stretching exercises, soft tissue manipulation alone, remedial exercise with posture education, and sham laser therapy. All patients underwent 6 treatment trials over a 1-month period. Outcomes were measured at the end of the treatment period and 1 month later. At the 1-month follow-up, massage therapy and soft tissue manipulation were found to be superior to sham laser therapy for pain and function, and were superior to exercise for pain. But there was no difference in effectiveness between massage and soft tissue manipulation.

Another RCT (76) compared massage therapy with progressive muscle relaxation. Twelve patients with chronic LBP were randomly assigned to each of these treatments. After ten 30-minute sessions over 5 weeks, massage therapy group revealed the superiority to progressive muscle relaxation for pain, depression, flexion, and sleep.

The last RCT (77) randomly assigned 262 patients with persistent low back pain to receive therapeutic massage, Traditional Chinese Medicine acupuncture, or self-care educational materials. At the end of the 10-week treatment period, therapeutic massage was superior to both acupuncture group for function, and self-care

educational materials for function and symptoms. At 1 year, therapeutic massage remained superior to acupuncture for symptoms and function but not to self-care educational materials. The benefits of massage continued for 1 year, even though the patients randomly assigned to receive therapeutic massage were not significantly more likely to receive massages during the final 6 months of follow-up.

Konstantinou and coworkers in 2002 studied the use and reported effects of mobilization with movement (MWM) techniques in patients with low back pain using a cross-sectional descriptive survey of physiotherapists in Britain (17). Mobilization with movement (MWM) has already pioneered and described by Mulligan in New Zealand in the 1992 and 1995. Briefly, MWM is the combination of passive accessory mobilization with simultaneous active movement. The basic role of the MWM is to decrease pain and/or increase range of motion (ROM) as well as Maitland's mobilization, and manipulation. MWM is pain-free in its technique, and produce immediate results. In case of lumbar spine, MWM involves the application of a passive accessory glide along the plane of the facet joint, in a weight-bearing position during active movement. MWM could be applied directly on the facet joint (unilateral techniques) or on the spinous process (central techniques). It is believed that these spinal techniques improve sign and symptoms by directly facilitating the restricted mobility of the facet joints and simultaneously influencing the mobility of the intervertebral joint (17, 78).

About the aforementioned study, Konstantinou and coworkers used a postal survey of a random sample of 3,295 practicing physiotherapists in Britain. The response rate was 72.1% (n = 2,357). Among these respondents, 48.2% (n = 1,136) reported treating LBP, of whom 41.1% (n = 467) reported using MWM in LBP management. Thus, the total sample for analysis consisted of 467 therapists currently treating LBP and using MWM. This indicated that at least one third of all physiotherapists in Britain tend to use MWM for LBP patients as part of their treatment approach. Eighty percent of all respondents had attended a formal MWM course. Fifty one point four percent of the respondents worked in a national health service setting and had more than 10 years experience in LBP management. Over half

of the respondents used MWM weekly at least, with 61.9% using MWM firstly for mechanical LBP, while 16.2% and 7.2% belongs to Chronic LBP and facet joint LBP, respectively.

The most commonly reported changes appeared immediately after the application of MWM were increases in range of motion (ROM) of 54.4%, pain alleviation of 27.5%, improvement in quality of movement of 15.5%, improvement in PPIVM of 4.5%, and improvement in function of 2.8%. This was also reflected in the outcomes selected to assess improvement. On average, the spine was applied by MWM using 2-3 sets of 4-5 repetitions. The lower lumbar levels were treated more frequently. Central MWM technique was used more frequently (67.5%). During the application of MWM, 61.7% patient was in sitting, 35.1% in standing. Most physiotherapists revealed using a combination of other treatment approaches such as Maitland's mobilization (30.8%), muscle imbalance exercise (27.7%), McKenzie approach (19.2%), and patient education (17.9%), together with MWM for LBP patients.

Wilson et al (79) in 2003 studied the outcomes of Muscle Energy Technique (MET) in patients with acute LBP. Nineteen patients with acute LBP were randomly assigned to control or experimental group. The control group underwent supervised neuromuscular re-education and resistance training, while the experimental group received the same exercises in combination with MET. Both groups received the selected exercise 8 times over a 4-week period, 2 times per week. Patients completed an Oswestry disability Index (ODI) on their first and 8^{th} visits and change scores were calculated. The results revealed a statistically significant difference with the experimental group revealing greater improvement in the ODI score than the control group. So, the researchers concluded that MET together with supervised and resistance exercises was superior to those exercises without MET.

About MET, Muscle Energy Technique or MET is an active exercise in that the patient supplies the corrective force instead of physical therapists. MET was also defined as a manual medicine treatment procedure that involves the voluntary

contraction of patient muscle in a precisely controlled direction at varying levels of intensity against a counterforce applied by the operator. It has been hypothesized that MET can be used to lengthen and strengthen muscles to increase fluid mechanics and decrease local edema and to mobilize a restricted articulation (80).

McNeely et al in 2003 (81) performed a systematic review concerning the effectiveness of physiotherapy intervention in the treatment of LBP related to spondylosis and spondylolisthesis. Seventy-one potential studies from published and unpublished sources were collected but only 2 studies met the preset relevance criteria for the critical appraisal. The results from both studies revealed that specific exercise interventions, alone or in combination with other interventions, have a positive effect on LBP related to spondylosis and spondylolisthesis.

Although, the fact that a diversity of treatments to cure LBP are provided by various health care professionals such as physicians, physical therapists, chiropractors (48). The efficacy of most of the available interventions has not been clearly demonstrated yet, and the effectiveness among these interventions is still controversial. While some interventions have been judged to have no benefit, or ineffective therapy, such as general practitioner care, home care, exercises, corset, topical gel, diathermy, minimal massage, traction, and bed rest (14).

The most recent meta-analysis (22) included RCTs reported through January 2000. This meta-analysis was to compare spinal manipulative therapy with other advocated therapies. Data were analyzed from 39 RCTs including 12 RCTs in which manipulation was given in combination with other therapies. The result of this meta-analysis revealed that spinal manipulative therapy was superior to sham manipulation and the aforementioned ineffective therapies. But the spinal manipulative therapy was not superior to other standard treatments. The result was similar for acute and chronic LBP (22).

From literature review, it has been recorded about the management of LBP by physical therapists. Foster et al in 1999 (82) studied the selection of intervention used

for LBP patients in Great Britain and Ireland, while Pensri in 2002 (83) studied the selection of intervention used in Thailand. Both studies were from surveys inquiring about the frequency of the use of physical therapy intervention that were commonly used by physical therapists. The results were reported in percentage of physical therapists who selected the intervention for management of LBP. The conclusion of selection of physical therapy intervention for LBP patients was shown in Table 2.1. The fewer uses of Maitland mobilization in Thailand might be due to the workloads for physical therapists. It was possible that physical therapists in Thailand had to handle a number of patients in a time period more than physical therapists in UK and Ireland. From the same study of Pensri (83) also affirmed the daily workloads to be responsible by Thai physical therapists.

Table 2.1 Selection of physical therapy intervention for LBP patients by physical therapists

Ranking	Pensri (2002) (% therapists)	Foster et al (1999) (% therapists)
1	Hot packs (64.1%)	Maitland mobilization (58.9%)
2	Ultrasound therapy (61.2%)	McKenzie approach (46.6%)
3	Mechanical traction (61%)	Interferential therapy (44.1%)
4	Passive stretching (32%)	Ultrasound therapy (22.3%)
5	SWD (28.5%)	Active exercises (17.5%)
6	Active exercises (27.5%)	Passive stretching (15.3%)
7	Maitland mobilization (24.7%)	Massage (9.3%)
8	McKenzie approach (15.7%)	Mechanical traction (7.1%)
9	Massage (10.4%)	SWD (5.2%)
10	Interferential therapy (5%)	Hot packs (2.7%)

2.6 Manipulative Therapy for LBP

Manipulative therapy in the spine or spinal manipulative therapy (SMT) includes both mobilization and manipulation. Mobilization is defined as a repetitive passive movement of varying amplitudes of low velocity applied at different parts of the range of motion depending on the effect desired, while manipulation involves a

high velocity thrust of small amplitude performed at the limit of available movement (9, 84). However, as compared to mobilization, manipulation technique has more precautions and contraindications to application, and the therapists who apply this technique should be skillful. (10, 11). The term mobilization is used to describe the different kind of manual treatment techniques in manual therapy that included soft tissue mobilization (massage, passive stretching), joint mobilization, neural tissue mobilization, and mobilizing exercises. These techniques are in order to alleviate pain and to increase mobility (10, 11, 18).

However, in the general sense, mobilization is mostly observed as any movement techniques that are applied to musculoskeletal tissues either localized or regional. Typically, in physical therapy, mobilization is recognized as a repetitive passive movement of varying amplitudes of low velocity applied at different parts of the range of motion depending on the effects desired (85).

2.6.1 Effects of Spinal Manipulative Therapy

From literature reviews, it was reported that spinal manipulative therapy has three main therapeutic effects such as psychological, mechanical, and neurophysiological effects.

Psychological effects, it should be considered in clinical practices. The manual contacts provided by the therapist might contribute adjunctive placebo effects together with actual physiological effects. It was postulated that patients might perceive the manual contacts and the explanations provided by the therapists as more satisfactory and confident. Because of the proper manual touch given by therapists, the precision of painful site identification, the confidence felt from physical examination, the relaxation occurred during treatment, all of these factors might affect the patients' perception (86, 87). Although, there was no formal investigations or clear explanations pertaining to these psychological effects, but physical therapists should consider these factors during providing treatments.

Mechanical effects, according to stress-strain curve; it is divided into elastic and plastic region. The elastic region was defined as when the elongation of a tissue is introduced by external forces or loads, or other words, strain is caused by stress. This region requires higher forces or loads for the elongation and the elongated tissue can be returned to original length as the beginning, or reversible. The usual works caused by any movements in daily living are mainly in elastic limit. While the movements that exceed the elastic limit can attribute to the injury of that involved tissues. The plastic region represents the microfailure of the tissue that is elongated beyond the elastic limit. The elongation in this plastic region, the length of the tissue can not be returned to the original length, or irreversible, after the release of the external forces or loads (88). In clinical settings, the plastic deformation is expected from the treatments of spinal manipulative therapy in order to diminish collagen cross link attached to the connective tissues or the tightness in joint capsule. Because of this adhesion or tightness, the movements of the connective tissue or the joint capsule are limited; or decreased extensibility. Therefore, the spinal manipulative therapy aims to increase the range of movement; or enhancing extensibility by stretching out the adhesion in the tissue or the tight capsule in the desired joint (84).

Neurophysiological effects attribute to pain modulation because of the application of spinal manipulative therapy including spinal and supraspinal levels.

The spinal level of pain modulation relates to gate control theory. The gate control theory or the control of pain sensation by the stimulation of large afferent fibers or A beta fiber that is faster in propagation and is sensitized by mechanical stimuli. The results from the sensitization of A beta is the perception of touch and pressure rather than painful sensations, while A delta and C fibers, especially C fiber. The C fiber is unmyelinated and polymodal, the polymodal means the sensitization is possible from many stimuli such as nociceptive, heat, and cold. The results from sensitizations of both A delta and C fibers are pain. However, the A delta and C fibers are slower in impulse propagation than A beta. Therefore, the mechanical stimuli to A beta would affect in faster propagation and the results in non-pain perception, or gate is closed for nociceptive sensitization (89).

The supraspinal level relates to descending inhibitory pathway. The pathway relates to the action of periaqueductal grey (PAG) and rostral ventromedial medulla (RVM). The PAG has many links in the brain and its neurons respond to integrate ascending nociceptive input with information from limbic system. Most of the projections to the spinal cord arise via the RVM and terminate in lamina of the spinal cord. The pain control is caused by the release of endogenous pain inhibitory factors in the brain affecting in descending inhibitory pathway via the connections between the spinal cord and the PAG and the RVM (90). This mechanism has an immediate analgesic effect (91).

2.6.2 Grades of Movement in Manipulative Therapy

The system of five grades of passive movement is applicable, with appropriate modifications to disordered joints or joint complexes requiring treatment, for example, the available excursion of physiological range of a single large peripheral joint (e.g. the shoulder or elbow joint), the available physiological range of a multi-joint articulation, e.g. rotation of the cervical spine, and the available accessory range of one joint, or segment, within a complex of joints, e.g. the cuboid, the 3rd lumbar vertebra.

Grades I to IV refer to mobilization, i.e. passive-movement treatment under control of the patient and Grade V refers to manipulation, i.e. a single passive movement that is not under the control of the patient. It may be regional or a localized manipulation. Grades I and IV are small-amplitude movements at the beginning and end, respectively, of the available range, while II and III are larger-amplitude movements at the middle and end, respectively, of available range (10, 16, 85, 92-94).

2.6.3 Selection of the Grades of Movement in Manipulative Therapy

As the therapist generally handles highly irritable joints and/or nerve roots, technique grading is guided in the first instance by pain, as follows.

1. If pain is constant and rises quickly on movement into range, or it appears early in the range and rises to a level sufficient to stop the movement well

before the normal limit, the techniques could be of small amplitude, gentle and near to the beginning of available range, i.e. grades I, I+, or II-.

2. If there is no pain at rest, and it only begins after more than half range has been traversed, then the mobilizing technique can touch into the pain a bit, and even up to the limit, with care.
3. A block of spasm more than pain can be treated by grade III up to the point of spasm so long as it occurs beyond half range. If it occurs before that, the therapist should select a lower grade.
4. A block by inert-tissue tension or compression with little pain or spasm could be applied with a grade IV technique, and a grade V technique may be indicated (16, 84, 85).

2.6.4 Selection of the Techniques

Central posteroanterior (PA) technique could be used for any low lumbar disorder at the central line of the lumbar spine. This technique was applied on the spinous process of the lumbar vertebrae. This technique was used for central pain at the lumbar spine. In addition, this technique was also suggested to be beneficial for those patients experiencing pain from a spondylolisthesis or intradiscal disorder. Unilateral PA technique was extremely valuable when muscle spasm of the deep intrasegmental muscles could be felt. This technique should be done on the side of the muscle spasm or the pain and its angle could be varied as indicated by the response to the technique. Transverse gliding technique should be used with the symptoms that have a unilateral distribution. Under these circumstances it is more likely to produce an improvement in the patient's symptoms and signs if it is done from the painless side. In this way the joint of the painful side is opened (84).

2.6.5 Associations between the Grades and the Weight Used

The techniques are quantified by a subjective grading structure, which is consequently open to interpretation. The grades are used according to the nature of the pain and the resistance offered by the joint and soft tissues. The decisions of selecting and defining the grades are subjective and they rely on the skill of the therapist and their perception of the nature and degree of joint movement.

Harms and Bader (93) studied the variation in forces used by different therapists during mobilization of the lumbar spine and the repeatability and reproducibility of individual therapists. A standard mobilization couch (Akron Therapy Products Ltd, Ipswich, UK) was used to measure the forces applied during mobilization of the lumbar spine. The couch contains six load cells and links to a personal computer to facilitate data collection, The couch allowed the magnitude of the mobilization force, its direction and the variation in applied load over time to be calculated. In order to compare all therapists under similar condition and minimize the sources of variation, one subject was selected. The subject aged 26 yr, of average built (64 kg, 1.70 m) in good general health acted as the subject for all measurement sessions. Modified Schober method was used to provide an estimate of spinal mobility. The range of lumbar spine movement of the subject was 76 mm. Data collection was performed over a period of 4 months. The subject was studied a maximum of two sessions each week that included up to three therapists, to allow any effects of mobilization to disappear. Thirty experienced therapists recruited in the study had been qualified for an average of 9.4 yr. The therapists repeated the test procedure twice within the same measurement session (A1, A2), and a subsequent study, each therapist repeated the procedure approximately 2 weeks (B1) after the first measurement session under similar experimental conditions. The therapists were asked to perform posteroanterior (PA) central spinal mobilization on the model's L3 spine. The therapists were then asked to describe grades I to IV and end feel. The end feel is thought to displacement of the joint through the full range of translatory movement available. The results of the study were revealed in Table 2.2.

Table 2.2 Mean maximum forces recorded during the two measurement sessions for 30 therapists.

Grade of mobilization	Measurement session		
	A1 (N)	A2 (N)	B1 (N)
Grade I	35	42*	34
Grade II	50	58*	52
Grade III	137	135	132
Grade IV	158	155	156
End feel	198	203	201

* $p < 0.01$, analysis of variance (ANOVA)

Grade I and grade II demonstrated that the comparisons among three sessions were highly significant ($p < 0.001$). The large variation between different therapists is obvious, for example, forces applied during a grade IV ranged from 63 to 347 N, with similar variation for the remaining four procedures. The researchers discussed that the characteristics of the therapists could be related to the maximum force applied. However, no statistically significant relationships were found for any of these parameters (93).

As well as the study conducted by Chiradejnant et al in 2002 (95), they measured the forces and investigated whether the force characteristics could be predicted on the background of physical therapists and patient characteristics. This study recruited 80 patients with LBP, providing data on treatment of 123 lumbar levels and 10 physical therapists performing a central posteroanterior (PA) mobilization treatment. The equipment for measuring force during mobilization treatment was a standard treatment couch with installed seven load cells. Their previous study showed that the couch was highly reliable when measuring the application of force in all 3 axes (96). Then, from the results, the forces in vertical direction were measured for grade I to IV were 50.1 ± 25.7, 84.9 ± 33.4, 121.4 ± 45.7, 194.8 ± 46.6 N respectively. The results suggested that physical therapists changed the magnitude of the force depending on the grade of mobilization. Additionally, one of the factors predicting the force used was the patient's age. It was found that the therapists tended to apply less

force and used smaller force amplitude in older patients than in younger. It was postulated that the therapists were modifying their forces because of a concern over the high incidence of osteoporosis in older patients (95).

2.7 Previous Studies of Mobilization and Manipulative Therapy

2.7.1 Experimental studies

Posteroanterior (PA) mobilization is a technique of mobilization that widely applied by physical therapists in the examination and intervention for patients with low back pain. The technique generally involves the application of PA forces over the spinous process while the subject is in prone lying (97).

The relationship between LBP and lumbar PA stiffness was found according to the study conducted by Latimer et al in 1996 (98). They measured the lumbar PA stiffness on two occasions in 25 subjects with acute or subacute LBP and 25 subjects without LBP. The PA stiffness was measured in subjects with LBP when they first presented with pain and again when pain reduced by more than 80%. For subjects without LBP, they were matched on gender, age, vertebral level to be tested and time between tests, and were also measured on two occasions. The results affirmed the relationship between LBP and the PA stiffness by which the subjects with LBP had a decrease in the PA stiffness by 1.21 N/mm between test 1 and test 2 with statistical significance. While the subjects without LBP had no significant difference in the PA stiffness between two tests. It had been suggested that restoration of normal spinal stiffness will result in a reduction of symptoms and a return of voluntary movement (98).

It is postulated that PA mobilization produces an anterior glide of one vertebra upon another, and that the physical therapist can feel the gliding movement and thereby identify a painfully stiff motion segment. However, Lee et al in 1997 has studied the intervertebral movement produced by PA mobilization by mean of lateral radiography. Twelve healthy male subjects who were in prone lying, and a static force of 150 N was applied vertically to the subjects' L4 spinous processes. The results revealed extension of lumbar segments, while the L5/S1 segment tended to flex.

Moreover, all the spinous processes were displaced anteriorly with the mean ranged from 8.8 to 11.5 mm. In addition, the magnitude of the intervertebral translations observed was small (less than 2 mm in all cases). The mean extension movements ranged from 1.20^{o} to 2.40^{o}. From the study, the researchers refuted the belief that PA mobilization simply produces anterior gliding of one vertebra upon another because PA mobilization elicits a complex movement pattern, not intersegmental or intervertebral movement. However, a limitation of the study is that the mobilization force used in this study was static. It did not fully simulate clinical mobilization during which the force is applied in an oscillatory pattern (97).

Goodsell et al in 2000 (99) studied the short-term effects of posteroanterior mobilization in the lumbar spine in subjects with low back pain, compared with a control intervention. Twenty-six subjects with nonspecific low-back pain that experienced pain on flexion or extension were measured range of movement, and pain score. PA mobilization technique was selected in this study. The magnitude of force was selected by the treating physiotherapist. The results showed no significant difference between the mobilization and the control interventions in range of movement, but the pain score on worst movement revealed significantly better in the mobilization intervention group. However, the factorial design was used in their study which might lead to misunderstanding and confuses because of double use of their subjects for both control and experimental groups. In addition, there was no washout period after the application of spinal mobilization. Therefore, the results should be interpreted with caution (99).

However, the basic concept of mobilization is the belief that spinal mobilization has an effect in mechanical properties of the symptomatic motion segment of the spine. Allison et al in 2001 (100) studied the influence of standardized mobilization on the PA segmental stiffness of the lumbar spine in asymptomatic subjects. In this study, a physiotherapist was trained to perform PA mobilization at a consistent load and frequency by using audio and visual feedback. The spinal posteroanterior mobilization (SPAM) apparatus was utilized to measure the PA stiffness at 3 sites (L1, L3, and L5). Twenty-four subjects without low back pain were

recruited. The subjects' L3 spinous process underwent the standardized PA mobilization for 2 minutes. After mobilization, PA stiffness was measured three times at the three locations. The physiotherapist could apply a standardized mobilization with a mean force of 146 N (SD 8 N) at the frequency of 1.5 Hz. The results revealed no significant difference in the PA stiffness of the lumbar spine at all 3 segments. The researchers concluded that a standardized mobilization of about 150 N and 1.5 Hz for 2 minutes did not affect segmental PA stiffness. Further studies should concern other mechanisms that may contribute to the changes that occur after PA spinal mobilization (100).

According to aforementioned study committed by Allison et al (100), it is exemplary for well-controlled force and frequency performed by physiotherapist in standardized manner. From basic knowledge, the use of mobilization techniques relies on the skill of the therapist and their perception of the nature and degree of joint movement. So, the assessment is complicated by a lack of objective measures because there is no normative data for the healthy population. Therefore, the variation in forces used by various physiotherapists could be observed. Harms et al in 1997 concluded that the inconsistency of magnitude and frequency of mobilization between experienced physiotherapists has considerable implications for clinical practice because the different magnitude and frequency of mobilization might influence inherent viscoelastic behavior of soft tissues. According to their study, the variation in forces used by various physiotherapists when performing the same technique (grade IV mobilization) ranged from 63 to 347 N (mean 158 N), the frequencies ranged from 0.7 – 2.2 Hz (93).

2.7.2 Clinical studies

Hanrahan et al (101) in 2005 examined the short-term effects of posteroanterior joint mobilization at the lumbar spine on pain intensity and muscle force after an episode of acute, mechanical LBP in 19 male collegiate athletes. Subjects were divided into control or experimental group, and then all subjects received a standardized treatment of cryotherapy and stretching. The experimental group also underwent posteroanterior joint mobilization, while the control group was

in prone position only. The results showed that the experimental group had significant decreases in sensory subscale scores of the McGill Pain Questionnaire and in pain during lumbar extension and a significant increase in muscle force. The researchers suggested that joint mobilization had short-term effects at the lumbar spine in reducing pain intensity and increasing force production.

From the meta-analysis in 2004 studied by Bronfort et al (12), this meta-analysis engaged in efficacy of spinal manipulation and mobilization for LBP using a technique of systematic review and best evidence synthesis. The researchers claimed that despite many published randomized clinical trials (RCTs), a great number of reviews and several national clinical guidelines, much controversy still remains regarding the evidence for or against efficacy of spinal manipulation and mobilization for LBP. So the authors aimed to analyze the efficacy of spinal manipulation and mobilization in LBP from published articles in English, Danish, Swedish, Norwegian, and Dutch reporting in randomized trials. Sixty-nine RCTs met the selection criteria but 43 out of 69 met the admissibility criteria determined by validity assignment. The results showed that spinal manipulation and mobilization is effective in the short term when compared with placebo and general practitioner care, and in long term compared to physical therapy. In addition, spinal manipulation and mobilization provided either similar or better pain outcomes in the short and long term when compared with placebo and with other treatments such as medication, McKenzie approach, physical therapy, back school. From the results, it has been suggested that spinal manipulation or mobilization can be recommended to LBP patients with some confidence because of the limited evidences. From the study, the researchers suggested that future studies should address the value of spinal manipulation or mobilization for acute patients, determine optimal number of treatment visits and consider the cost-effectiveness of care.

Assendelft et al (22) in 2003 selected 39 high-quality RCT studies for meta-analysis regarding the effectiveness of spinal manipulation and mobilization. The data of these high-quality RCT were searched via MEDLINE, EMBASE, CINAHL, the Cochrane Controlled Trials Register, and previous systematic reviews. And all

selected RCT were passed the criteria listed by the Cochrane Back Review Group. The results of the meta-analysis showed that the use of manipulative therapy alone had no statistically significant advantage over general practitioner care, analgesics, physical therapy, exercises, or back school in both acute and chronic low back pain patients. In addition, radiation of pain, study quality, profession of manipulator, and use of manipulation alone or combination with other therapies did not affect their results.

Ferreira et al (102) in 2003 reviewed the efficacy of spinal manipulation for LBP of less than 3 months duration by searching via EMBASE, CINAHL, MEDLINE, and the Physiotherapy Evidence Database (PEDro). Thirty-four studies met inclusion criteria and passed the methodological assessment defined by the PEDro scale. Three studies revealed that spinal manipulative therapy had better outcomes than placebo therapy or no treatment for nonspecific LBP of less than 3 months duration. The results of other studies also suggested that spinal manipulative therapy seemed to be more effective than massage and short wave therapy. However, it was not clear whether spinal manipulative therapy was more effective than exercise, physiotherapy, or medical care in the first 4 weeks of treatment.

Ferreira et al (103) in 2002 investigated the effect of spinal manipulative therapy for patients with chronic LBP by searching via EMBASE, CINAHL, MEDLINE, and the Physiotherapy Evidence Database (PEDro). Nine studies met inclusion criteria and passed the methodological assessment defined by the PEDro scale. Two studies compared between spinal manipulative therapy and placebo treatment, and 2 other studies compared between spinal manipulative therapy and non-steroidal anti-inflammatory drugs (NSAIDs). The results of visual analog scale (VAS) revealed that spinal manipulative therapy reduced pain by 7 mm on a 100 mm scale when compared with placebo treatment, and by 14 mm when compared with NSAIDs at one month follow-up. Spinal manipulative therapy also decreased disability by 6 points on a 100-point disability questionnaire compared with NSAIDs.

Hurwitz et al (104) in 2002 investigated the superiority of using physical modalities in combination with spinal manipulation compared with spinal

manipulation alone. This study consisted of 341 subjects with LBP that were randomized to physical modalities with spinal manipulation or spinal manipulation alone. All subjects were followed for 6 months with assessments at 2, 4, 6 weeks, and 6 months. The parameters of this study consisted of pain intensity by using numerical rating scale and disability assessed by Roland-Morris Disability Questionnaire. The results showed no significant difference between two groups, but improvements in pain and disability were more likely in the physical modalities with spinal manipulation group at 2 and 6 weeks but the improvement disappeared at 6 months.

The meta-analysis done by Ottenbacher et al (24) selected nine out of 57 titles which potentially relevant to manipulation/mobilization and met prespecified criteria for inclusion. The analysis revealed that the effects of manipulation or mobilization were greater when it was combined with other treatments and were also greater when the treatment effects were measured immediately following therapy. In addition, in journals published in the United States revealed manipulation/mobilization less effective in comparison with results showing in English language journals published outside the United States. From their conclusion, it was claimed that the number of spinal manipulation/mobilization studies was limited to support that spinal manipulation/mobilization was effective when used to treat pain, flexibility limitations, and impairment in physical activity.

From the literature review, the evidence of benefits of spinal mobilization in managing pain and hypomobility in LBP could be found with the limited number of supportive studies, especially in acute LBP. In addition, the effectiveness of spinal mobilization was still controversial that might be due to the varied methodology, clinical measurement, and clinical settings, especially in acute nonspecific LBP. Therefore, it is interesting and susceptible to investigate the effects of physical therapy combined with spinal mobilization in patients with acute nonspecific LBP in clinical settings compared with physical therapy alone in order to study the superiority of the use of spinal mobilization in combination with physical therapy.

CHAPTER III
MATERIALS AND METHODS

3.1 Subjects

Patients with acute low back pain (LBP) seeking physical therapy treatment at Physical Therapy Clinic, Faculty of Physical Therapy and Applied Movement Science, Mahidol University were asked to participate in the study. Fifty patients were included into the study. They were explained general information and objectives of the study. The procedure of this study was approved by Ethics Committee Faculty of Medicine Siriraj Hospital, Mahidol University (Appendix H).

3.1.1 Inclusion Criteria

Men and women, who comprehended to general objective of the study and basic instructions, aged 30-50 years with acute LBP (pain less than 1 month), the area of pain was at lumbar region, not lower than gluteal folds. The characteristics of pain was without numbness, paraesthesia, or neurologically involved. The severity of pain was from mild to moderate, and the subjects denied a prior episode of LBP within previous 6 months.

3.1.2 Exclusion Criteria

1. The area of symptom was lower than gluteal folds
2. Involvement with neurological disorders determined by muscle strength by manual muscle testing, reflex test, neurodynamic test by straight leg raising test (SLR), and sensation test by pin prick and light touch
3. Pregnancy
4. Received other forms of treatment rather than physical therapy such as back pain injection
5. Red flags could be identified. The red flags are defined in 6 categories as follows (46):

    5.1 Spinal fracture or spinal trauma

5.2 Corticosteroid use (all any types) of more than 3 months duration within the preceding year

5.3 Disc hernia: history of leg pain radiating below the knee, history of persistent numbness or weakness in the leg or legs

5.4 Ankylosing spondylitis

5.5 Cauda equina syndrome: history of bladder dysfunction, saddle anesthesia, or fecal incontinence

5.6 Cancer: history of previous cancer, unexplained weight loss of at least 10 pounds or 5% of body weight within the preceding year, or no relief of low back symptoms with bed rest for persons older than 50 years

3.2 Instrumentation

1. Visual analog scale (VAS), for pain assessment and patient's perception of change
2. A tape for measurement of active range of motion (AROM)
3. Modified Oswestry Disability Questionnaire (ODQ)
4. Treatment diary

3.3 Assessments

3.3.1 Pain Assessment

To assess pain intensity of LBP, visual analog scale (VAS) (105) was used. The VAS is a 100 mm horizontal line, anchored from 'no pain' to 'worst pain imaginable'. The patient exposed the intensity of pain with a mark on the VAS line.

3.3.2 Patient's Perception of Change

As pain assessment, VAS was used again for assessing patient's perception of change to the treatment. The VAS line is 100 mm long horizontally (-50 to 50), while the left end was noted as 'worst change', the middle, or 0, was defined as

‘unchanged’, and the right end defined ‘completely recovered’. The patients replied their own perceived satisfaction with a mark on the VAS line.

3.3.3 Active Range of Motion (AROM)

In order to assess the improvement of the patients’ back mobility, AROM was measured to detect the change. In the study, the patient was asked to perform back flexion, back extension, and left and right lateral flexion with fixation of hip movement by the researcher. This study used tape measure method for measuring AROM of lumbar spine. Firstly, the tape measure method or Schober method described the original two-mark method, in which one mark at the lumbosacral junction, and another at 10 cm above the first mark. Macrae and Wright (106) modified the original Schober method by adding the third mark, 5 cm below the lumbosacral junction, so-called modified Schober test. Van Adrichem and van der Korst (107) discussed that the original Schober and modified Schober were difficult in identification of lumbosacral junction by palpation. Williams et al (108) introduced the use of modified-modified Schober which consisted of two landmarks, one mark at the middle of spine in line between both sides of posterior superior iliac spine (PSIS) and the second mark at 15 cm above. Intraclass correlation coefficient (ICC) 3,1 model for test-retest reliability and standard error of measurement (SEM) of AROM measurement, modified-modified Schober technique, were reported in Appendix C. The validity of the technique as compared with radiographic examination was done in the previous study, the value of correlation coefficient was 0.97 (106).

In the present study, the modified-modified Schober technique (109) was used and the measurements were done by the research assistant to measure subject’s back mobility. The researchers and the therapists in this study were blinded to values measured. The descriptions of protocol of the technique were provided as follows. A subject was instructed in desired motion: flexion, extension, right and left lateral flexion. The subject moved both hands in the selected direction accordingly as far as possible while keeping knees extended. The starting position of measurement

for all directions, the subject was in standing position keeping the hips and the knees in neutral position; the subject's feet placed apart equal to shoulder's width. The subject's feet placed in neutral position. Then, for flexion and extension, the tape was aligned from baseline landmark (at the middle of spine in line between both sides of PSIS) to 15 cm above the baseline landmark (Figure 3.1). The research assistant recorded the difference of distance between the superior and the baseline landmarks by subtracting from 15 cm while the subject fully flexed or extended (Figures 3.2, 3.3). The research assistant prevented a compensatory movement. For right and left lateral flexion, the subject was in erect standing, the research assistant marked the position of the tip of middle finger. Then the subject laterally flexed the spine, moving hand down side of leg as far as possible. The difference between skin mark on thigh in erect standing and skin mark on thigh in full lateral flexion was recorded (Figure 3.4).

Before the study, the research assistant, who graduated in physical therapy for 3 years, was trained about the measurement of subject's back mobility in following movements: flexion, extension, and left and right lateral flexion. After training program, the research assistant was assessed test-retest reliability in all movements. Intraclass correlation coefficient (ICC) 3,1 model was used to assess the test-retest reliability of the research assistant. The ICC 3,1 values ranged from 0.9431-0.9795. The standard error of measurement (SEM) was also measured. The SEM values for AROM in flexion, extension, right and left lateral flexion ranged from 0.2411-0.6576 cm (Appendix C).

Figure 3.1 Starting position for flexion and extension revealing the baseline landmark, between the midline between both sides of PSIS, and the superior landmark, 15 cm above the baseline landmark.

Figure 3.2 The measurement for flexion.

Figure 3.3 The measurement for extension.

Figure 3.4 The measurement for right lateral flexion.

3.3.4 Outcome Measure

Thai modified Oswestry Disability Questionnaire (ODQ) was used to assess physical function. Thai modified ODQ is composed of 10 items: pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, traveling, employment/ home making, which is categorized into 6 levels of each item starting from 0 (representing no disability) to 5 (representing highest disability of that function). The report of ODQ was collected both a percentage score that summarized from all items and a score of each item separately. The ODQ is designed to assess how pain affects various activities of daily living (56).

3.4 Intervention

3.4.1 Control Group

The patients underwent a 6-week treatment program, visiting a physical therapist (M.V.) who had 13 years of experience in musculoskeletal physical therapy. The patients met the therapist twice a week. On the first visit, the patients were told about general knowledge of how to correctly perform tasks in daily living, and how to prevent recurrent LBP with proper postures. After that, the patients underwent approximately 1-hour treatment that specified by the therapist according to physical examination assessed by the therapist. The selection of intervention, and the duration of each depended on the therapist with the rationale of offering the proper treatment to each individual. During the treatment, the therapist recorded her treatments given to the patient in the treatment diary. The diary was noted about what intervention selected and how long each intervention was given. The patients were given any of these following interventions: hot pack/ cold pack, electrotherapy (transcutaneous electrical nerve stimulation; TENS, interferential current; IF), ultrasound therapy, manual therapy (only massage), lumbar traction, and therapeutic exercises (stretching, strengthening, or specific training). In this study, the therapist was blinded to the measurements of all parameters. By which, the measurements were done by the research assistant.

3.4.2 Experimental Group

The patients received a 6-week treatment program, visiting a physical therapist (P.S.), who had 5 years of experience in musculoskeletal physical therapy. The patients met the therapist twice a week. The process of treatment in this group was similar to the control group, on the first time, the patients were told about general knowledge of preventing LBP recurrence and performing tasks with proper postures. The patients underwent approximately 1-hour treatment (10 minutes of spinal mobilization assessment and treatment included) that specified by the therapist and the selection of intervention, and the duration of each depended on the therapist. During the treatment, the therapist recorded his treatments given to the patient in treatment diary. The patient received any of these followings: hot pack/ cold pack, electrotherapy (TENS, IF), ultrasound therapy, lumbar traction, therapeutic exercises (stretching, strengthening, or specific training), and manual therapy (massage). In addition, for the experimental group, spinal mobilization was also given in all cases. For this study, the mobilization technique consisted of following accessory techniques: posteroanterior or PA (central and/or unilateral), and transverse gliding. The selection of technique depended on the subjects' symptoms based on Maitland's principles (84) as reported in Chapter II. By which the direction of central PA was used for central pain at the lumbar spine, unilateral PA was used for pain laterally to the spinous process of the lumbar spine, if the pain occurred at the right side and the left side of the lumbar spine, two unilateral PA, one side each at the right and the left of that symptomatic level were used. The use of unilateral PA technique was also good in releasing muscle spasm (84). In addition, transverse gliding was used when the symptoms had a unilateral distribution, by pushing the spinous process towards the painful side. In this way the joint of the painful side was opened. In this study, the therapist was blinded to the measurements of all parameters. By which, the measurements were done by the research assistant.

3.5 Procedure

The eligible patients were asked to participate in the study. Before the trial, the patients were given the basic information pertaining to general procedure of this study,

and were asked to refrain from any restrictions that might affect results of the study such as undergoing other additional treatments or engaging in unaccustomed activities. Then, the researchers inquired about patients' history and investigated patients' physical examination. Before the trial, the following assessments were recorded as baseline data: pain intensity, active range of motion (AROM) in flexion, extension, and left and right lateral flexion, and outcome measurement (ODQ). In this study, the research assistant who blinded to the random assignment performed all measurements throughout the study. After the baseline data assessments, the patients drew a label in an opaque container determining either group of the study: control group (physical therapy treatments) and experimental group (physical therapy treatments with spinal mobilization). The random assignment for group allocation by drawing labels was managed by a researcher in this study. After drawing labels, the patients and the research assistant were blinded to the information of group allocation. Then, all patients had an appointment for next time treatments. The patients were asked to meet the researchers for treatments and assessments twice a week (with at least 1 day apart). The interval of treatment program is 6-week long or until the symptoms of LBP disappeared (if less than 6 weeks), or when the patients satisfied the outcome and would like to stop the treatment program within 6 weeks.

After each week and at week 6 or at the end of treatment program, following assessments were performed: pain intensity, and active range of motion (AROM) in flexion, extension, and left and right lateral flexion. And about patient's perception of change, and outcome measurement (ODQ) were measured at week 3 and week 6 or at the end of treatment program. For 3-month follow ups, all patients were asked to come back for re-evaluation for VAS: pain intensity and patient's perception of change, AROM and ODQ, and inquired for recurrence rate. All measurements were done by the research assistant and the two therapists were blinded to the values measured throughout the period of data collection (For summary see figure 3.5).

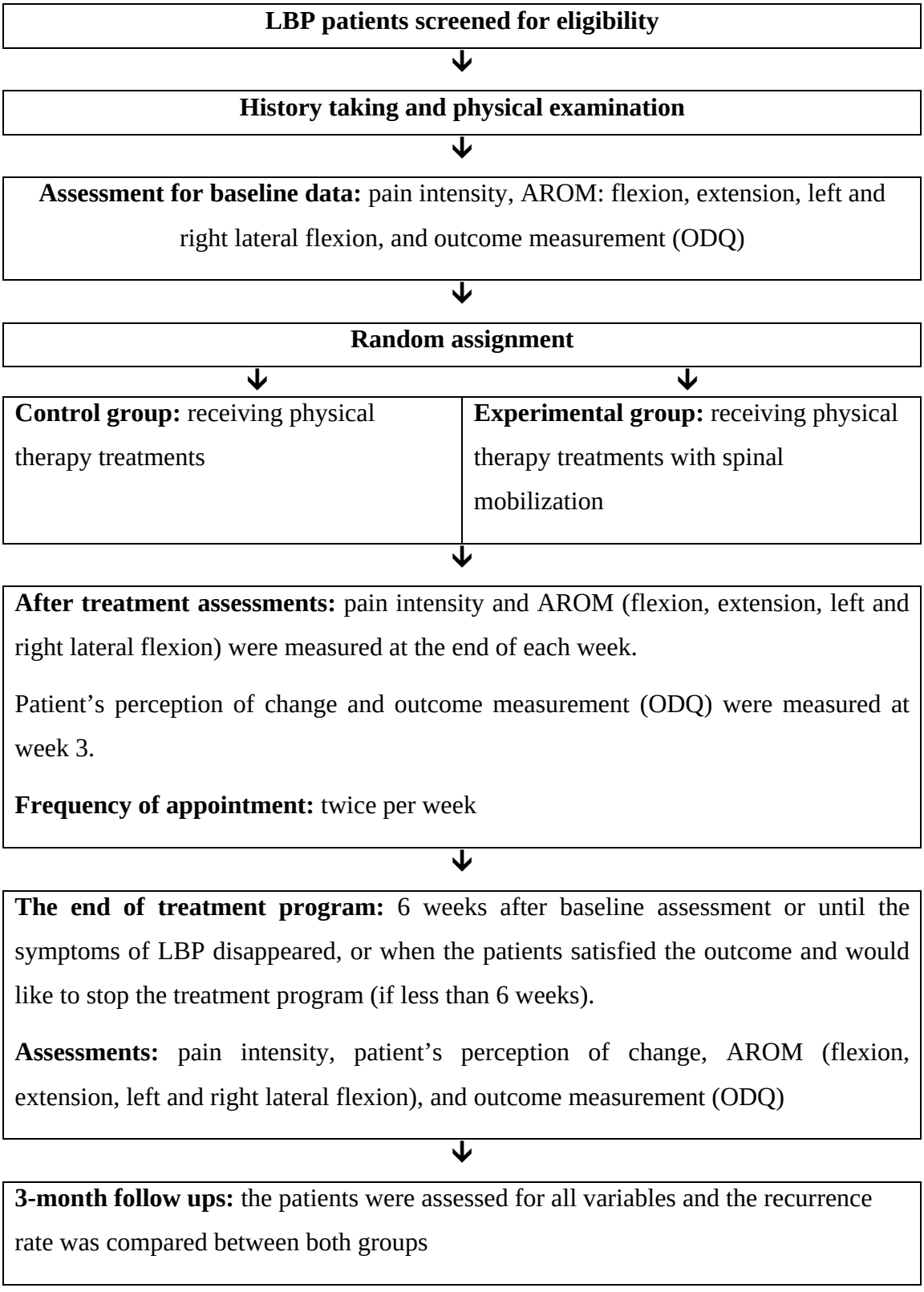

Figure 3.5 Flowchart of procedure of the study.

3.6 Data Analysis

The statistical significance was set at probability level less than 0.05 ($p<0.05$). The data in this study were normally distributed; and the statistics were used as followed.

1. Unpaired t-test was used to assess the demographic data of subject's characteristics between two groups and change score between two groups.
2. Two-way Repeated Measures Analysis of Variance (ANOVA) was used to assess difference in all assessments within each group throughout the study and between groups of the study in each time of assessment.
3. Bonferroni post hoc was used for multiple comparisons between two groups or between different times of assessment within each group if the results were statistically significant.
4. Mann-Whitney U test was used to compare the number of visit between two groups.
5. Chi-Square test was used to compare the recurrence rate between two groups.
6. Pearson correlation was used to estimate the relationships between patient's perception of change and change scores: pain intensity, AROM, and modified ODQ total score.
7. Spearman correlation was used to estimate the relationships between patient's perception of change and change scores of modified ODQ individual item.

CHAPTER IV
RESULTS

4.1 Characteristics of Subjects

In this study, fifty subjects both men and women were recruited. All subjects who met inclusion criteria and had no limitations according to pre-specified exclusion criteria were given general information about the study procedures, and then they had given informed consent. The susceptible subjects were then randomly divided into control or experimental group by drawing lots. The data of age, weight, height, and BMI, location of pain, and drop-outs were recorded. The drop-outs were determined in the case of loss of contact from the subjects. Then, new subjects would be recruited for the replacement until the number of subjects in each group was 25 from sample size calculation accordingly. The characteristics of subjects are reported in Table 4.1.

Table 4.1 Characteristics of subjects

Characteristics	**Control group (n=25)**		**Experimental group (n=25)**		p-value[a]
	Mean	SD	Mean	SD	
Gender (F / M)	20 / 5		13 / 12		-
Age (years)	39.24	6.11	39.52	6.04	0.871
Weight (kg)	59.74	11.00	64.48	11.56	0.144
Height (cm)	159.64	6.82	162.64	6.90	0.129
BMI (kg/m^2)	23.43	4.04	24.47	4.76	0.411
Duration of symptom (days)	11.60	4.88	10.88	5.47	0.626
Location of pain	**Number (%)**		**Number (%)**		
Left side	6 (24%)		4 (16%)		
Right side	2 (8%)		4 (16%)		
Both sides / Central	17 (68%)		17 (68%)		
Upper (L1-L3)	3 (12%)		2 (8%)		
Lower (L4-L5)	5 (20%)		7 (28%)		
Both (L1-L5)	17 (68%)		16 (64%)		
Drop-outs	**Number**		**Number**		
After 1st treatment	4		0		
After 1st week	1		2		
After 3rd week	0		1		

a = p-value from unpaired t-test

4.2 Comparison of VAS Scores for Pain Intensity

Visual Analog Scale (VAS) scores for pain intensity represented the worst pain perceived by the subjects on aggravating movement or action. Then, the subjects expressed their pain intensity by marking on a given 100-mm scale.

From the study, the data of pain intensity before receiving interventions or baseline data were similar between control and experimental groups (44.9 ± 23.7 mm and 52.4 ± 24.5 mm respectively). After the first physical therapy intervention, the subjects in both groups showed immediate effect on pain decrement from baseline measurements with statistical significant differences ($p < 0.001$). When compared with baseline data, the decrease of pain still existed from week-1 measurement to the end of program and at month-3 measurement in both control and experimental groups with statistical significant differences ($p < 0.001$). However, the comparison between two groups at any time of measurement had no difference (Table 4.2).

The values of both groups and statistical analysis between two groups are shown in Table 4.2, and multiple comparisons among various times of measurement for each group are reported in Table 4.3 and Table 4.4.

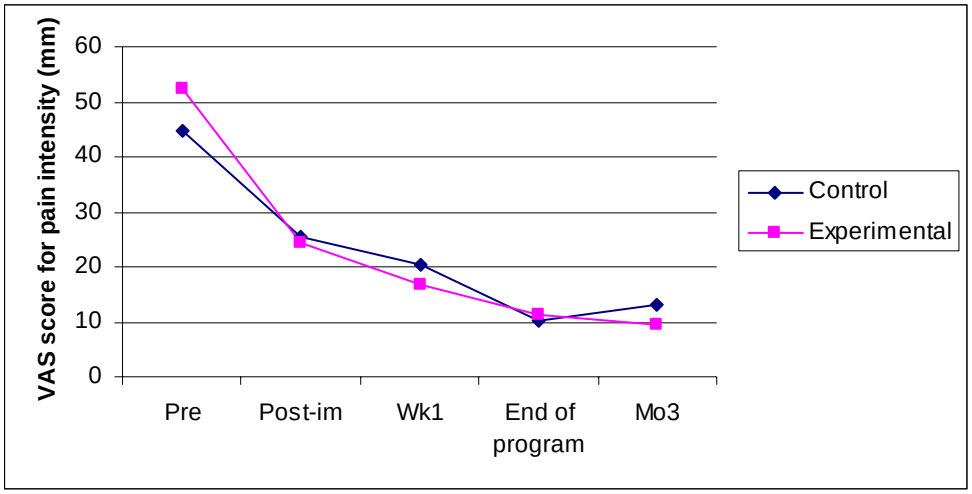

Figure 4.1 Means of VAS score for pain intensity for control and experimental groups.

Table 4.2 Comparison of VAS scores for pain intensity between control and experimental groups (mm)

Group	**Control group**		**Experimental group**	
Time	Mean	SD	Mean	SD
Pre-treatment	44.9	23.7	52.4	24.5
Post-immediately	25.3	19.9	24.4	20.2
Week1	20.4	18.9	16.7	17.3
End of program	10.3	9.3	11.3	17.6
Month3 follow-up	13.2	17.4	9.4	21.5
p-value Within group	<0.001*			
p-value Between groups	0.921			
p-value Interaction time x group	0.197			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.3 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Post-immediately	Week1	End of program	Month3 follow-up
Pre-treatment	-	<0.001*	<0.001*	<0.001*	<0.001*
Post-immediately	-	-	1.000	<0.001*	0.099
Week1	-	-	-	<0.001*	0.818
End of program	-	-	-	-	1.000
Month3 follow-up	-	-	-	-	-

Table 4.4 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Post-immediately	Week1	End of program	Month3 follow-up
Pre-treatment	-	<0.001*	<0.001*	<0.001*	<0.001*
Post-immediately	-	-	0.189	0.003*	0.017*
Week1	-	-	-	0.161	0.754
End of program	-	-	-	-	1.000
Month3 follow-up	-	-	-	-	-

4.3 Comparison of AROM Flexion

Active range of motion (AROM) in flexion was one of the parameters of the study. It was measured when the subjects bended forward as much as possible and a measuring tape was attached directly to the subjects' skin. The difference from the beginning of 15 cm was recorded (see also in Chapter III).

From the study, the baseline data of AROM flexion were similar between control and experimental groups (5.03 ± 1.45 cm and 5.15 ± 1.36 cm respectively). Compared with the baseline data, the subjects of both groups were likely to show better results in AROM flexion at week 1, the end of program, and at month-3 follow up (Figure 4.5). However, the statistical difference was not found in multiple comparison of time for both groups (except between baseline and month 3 in control group, Table 4.6). In addition, the comparison between two groups at any time of measurement showed no difference (Table 4.5).

The values of both groups and statistical analysis between two groups are shown in Table 4.5, and multiple comparisons among various times of measurement for each group are reported in Table 4.6 and Table 4.7.

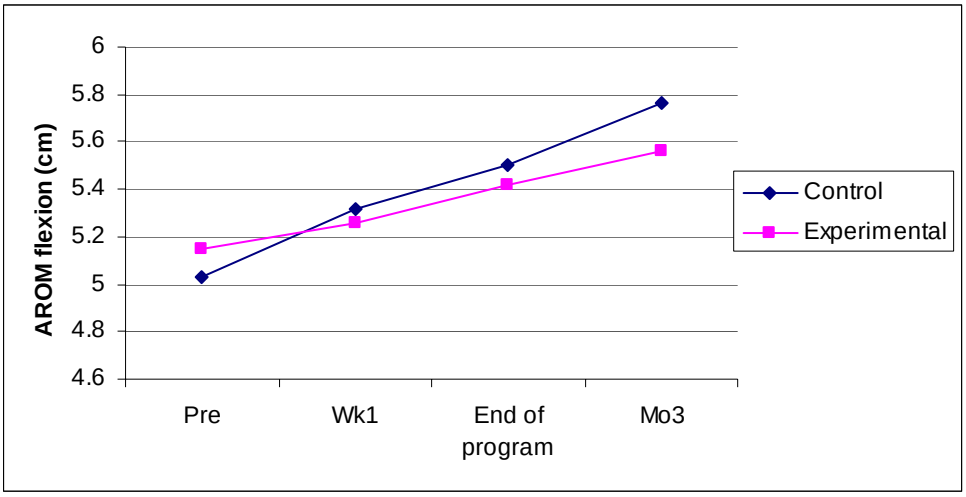

Figure 4.2 Means of AROM flexion for control and experimental groups.

Table 4.5 Comparison of AROM flexion between control and experimental groups (cm)

Group / **Time**	**Control group**		**Experimental group**	
	Mean	SD	Mean	SD
Pre-treatment	5.03	1.45	5.15	1.36
Week1	5.32	1.45	5.26	1.20
End of program	5.50	1.21	5.42	1.24
Month3 follow-up	5.76	1.37	5.56	1.40
p-value Within group	0.013*			
p-value Between groups	0.712			
p-value Interaction time x group	0.392			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.6 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.863	0.257	0.009*
Week1	-	-	1.000	0.178
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.7 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	1.000	1.000	0.387
Week1	-	-	1.000	0.777
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

4.4 Comparison of AROM Extension

The baseline data of AROM extension in control and experimental groups were 1.70 ± 1.27 cm and 1.48 ± 1.08 cm respectively. The comparison between two groups at baseline measurement had no difference. When the subjects had received interventions, the values of AROM extension were significantly higher in both groups at week-1, the end of program, and month-3 measurements, as shown in Table 4.9 and Table 4.10. However, the comparison between two groups had no difference (Table 4.8).

The values of both groups and statistical analysis between two groups are shown in Table 4.8, and multiple comparisons among various times of measurement for each group are reported in Table 4.9 and Table 4.10.

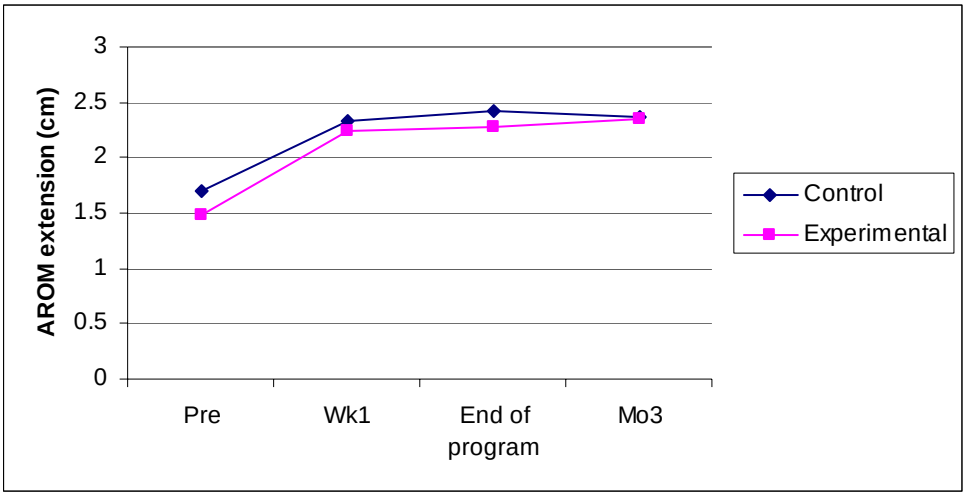

Figure 4.3 Means of AROM extension for control and experimental groups.

Table 4.8 Comparison of AROM extension between control and experimental groups (cm)

Group / **Time**	**Control group**		**Experimental group**	
	Mean	SD	Mean	SD
Pre-treatment	1.70	1.27	1.48	1.08
Week1	2.33	1.40	2.24	1.16
End of program	2.42	1.36	2.28	1.09
Month3 follow-up	2.36	1.37	2.35	1.27
p-value Within group	<0.001*			
p-value Between groups	0.719			
p-value Interaction time x group	0.779			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.9 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.025*	0.021*	0.048*
Week1	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.10 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.004*	0.008*	0.004*
Week1	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

4.5 Comparison of AROM Right Lateral Flexion

The baseline data of AROM right lateral flexion in control and experimental groups were 18.65 ± 4.86 cm and 20.00 ± 3.92 cm respectively without between-group difference. The subjects in both groups were likely to get improvement in AROM right lateral flexion. Especially, for the experimental group, the values were significantly higher from baseline data at the end of program and at month-3 measurements with statistical significances of p = 0.003 and 0.036 respectively, see also in Table 4.13. However, the comparison between two groups had no difference at any time of measurement, as shown in Table 4.11.

The values of both groups and statistical analysis between two groups are shown in Table 4.11, and multiple comparisons among various times of measurement for each group are reported in Table 4.12 and Table 4.13.

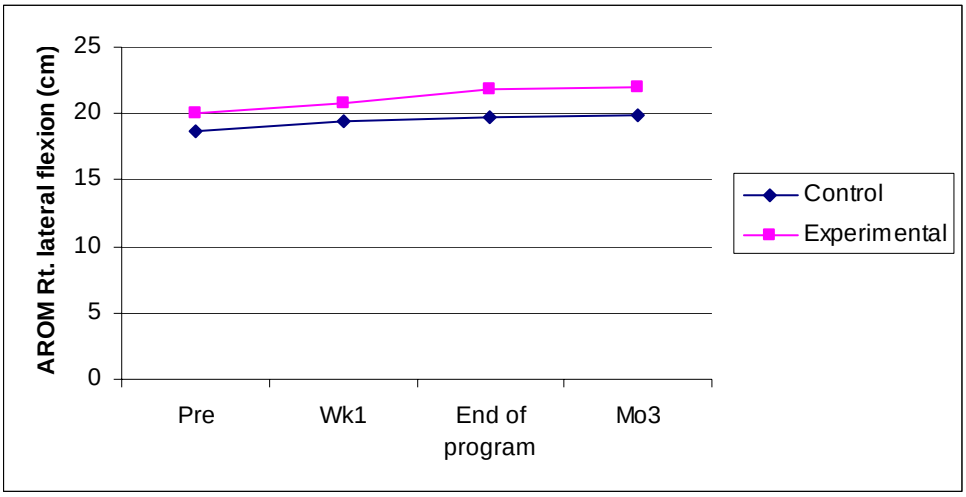

Figure 4.4 Means of AROM right lateral flexion for control and experimental groups.

Table 4.11 Comparison of AROM right lateral flexion between control and experimental groups (cm)

Group	**Control group**		**Experimental group**	
Time	Mean	SD	Mean	SD
Pre-treatment	18.65	4.86	20.00	3.92
Week1	19.48	4.55	20.80	4.47
End of program	19.80	4.59	21.80	4.23
Month3 follow-up	19.84	4.28	21.92	4.17
p-value Within group	<0.001*			
p-value Between groups	0.153			
p-value Interaction time x group	0.542			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.12 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.274	0.128	0.492
Week1	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.13 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.319	0.003*	0.036*
Week1	-	-	0.069	0.329
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

4.6 Comparison of AROM Left Lateral Flexion

AROM left lateral flexion at baseline measurement for control and experimental groups were 19.27 ± 3.67 cm and 19.88 ± 3.81 cm respectively without between-group difference. The subjects in both groups seemed to be better in AROM left lateral flexion. But only for the experimental group, the values were significantly higher from baseline data at week-1, the end of program, and at month-3 measurements with statistical significances of p = 0.014, 0.004, and 0.001 respectively, see also in Table 4.16. However, the comparison between two groups had no difference at any time of measurement, as shown in Table 4.14.

The values of both groups and statistical analysis between two groups are shown in Table 4.14, and multiple comparisons among various times of measurement for each group are reported in Table 4.15 and Table 4.16.

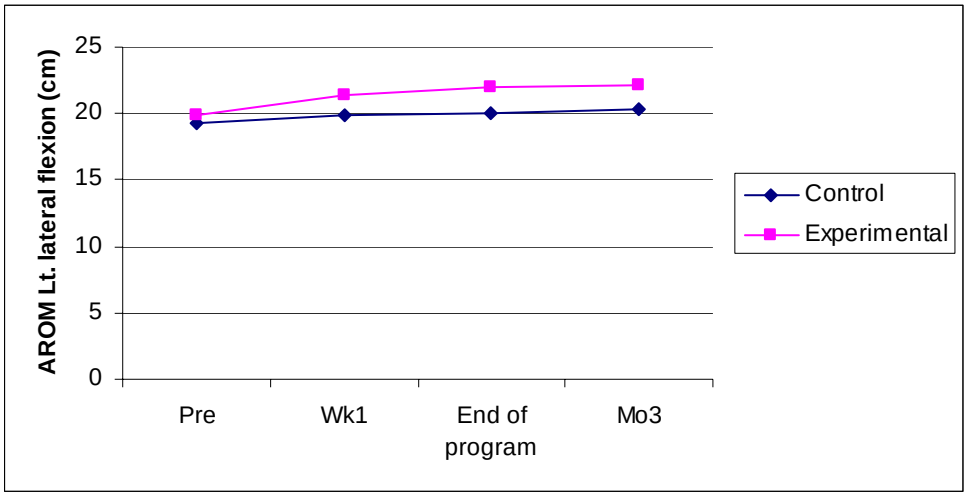

Figure 4.5 Means of AROM left lateral flexion for control and experimental groups.

Table 4.14 Comparison of AROM left lateral flexion between control and experimental groups (cm)

Group	**Control group**		**Experimental group**	
Time	Mean	SD	Mean	SD
Pre-treatment	19.27	3.67	19.88	3.81
Week1	19.95	3.59	21.46	3.76
End of program	20.01	3.98	21.94	3.64
Month3 follow-up	20.38	3.35	22.18	3.49
p-value Within group	<0.001*			
p-value Between groups	0.132			
p-value Interaction time x group	0.193			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.15 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	1.000	1.000	0.310
Week1	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.16 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.014*	0.004*	0.001*
Week1	-	-	0.641	0.540
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

4.7 Comparison of Modified ODQ Total Scores

Thai modified ODQ was used in this study to indicate the disability level that presented in the subjects with the higher scores representing the higher disability.

The baseline data of Thai modified ODQ total scores for control and experimental groups were 23.60 ± 17.01 % and 21.12 ± 17.57 % respectively without between-group difference. The scores decreased significantly and rapidly at within week-3 measurement in control group ($p < 0.001$) and experimental group ($p < 0.001$). The decrease of the scores still occurred at the end of program and at month-3 measurements for both groups ($p < 0.001$). However, the difference was not found between two groups at each time of measurement ($p > 0.05$), as shown in Table 4.17.

The values of both groups and statistical analysis between two groups are shown in Table 4.17, and multiple comparisons among various times of measurement for each group are reported in Table 4.18 and Table 4.19.

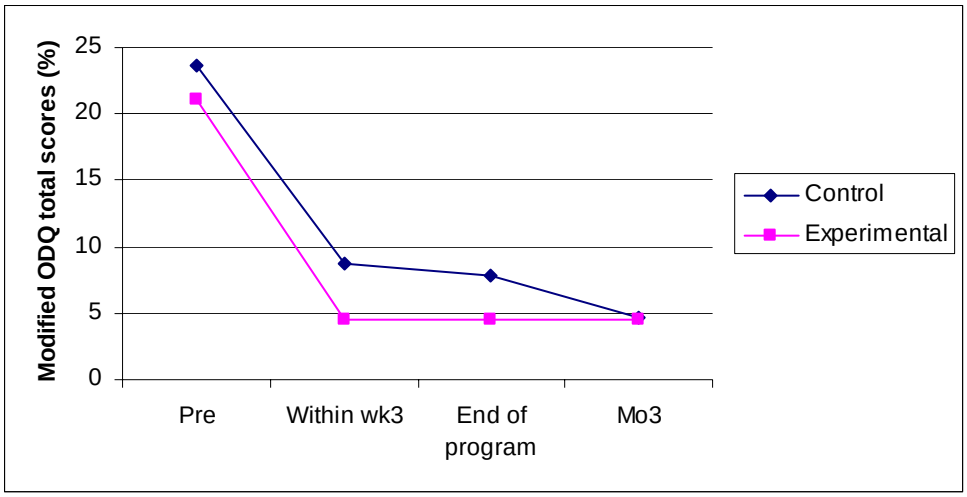

Figure 4.6 Means of Thai modified ODQ total scores for control and experimental groups.

Table 4.17 Comparison of Thai modified ODQ total scores between control and experimental groups

Group	**Control group**		**Experimental group**	
Time	Mean	SD	Mean	SD
Pre-treatment	23.60	17.01	21.12	17.57
Within week3	8.80	10.17	4.48	5.11
End of program	7.84	7.61	4.48	5.11
Month3 follow-up	4.72	6.05	4.56	7.27
p-value Within group	<0.001*			
p-value Between groups	0.236			
p-value Interaction time x group	0.529			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.18 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Within week3	End of program	Month3 follow-up
Pre-treatment	-	<0.001*	<0.001*	<0.001*
Within week3	-	-	0.600	0.123
End of program	-	-	-	0.332
Month3 follow-up	-	-	-	-

Table 4.19 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Within week3	End of program	Month3 follow-up
Pre-treatment	-	<0.001*	<0.001*	<0.001*
Within week3	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

4.8 Comparison of VAS Scores for Patient's Perception of Change

When the subjects received the first physical therapy intervention, they would be inquired about the change in back pain they perceived possibly either better or worse. The subjects expressed their perception of change by marking on 100 mm scale which divided into worse 50 mm on the left and better 50 mm on the right.

The immediate effect of the intervention also reflected in better results in the use of VAS scores for patient's perception of change for both groups with the values of 21 ± 12.8 mm for control group and 28.9 ± 17.8 mm for experimental group. The positive changes gradually increased throughout the study for both groups. However, the difference was not found between two groups at each time of measurement, as shown in Table 4.20.

The values of both groups and statistical analysis between two groups are shown in Table 4.20, and multiple comparisons among various times of measurement for each group are reported in Table 4.21 and Table 4.22.

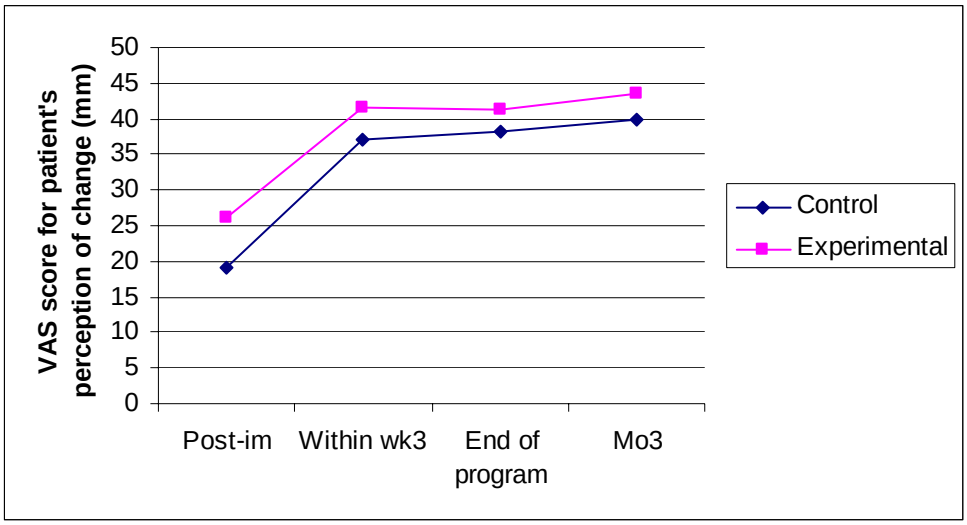

Figure 4.7 Means of VAS scores for patient's perception of change for control and experimental groups.

Table 4.20 Comparison of VAS scores for patient's perception of change between control and experimental groups (mm)

Group	**Control group**		**Experimental group**	
Time	Mean	SD	Mean	SD
Post-immediately	19.16	13.64	26.00	14.71
Within week3	37.16	10.41	41.44	10.76
End of program	38.32	8.69	41.40	10.77
Month3 follow-up	39.88	12.13	43.48	12.47
p-value Within group	<0.001*			
p-value Between groups	0.082			
p-value Interaction time x group	0.654			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.21 Multiple comparison of control group among various times of assessment

Time	Post-immediately	Within week3	End of program	Month3 follow-up
Post-immediately	-	<0.001*	<0.001*	<0.001*
Within week3	-	-	0.301	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.22 Multiple comparison of experimental group among various times of assessment

Time	Post-immediately	Within week3	End of program	Month3 follow-up
Post-immediately	-	0.003*	0.003*	0.001*
Within week3	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

4.9 Number of Visits

All subjects in this study recovered from their back pain within 6 weeks. The medians and 25^{th} and 75^{th} percentile ranks of the number of visits for control and experimental groups are reported in Table 4.23. The comparison between two groups showed no difference in number of visits (Table 4.23).

Table 4.23 Comparison of the number of visits between control and experimental groups

Visits	**Control group (n=25)**		**Experimental group (n=25)**		p-value#
	Median	25^{th} / 75^{th} *	Median	25^{th} / 75^{th} *	
Total visits	3	2 / 4	2	1 / 4	0.610

* = 25^{th} percentile rank / 75^{th} percentile rank

= p-value from Mann-Whitney U test

4.10 Recurrence Rate

At month-3 follow-ups, all subjects were inquired whether the symptoms were recurrent or not. For the control group, six subjects of 25 (24%) reported the recurrence after the end of program. For the experimental group, three subjects of 25 (12%) reported the recurrence after the end of program. However, the comparison of the recurrence rate was made, the result showed no significant difference (Table 4.24).

Table 4.24 Comparison of the recurrence rate between control and experimental groups

Control group (n=25)		**Experimental group (n=25)**		p-value#
Recurrent	Non-recurrent	Recurrent	Non-recurrent	
6	19	3	22	0.269

= p-value from 2×2 Chi-Square test

4.11 Comparisons of Change Scores

Another way of comparison of means was the comparison of the change score. The change score was derived by subtracting post values by pre values or post – pre. The change score of each group reflected the magnitude of difference caused by the given interventions. The comparisons would be made together with the reference, the control group.

In this study, the change scores were studied at week-1 measurement and at the end of program. For week-1 change score, the parameters consisted of VAS pain intensity, AROM flexion, AROM extension, AROM right lateral flexion, and AROM left lateral flexion. The comparison between two groups showed no significant difference (Table 4.25).

For end-of-program change score, the parameters consisted of VAS pain intensity, AROM flexion, AROM extension, AROM right lateral flexion, AROM left lateral flexion, and Thai modified ODQ total score. The comparison between two groups showed no significant difference (Table 4.26).

Table 4.25 Means comparison of the change score (wk1 post-treatment – pre-treatment) between control and experimental groups

Parameters	**Control group (n = 25)**		**Experimental group (n = 25)**		p-value[a]
	Mean	SD	Mean	SD	
VAS pain intensity (mm)	-24.6	24.0	-35.6	24.8	0.115
AROM flexion (cm)	0.30	1.25	0.11	0.65	0.517
AROM extension (cm)	0.63	0.95	0.76	1.13	0.656
AROM Rt. lateral flexion (cm)	0.83	2.02	0.80	2.02	0.961
AROM Lt. lateral flexion (cm)	0.68	1.99	1.58	2.85	0.202

a = p-value from unpaired t-test

Table 4.26 Means comparison of the change score (end of program – pre-treatment) between control and experimental groups

Parameters	**Control group (n = 25)**		**Experimental group (n = 25)**		p-value[a]
	Mean	SD	Mean	SD	
VAS pain intensity (mm)	-34.6	19.4	-41.1	23.8	0.300
AROM flexion (cm)	0.47	1.33	0.37	0.82	0.761
AROM extension (cm)	0.72	1.10	0.80	1.24	0.811
AROM Rt. lateral flexion (cm)	1.15	2.19	1.80	2.61	0.344
AROM Lt. lateral flexion (cm)	0.74	2.21	2.06	3.35	0.108
Thai modified ODQ total scores	-15.76	13.84	-16.64	14.74	0.829

a = p-value from unpaired t-test

4.12 Correlations between VAS Score for Patient's Perception of Change and Change Scores

In order to study the change over time, VAS score for patient's perception of change at the end of program and the change scores of other parameters were selected to determine the correlation. The correlation calculations included VAS pain intensity, AROM flexion, AROM extension, AROM right lateral flexion, AROM left lateral flexion, and Thai modified ODQ both total scores and separated items. The results are reported in Table 4.27 and Table 4.28.

From the results, only Thai modified ODQ total score showed significant correlation with VAS score for p = 0.03, Pearson's correlation index of -0.306 (Table 4.27), while other parameters had no significant correlation.

Table 4.27 Correlations between VAS score for patient's perception of change and the change scores (end of program – pre-treatment): VAS score for pain intensity, AROM flexion, extension, right and left lateral flexion, and Thai modified ODQ total scores (n = 50)

Parameters	**Pearson's Correlation**	**Sig (p-value)**
VAS pain intensity	-0.200	0.163
AROM flexion	0.240	0.094
AROM extension	-0.039	0.788
AROM Rt. lateral flexion	0.274	0.054
AROM Lt. lateral flexion	0.267	0.061
Modified ODQ total score	-0.306	0.030*

Table 4.28 Correlations between VAS score for patient's perception of change and the change scores (end of program – pre-treatment) of individual items of Thai modified ODQ (n = 50)

Parameters	**Spearman's Correlation**	**Sig (p-value)**
Pain intensity	-0.193	0.180
Personal care	-0.257	0.072
Lifting	-0.228	0.111
Walking	-0.179	0.213
Sitting	-0.237	0.097
Standing	-0.241	0.092
Sleeping	-0.102	0.483
Social life	-0.099	0.496
Traveling	-0.229	0.109
Employment	-0.175	0.224

4.13 The Use of Physical Therapy Interventions

According to the procedures, all physical therapy modalities, plus spinal mobilization for the experimental group, could be used according to clinical reasoning, and the decisions were made by the therapists. From the recorded data, the frequencies of the use of physical therapy modalities are shown in Table 4.29.

Table 4.29 Selection of physical therapy intervention

Ranking	Control group (%)	Ranking	Experimental group (%)
1	Ultrasound therapy (94.55%)	1	Mobilization (100%)
2	Massage (83.64%)	2	Massage (80.56%)
3	Stretching exercise (76.36%)	3	Ultrasound therapy (73.61%)
4	Hot packs (41.82%)	4	Hot packs (66.67%)
5	SWD (5.45%) Cold packs (5.45%) Active exercise (5.45%)	5	Cold packs (40.28%)
		6	Stretching exercise (36.11%)
		7	Mechanical traction (33.33%)
8	Mechanical traction (3.64%)	8	Active exercise (6.94%)
9	Mobilization (0%)	9	SWD (1.39%)

4.14 Results of Subjects with Both Sides or Centralized LBP

In order to minimize the diversity of the subjects within group found in both groups, the comparisons were made to compare the subjects with only both sides or centralized LBP. The subjects with the painful location in only left or right side were excluded. The purpose of this study was to minimize the confounding effects of pain location of the subjects by which might attribute to the effectiveness of the treatment of spinal mobilization. Therefore, this study might emphasize the effects of spinal mobilization.

This study as well as the main study was to compare the parameters of VAS scores for pain intensity, AROM flexion, extension, right and left lateral flexion, modified ODQ total scores, VAS scores for patient's perception of change between the control and the experimental groups.

Seventeen subjects with both sides of LBP or centralized LBP for each group were included for statistical analysis. So the total number of subjects from two groups was 34. By which, the subjects in the control group were included as follows; C2, C4, C6, C7, C9, C11, C12, C13, C14, C15, C16, C17, C19, C21, C22, C24, and C25, and the subjects in the experimental group were included as follows; E1, E7, E9, E11, E13, E14, E15, E16, E17, E18, E19, E20, E21, E22, E23, E24, and E25, the raw data could be retrieved from Appendix G. From the calculation, the data were normally distributed, therefore, the statistical used was Two-way Repeated Measures ANOVA.

Table 4.30 Comparisons of VAS scores for pain intensity (mm) in the subjects with both sides or centralized LBP between the control and the experimental groups (n = 17)

Group	**Control group**		**Experimental group**	
Time	Mean	SD	Mean	SD
Pre-treatment	45.5	21.0	53.3	25.9
Post-immediately	22.1	14.6	21.8	21.2
Week1	20.7	16.9	14.9	17.0
End of program	10.2	9.0	12.5	17.3
Month3 follow-up	12.4	18.3	10.1	22.5
p-value Within group	<0.001*			
p-value Between groups	0.942			
p-value Interaction time x group	0.379			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.31 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Post-immediately	Week1	End of program	Month3 follow-up
Pre-treatment	-	<0.001*	0.002*	<0.001*	<0.001*
Post-immediately	-	-	1.000	0.036*	0.861
Week1	-	-	-	0.003*	1.000
End of program	-	-	-	-	1.000
Month3 follow-up	-	-	-	-	-

Table 4.32 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Post-immediately	Week1	End of program	Month3 follow-up
Pre-treatment	-	<0.001*	<0.001*	<0.001*	<0.001*
Post-immediately	-	-	0.763	0.196	0.395
Week1	-	-	-	1.000	1.000
End of program	-	-	-	-	1.000
Month3 follow-up	-	-	-	-	-

Table 4.33 Comparisons of AROM flexion (cm) in the subjects with both sides or centralized LBP between the control and the experimental groups (n = 17)

Group	**Control group**		**Experimental group**	
Time	Mean	SD	Mean	SD
Pre-treatment	5.01	1.54	5.21	1.54
Week1	5.29	1.51	5.44	1.32
End of program	5.18	1.48	5.50	1.44
Month3 follow-up	5.85	1.44	5.52	1.69
p-value Within group	0.120			
p-value Between groups	0.845			
p-value Interaction time x group	0.482			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.34 Comparisons of AROM extension (cm) in the subjects with both sides or centralized LBP between the control and the experimental groups (n = 17)

Group / **Time**	**Control group**		**Experimental group**	
	Mean	SD	Mean	SD
Pre-treatment	1.52	1.17	1.26	1.00
Week1	2.36	1.43	2.02	1.12
End of program	2.48	1.40	2.17	1.14
Month3 follow-up	2.44	1.41	2.14	1.20
p-value Within group	<0.001*			
p-value Between groups	0.445			
p-value Interaction time x group	0.965			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.35 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.020*	0.009*	0.009*
Week1	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.36 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.040*	0.014*	0.012*
Week1	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.37 Comparisons of AROM right lateral flexion (cm) in the subjects with both sides or centralized LBP between the control and the experimental groups (n = 17)

Group / **Time**	**Control group**		**Experimental group**	
	Mean	SD	Mean	SD
Pre-treatment	18.81	4.57	20.11	4.07
Week1	19.82	3.91	21.17	4.40
End of program	20.11	4.07	21.82	4.79
Month3 follow-up	20.05	3.94	22.08	4.60
p-value Within group	0.012*			
p-value Between groups	0.250			
p-value Interaction time x group	0.754			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.38 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.360	0.285	1.000
Week1	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.39 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.297	0.067	0.259
Week1	-	-	0.403	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.40 Comparisons of AROM left lateral flexion (cm) in the subjects with both sides or centralized LBP between the control and the experimental groups (n = 17)

Group / **Time**	**Control group**		**Experimental group**	
	Mean	SD	Mean	SD
Pre-treatment	19.01	3.50	19.73	3.44
Week1	20.04	3.12	21.50	3.40
End of program	20.04	3.71	21.88	3.72
Month3 follow-up	20.35	3.20	22.17	3.43
p-value Within group	0.001*			
p-value Between groups	0.183			
p-value Interaction time x group	0.437			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.41 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.733	1.000	0.464
Week1	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.42 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Week1	End of program	Month3 follow-up
Pre-treatment	-	0.062	0.045*	0.013*
Week1	-	-	1.000	0.795
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.43 Comparisons of Thai modified ODQ total scores in the subjects with both sides or centralized LBP between the control and the experimental groups (n = 17)

Group / **Time**	**Control group**		**Experimental group**	
	Mean	SD	Mean	SD
Pre-treatment	26.00	17.56	22.47	17.82
Within week3	8.23	7.37	4.94	5.57
End of program	8.23	7.37	4.94	5.57
Month3 follow-up	2.58	3.92	4.23	6.35
p-value Within group	<0.001*			
p-value Between groups	0.381			
p-value Interaction time x group	0.452			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.44 Multiple comparison of control group among various times of assessment

Time	Pre-treatment	Within week3	End of program	Month3 follow-up
Pre-treatment	-	<0.001*	<0.001*	<0.001*
Within week3	-	-	1.000	0.049*
End of program	-	-	-	0.049*
Month3 follow-up	-	-	-	-

Table 4.45 Multiple comparison of experimental group among various times of assessment

Time	Pre-treatment	Within week3	End of program	Month3 follow-up
Pre-treatment	-	<0.001*	<0.001*	0.002*
Within week3	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.46 Comparisons of VAS scores (mm) for patient's perception of change in the subjects with both sides or centralized LBP between the control and the experimental groups (n = 17)

Group	**Control group**		**Experimental group**	
Time	Mean	SD	Mean	SD
Post-immediately	21.64	12.76	28.17	15.52
Within week3	37.52	9.15	41.76	10.10
End of program	37.52	9.15	41.76	10.10
Month3 follow-up	42.11	10.75	44.11	10.83
p-value Within group	<0.001*			
p-value Between groups	0.135			
p-value Interaction time x group	0.686			

p-value from Two-way Repeated Measures Analysis of Variance (ANOVA)

Table 4.47 Multiple comparison of control group among various times of assessment

Time	Post-immediately	Within week3	End of program	Month3 follow-up
Post-immediately	-	<0.001*	<0.001*	<0.001*
Within week3	-	-	1.000	0.710
End of program	-	-	-	0.710
Month3 follow-up	-	-	-	-

Table 4.48 Multiple comparison of experimental group among various times of assessment

Time	Post-immediately	Within week3	End of program	Month3 follow-up
Post-immediately	-	0.003*	0.003*	0.003*
Within week3	-	-	1.000	1.000
End of program	-	-	-	1.000
Month3 follow-up	-	-	-	-

Table 4.49 Comparison of the number of visits and the recurrence rate between the control and the experimental groups

Number of visits	**Control group (n=17)**		**Experimental group (n=17)**		p-value[#]
	Median	25^{th} / 75^{th} *	Median	25^{th} / 75^{th} *	
Visits	2	1.5 / 4	2	1 / 4	0.381
Recurrence rate	**Recurrent**	**Non-recurrent**	**Recurrent**	**Non-recurrent**	p-value[$]
Subjects	3	14	2	15	0.633

* = 25^{th} percentile rank / 75^{th} percentile rank

= p-value from Mann-Whitney U test

$ = p-value from 2×2 Chi-Square test

CHAPTER V
DISCUSSION

5.1 Characteristics of Subjects

In order to study the effects of spinal mobilization in individuals with low back pain without restriction of gender, this study recruited both male and female subjects for both control and experimental groups. From the results, it was found that the numbers of males/females were not equal between two groups. The control group had more female subjects when compared to the experimental group. However, female subjects were more than males in both groups. The unequal number might be due to the design of this study, it was not gender-matched, but randomization. Therefore, the ratio of male/ female of one group was not equal to another group.

However, from the literature review, there were some studies considering the association between genders and low back pain; consequences of LBP and the outcomes of physical therapy treatments (110, 111). Wijnhoven et al in 2007 (111) studied in individuals with musculoskeletal pain. For back pain group, they reported that the difference of gender did not affect limitation of function, work disability (ever in life), frequency of contact with a medical caregiver, use of medicines, and work leave. In addition, George and coworkers in 2006 (110) studied gender differences in predictors of outcome in selected physical therapy interventions for acute low back pain. The researchers reported that there was no significant interaction between gender and intervention for pain intensity. They indicated that both genders responded similarly to the three types of physical therapy intervention. So, conclusively, the aforementioned studies indicated no significance of gender upon the consequences of LBP. In addition, there was no significance of gender difference upon the outcomes of any types of physical therapy intervention. Therefore, it is possible to indicate that both genders might respond to physical therapy interventions indifferently, and the consequences after the occurrence of LBP were similar as well. These findings

corresponded to the International Association for the Study of Pain (IASP) reporting that the pain depends on individual's perception (73).

Considering the age of the subjects, this study recruited the subjects with the age of between thirty and fifty, and the average values were 39.24 and 39.52 years for the control and the experimental groups. The age of the subjects in this study was similar to other related manipulative studies. For example, the studies conducted by Chiradejnant et al (112) in 2002, the subjects aged 41.1 and 41.3 years for correct level and random level groups, respectively. And another study (113) in 2003 aged 47.4 years and 45.4 years for correct and random groups, respectively. Goodsell and coworkers recruited subjects with the average age of 39.4 years (99). The study conducted by Rasmussen-Barr et al (4) recruited the subjects with median value of age of 39 and 37 years for stabilizing training and manual treatment groups, respectively.

Most studies recruited patients with similar age in the range of 30-50 years. It might represent that the subjects in this age were in active period of working and personal life. Perhaps, this age group ranked highly regarding number amidst the LBP population. In other words, because of their active life, these subjects were easily to suffer from LBP, which simply drawn into the researches and quite easily to imply for clinical and social concerns. Another consideration regarding the age was influenced by the study done by Hicks et al (65) in 2005, they found the associations between trunk muscle composition and physical function in older adults, and suggested a link between trunk muscle composition and history of low back pain. The main factor was related to the gradual loss of muscle mass (63-65). Therefore, in this present study, the age of subjects was limited to 50 years.

When considering the parameters involving physical aspects such as active range of motion (AROM) in four directions, the factors of height and weight should be concerned. The height and weight of the subjects also affect the displacement of the spine, especially, when the tape measure technique was used and the subjects were asked to move actively (109). Therefore, if the data of the height and the weight were significantly different between two groups, the comparison and interpretation of data

should be done with care. Even though, the number of male and female subjects in the control group in this study was not equal to another group, however, the means of weight, height, and body mass index (BMI) had no differences between two groups. The indifferent data of weight, height, and BMI between both groups might reflect that the subjects in both groups had similar physical aspects.

The duration of symptom in the control group was 11.60 ± 4.88 days and in the experimental group was 10.88 ± 5.47 days. The data reflected that all subjects were in acute phase of low back pain. As well as a previous study regarding acute LBP, George et al (110) studied in subjects with acute low back pain. The average duration of symptom was 13.3 ± 8.0 days. The similarity of duration between this study and the previous study might indicate that the patients with acute LBP who came for physical therapy treatments had the onset within 2 weeks.

From the characteristics of the subjects, conclusively, it was shown that the subjects between both groups were similar in age, weight, height, BMI, duration of symptoms, and works and activities in daily living. This similarity represented the homogeneity of the subjects between two groups in this study. The homogeneity was from the pre-specified criteria for inclusion and exclusion determined before the beginning of the study in order to control the background of the upcoming recruited subjects. The benefits of control, or homogenous subjects were to minimize some confounding factors influencing the subjects' performances or parameters' measurements. However, the disadvantage of the control was the limitation of generalization (114). Anyhow, in order to achieve the objectives of the study, the focus regarding the characteristics of the subjects was needed. In addition, the present study was a clinical study and was conducted in a real clinical setting.

The subjects were examined by the determined physical therapist according to random assignment. Before the intervention, each subject was examined individually by that therapist. The physical examinations consisted of palpation, active movement, passive accessory movement of the spine, muscle strength and length testing, neurodynamic and sensation tests for exclusion of neurological involvement, and

others if needed. The location of the symptom of most subjects in both groups represented bilateral aspects and both upper and lower levels of the lumbar spine. From the history taking, all subjects engaged with prolonged sitting or working. Of which forty-five subjects of all subjects, or 90%, stated that the symptoms were from regular works. The symptoms gradually accumulated and then emerged suddenly and markedly in one day before coming for PT intervention in this time. While five subjects or 10% were affected by accident or trauma. The subjects with trauma suffered from LBP because of inappropriate activities or from quick movements in daily life. However, all of them neither had symptoms lower than gluteal folds nor positive results of the neurodynamic test. The therapists from both groups diagnosed that most of them had 1) strain or myofascial pain syndrome (MPS) of paravertebral or related muscles, or 2) back stiffness or dysfunction, or 3) lumbar fascia injury, or 4) in combination. Most subjects had the combination of the sources of pain. Therefore, the data showed bilateral aspects and both upper/ lower levels of the lumbar spine in a greater number.

The activity in daily living, all subjects in both groups were sedentary. None of subjects in both groups was construction workers or any other heavy workers. Most of subjects in both groups worked in an office which the tasks mainly involving the prolonged sitting and using computers, while some subjects in both groups engaged house works. These activities in daily living in both groups corresponded to the last item of modified ODQ questioning employment/ home making. From, the activity of all subjects, there was no report about the difficulty or inappropriateness in measurements of any parameters. In addition, the similarity of activity of all subjects might indicate the similar patterns and backgrounds of the subjects in their daily living and the similar causes of LBP.

The therapists in this present study were different in the years of experience. Actually, the experience is an important factor and the experience might also influence on the effectiveness of the treatments. Anyhow, it was affirmed that both therapists have been working as musculoskeletal physical therapist for a period of time together with the experience of spinal mobilization in terms of understanding and practices. In

addition, clinical reasoning is more important and more crucial in research and clinical settings. Before the study, the session of clinical reasoning was held for the two therapists determining the general understandings and agreements in clinical practices. Both therapists showed good clinical reasoning and had similar general understandings pertaining to clinical practices.

5.2 Effects of Physical Therapy Treatments with or without Spinal Mobilization on Pain Intensity

The present study was conducted in a clinical setting. The atmosphere was actually clinically real, and the methodology of the study was introduced in the clinical setting. The subjects were patients who came for physical therapy treatments and the therapists regularly worked in the clinic.

The obvious symptom of LBP is definitely to be pain. The importance of pain was raised in the 1990s when the American Pain Society announced that pain is the fifth vital sign of medical examination. And in LBP, pain has been annexed as one of the cardinal domains to be evaluated together with back-specific function, generic health status, work disability, and patient satisfaction (115). Measurement of pain usually gets much greater treatment effect sizes, or sensitivity, rather than physical variables, which is the more sensitive measure for assessing the effects of treatment (26). In other words, pain itself is the most relevant variable in LBP (116).

Pain has been given the definition of an unpleasant sensory and emotional experience associated with actual or potential tissue damage (73). Pain is a highly personal experience and the patient is therefore the best information giver that is a multidimensional phenomenon including physiological, sensory, affective, cognitive, behavioral, and sociocultural aspects. Consideration of these various dimensions reflects the multifaceted nature of pain and affirms that the total evaluation of pain is not a straightforward matter, therefore, the researchers or the clinicians should interpret the data or the results pertaining to LBP studies with care (73, 116).

From the results, it was reported that the average pain intensity at the beginning for the control group was 44.9 ± 23.7 mm and the experimental group was 52.4 ± 24.5 mm. These intensities might represent moderate level of pain. Comparing with other studies which most studied in chronic LBP, the starting pain intensities were similar, for example, 4.6 ± 1.5 on 11 point scale for correct group and 4.7 ± 1.6 for random group (113), 33 mm for stabilizing training group and 32 mm for manual treatment group (4), 65 mm for general exercise group, 63 mm for motor control group, and 62 mm for spinal manipulative therapy group (117), approximately 50 mm for control group and approximately 45 mm for experimental group (101). The similar pain intensity in the beginning among various studies could indicate that most patients with LBP, both acute and chronic, usually had mild to moderate levels of pain intensity when they came to physical therapy clinics for treatments. They perceived that such intensity of pain required treatments or being under physical therapists' supervisions.

In this study, the immediate decreases of pain after the intervention were found in both groups with statistical significance. The decrease of pain might represent immediate effects of physical therapy interventions either with or without spinal mobilization. However, the difference between the control and the experimental groups was not found. The decreased pain could be also detected in week 1, end of program, and 3 months follow-up measurements in both groups. The decrease of pain in immediate term and short term might be due to the physical therapy interventions given for both groups. Anyhow, the long-term effect, at month 3, was also found even though all subjects did not receive any forms of interventions. This finding might be possible to affirm the long term effects of physical therapy interventions in acute cases of LBP and when the patients received the proper interventions according to his or her locations and causes by physical examination.

From the results, the statistical significance was found in both groups over time, anyhow, another aspect that should be considered is clinical significance or so-called minimal clinically important difference (MCID) that is the minimum change score that represents a noteworthy clinical difference due to interventions (116). For

patients with acute LBP, the MCID for improvement on the 0-100 mm VAS is about 35 mm (118). The change score from baseline to the end of program of pain intensity in this study was 34.6 mm for the control group and 41.1 mm for the experimental group. Therefore, the decreases of pain intensity in both groups might yield clinical significance or MCID defined by Ostelo et al. In addition, it was suggested that a score of zero for pain intensity might not be a realistic or necessary target, and a score of 10-25 mm on a 100 mm VAS might represent a relatively normal or acceptable status (119), which corresponding to the end of program in this study that was 10.3 mm and 11.3 mm left for the control and the experimental groups respectively.

According to the results of this study, pain reduction may be attributed to the therapeutic effects of physical therapy intervention no matter with or without spinal mobilization. Both groups showed pain reduction from time to time. There was no difference between two groups at any time of measurement.

All subjects in this study suffered from acute LBP with the duration of symptom of 11.60 and 10.88 days for the control and the experimental groups respectively. According to the inflammatory process of muscle or tissue injury, the inflammation phase is in first 3 days, followed by fibroplasia in first 21 days, and then remodeling phase from 3 to 12 months (120, 121). During the remodeling phase, scar tissue can be formed in the injured area, and if it is massive it may cause loss of function or limited movement (120).

From the duration of symptom in this study, the subjects from both groups were possibly in the phase of inflammation or fibroplasia. According to duration criteria, it indicated that the most patients in both groups were in the phase of fibroplasia. In addition, from the history taking, the subjects may have been ever experienced LBP before this onset, so it is possible that they were now on or have had the remodeling phase already. Therefore, it is possible that most subjects suffered from LBP because of the inflammation of injured area of the paravertebral muscles or scar tissue deposited in injured area such as muscles, tendons, or ligaments. The literature additionally suggested that the immobilization effect contributed to the loss of

glycoaminoglycan (GAG) and increased crosslink formation in connective tissues, poor orientation of newly deposited collagen fibers (120).

The results could affirm the therapeutic effects of physical therapy interventions used in both groups. Ultrasound therapy, massage, and stretching exercise were mainly used in the control group. While other than spinal mobilization in all cases, massage, and ultrasound therapy were mainly used in the experimental group.

For the control group, therapeutic effects might be due to massage, namely deep transverse friction massage. Deep transverse friction massage aims to minimize abnormal fibrous adhesions and makes scar tissue more mobile by realigning the normal soft tissue fibers. This technique also enhances normal healing conditions by breaking cross bridges and preventing abnormal scar formation. This mechanical action causes hyperaemia, which results in increased blood flow to the area (122). Together with stretching exercise, this technique promotes the effects of deep transverse friction massage in enhancing mobility because of muscles and its surrounding structures elongation. So, these two techniques had the same direction of therapeutic purposes, that is, promotion of mobility and restoration of normal function.

Ultrasound therapy has both thermal and non-thermal effects. Briefly, thermal effect has therapeutic effect because of hyperaemia that occurred when the temperature of the damaged tissues is raised to 40-45^{o}C. The thermal effect mainly occurred with the continuous wave technique (123). While, non-thermal effect is postulated that attributes to the mixture of cavitation, acoustic streaming, and micromassage. This mixture is therapeutic because it helps altering cell membrane potential and changing in cell membrane transport mechanisms. And then, this leads to altered protein synthesis, altered release of cell contents, altered blood flow, altered vascular permeability, angiogenesis, and altered collagen content and alignment (123).

From these reviews, it is feasible that the reduction of pain in the control group may be attributed to the therapeutic effect that results in minimizing fibrous adhesions,

lengthening underlying structures, and promoting the repair of injured tissue. Another possible mechanism of pain relief is due to descending inhibitory pathway. The deep massage is as a stimulus that activates descending mechanical pain inhibitory systems in the dorsal periaqueductal gray region. This mechanism has an immediate analgesic effect (91). The last possible explanation of pain relief relates to psychological effect. The patients might think that they had received the treatments that right to their sites of pain with the touch of confidence from the therapist, and they might think that this approach was appropriate for them that made them ensured and satisfied in the treatments (87).

For the experimental group, all subjects underwent spinal mobilization and most of all also underwent massage and ultrasound therapy. Therefore, as well as the aforementioned physiological effects described in the control group pertaining to massage and ultrasound therapy, the subjects in the experimental group also received the benefits of the applications of massage or ultrasound in terms of minimizing fibrous adhesions and promoting the repair or injured tissue as well (91) However, in addition, the subjects in the experimental group underwent spinal mobilization, while the control group mainly received general stretching exercise. By which spinal mobilization is claimed to be beneficial in alleviating pain in patients with LBP and altering mechanical properties of the spine from oscillatory movements (84, 94).

The physiological effects of spinal manipulative therapy or SMT including spinal mobilization was described as stretching the ligaments, intervertebral discs, joint capsules, or muscles. SMT might also activate the diffuse descending pain inhibitory system, whose neurons are located in the periaqueductal gray matter (91). In addition, muscle stretching triggers presynaptic inhibition of afferents from the skin, which might explain why the local cutaneous pain threshold increases after SMT but not after a placebo (124, 125). The latter pain relief mechanism corresponded to gate control theory (73). According to the previous literature, neuromuscular reflex responses was actually found in patients with LBP after the application of SMT. After the mechanical stimulation of both paravertebral muscles and spinous processes was applied, the consistent localized positive EMG responses were found in the

paravertebral muscles covering throughout the lumbar spine. The time to peak tension ranged from 50 to 200 msec, and the reflex response times ranged from 2 to 4 msec. The results demonstrated neuromuscular reflex responses associated with mechanical stimulation from spinal thrusts in patients with LBP (126).

The psychological effects should be considered in the experimental group as well. The manual contacts provided by the therapist might contribute adjunctive placebo effects together with actual physiological effects. Patients might perceive the manual contacts and the explanations provided by the therapists as more satisfactory and confident, meanwhile, many spinal pain syndromes could improve spontaneously (86, 87).

Therefore, the results in both groups showed the similar patterns in diminishing pain over time without statistical significance between two groups. It was possible to postulate that the therapeutic effects of physical therapy interventions were believable in managing the patients with acute nonspecific LBP. Or in other words, physical therapy interventions were sufficient in relieving pain in acute LBP. Compared with the experimental group, by applying spinal mobilization, there was no additional advantage over without spinal mobilization in terms of minimizing pain over time. Because of the combinations of the uses of physical therapy modalities in both groups, the therapeutic effects found in this study were due to the mixture of those modalities as well. By the way, the therapeutic effects from the use of specific modality were well concerned by the therapists according to history takings and physical examinations because the protocol of this study included the specific program of history taking and physical examination upon individuals. And then, the appropriate interventions were selected specifically for each case according to his or her diagnoses with the control of treatment time of not more than 1 hour. The therapists would select essential modalities that they thought it would be therapeutic and beneficial to such lesion of that case. So, the results proved that the selection of interventions in both groups was beneficial in relieving pain as found right after the first treatment or immediate effect, and followed by week1, end of program, and month 3 as well for

both groups, while the total considerations of aforementioned physiological and psychological aspects should be concerned.

The decrease of pain intensity in both groups might also be due to the accumulative effects of all interventions used in both groups. By which, the therapeutic effects of used modalities played an important role in pain reduction altogether. Therefore, the reduction of pain should be considered that it was attributed to the accumulative effects from all used modalities, not only one modality. However, the use of modalities in this study was thought carefully in order to prevent the overuse of modalities. This study, therefore, limited the treatment time for one trial of less than one hour and the therapists were informed to use only modalities that they concerned necessarily according to their clinical reasoning.

The effects of physical therapy interventions and spinal mobilization on pain relief in patients with LBP were corresponded to most previous studies. According to a study conducted by Chiradejnant et al (112), the aim of the study was to investigate whether posteroanterior (PA) mobilization given according to therapist's identification or random selection was more effective. The result of their study showed that PA mobilization significantly and immediately decreased pain in subjects with LBP, especially, when PA mobilization was applied to the most symptomatic level of the lumbar spine identified by the therapist rather than when applied by random selection. The authors explained that the greater pain reduction could be due to the force was applied directly to the painful level of the spine that causing more mechanical effect.

Another study of Chiradejnant (113) was to study whether various lumbar mobilization techniques were similar in pain reduction. The study also showed the immediate effect of spinal mobilization on pain reduction in patients with nonspecific LBP but there was no difference in pain reduction among various mobilization techniques. However, the mobilization applied to lower lumbar spine was associated with a greater pain reduction than applied to upper lumbar spine. The researchers explained that lower lumbar spine allows greater posteroanterior translation (127).

Also, the larger oscillation of mobilization would result in more pain alleviation than a smaller oscillation of mobilization (84).

Another significant study pertaining to pain alleviation after applying spinal mobilization was the study done by Hanrahan et al (101). The researchers' purpose was to investigate the short-term effects of mobilization on acute LBP in collegiate athletes. The mobilization group underwent grade 1 followed by grade 2 oscillations for 30 seconds each to pathological level and 2 surrounding levels, total of 6 repetitions, while the control group was positioned in prone lying for the same duration of the mobilization group. The results showed that the mobilization group had significant decreases in McGill Pain Questionnaire sensory subscale scores and in VAS scores during lumbar extension and a significant increase in force production. The researchers concluded that the significant results might be attributed to the stimulation of mechanoreceptors at the facet joint and its relationship to the neighboring musculature (101). Stimulation of mechanoreceptors within the joint capsules of the facet inhibits the nociceptive fibers in the area, thereby interfering the pain-spasm cycle (126).

From the results of previous studies, Goodsell and coworkers (99) also showed the significant decrease in pain after immediate mobilization. The researchers reported the significant improvement in pain reduction on worst movement measuring by VAS scores in the mobilization procedure compared with the control procedure. As well as Ferreira and colleagues (117), they could detect the short-term improvement in Patient-Specific Functional Scale (PFPS) and Global Perceived Effect Scale (GPE) in manipulative therapy group after 12 sessions of treatment over 8 weeks. Compared with general exercise group, the manipulative therapy group had better and significant improvement in PFPS and GPE at 8-week measurement. However, the long-term measurements, 6 months and 12 months, showed no better outcomes over the general exercise group. The study in sub-acute and chronic subjects done by Rasmussen-Barr et al (4) found the decrease in pain intensity by VAS score after a 6-week program on a weekly basis in both stabilizing training (ST) group and manual therapy (MT) group but without statistical significance for MT group. The researchers suggested that

manual therapy may be beneficial in minimizing pain immediately after mobilization but it was still unchanged for 3-month and 12-month measurements. The chronic subjects in the MT group seemed to get a short-term benefit after the treatment, but, in the long term, most subjects reported a recurrent need for treatment.

The previous studies that were mentioned also showed a tendency in pain alleviation in immediate effect and short-term effect despite of different protocols of physical therapy interventions or spinal manipulative therapy were used. Together with this study, it is feasible to accept that physical therapy interventions with or without spinal mobilization could alleviate the pain in subjects with acute LBP if the subjects have undergone the specific treatments that were suitable to individuals according to their physical examinations. Although, there was no better result in pain reduction found in the experimental group but from physical examinations, the experimental physical therapist found that most subjects needed spinal mobilization because of their obvious resistance found from passive accessory assessment. As well as the control group, the physical therapist also found the resistance in subjects' spine from active physiological assessment. Therefore, the subjects in both groups actually needed the intervention that could promote spinal mobility. From the results, it was possible that the patients with acute LBP might be beneficial from spinal mobilization or other relevant manual therapy. The physical therapist in the control group reported the uses of forward bending of lumbar spine for stretching treatment and deep friction in the area of muscle strain. So, it could be recognized that these treatments provided in the control group might be sufficient and effective in patients with acute LBP as well as spinal mobilization. Anyhow, the advantages of spinal mobilization are the specific techniques that suitable for some movement disorders in some specific locations (84). The patients who need for specific techniques might be especially beneficial for that specific approach.

Spontaneous recovery might be another factor to be considered regarding the patients' better outcomes after baseline assessment. Some previous studies supported the spontaneous recovery in patients with acute LBP (128, 129). Werner et al (129)

reported that 20.9% of patients with acute LBP recovered by themselves in a couple of weeks.

5.3 Effects of Physical Therapy Treatments with or without Spinal Mobilization on Active Range of Motion (AROM)

From history taking, all subjects replied that they engaged in prolonged activities such as repetitive movements or prolonged sitting. According to the study done by Beach et al (130), they found that passive flexion stiffness was significantly changed in subjects after prolonged sitting. The lumbar spine became stiffer after one hour of sitting. The increased passive flexion stiffness coupled together with constrained flexion postures during working could stimulate pain receptors in the posterior spinal ligaments (131, 132). This could probably explain why prolonged sitting is often associated with low back pain and decreased range of motion.

Decreased flexibility and increased stiffness of the lumbar spine are often found in patients that caused by increased muscular activation. Although the clear mechanism behind muscle pain awaits formal study, it is a common experience to feel pain from muscles, especially after prolonged static work. In addition, in most patients with LBP, prolonged muscular activation of various degrees could be surmised as a part of the pain-spasm-pain cycle (133). The association between facet joints and paraspinal muscles was also found (134, 135). Injection of physiologic saline into the facets joints, most likely causing a stretching effect of the facet capsule, reduced the response in multifidus and longissimus muscles as detected by EMG. The stretch reflex from the joint capsule contributes to an inhibitory action on muscle spasm, thereby relieving pain. The finding showed a complex reflex system that is responsible for the motion and stabilization of the lumbar spine (134). While, deformation or stress in supraspinous ligaments recruits multifidus muscles to stiffen lumbar segments and prevent instability. Strong muscular activity could be seen when loads that could cause permanent damage to the ligaments was introduced, indicating the spastic muscle activity and possibly pain could be caused by ligament overloading (135).

The aforementioned reviews represented the association of the activation and response between the facet joints and surrounding muscles, and the association between the decreased flexibility and increased muscular activation. Therefore, due to the reviews, it is possible that decreased range of motion could be found in patients with low back pain.

In this study, four directions of active range of motion were studied: flexion, extension, right lateral flexion, and left lateral flexion. The methods of tape measures were used. These techniques were already investigated about the test-retest reliability with the ranges of 0.9431 – 0-9795 as reported in Appendix C.

For flexion, there was no significant difference between two groups at any time of measurement. The increase of AROM could be observed even though the increases were only of 0.47 cm and 0.27 cm for the control group and the experimental group from the beginning to the end of program.

For extension, there was also no significant difference between two groups at any time of measurement. The increases of both groups seemed easily observable rather than flexion yet the increases also not much, 0.72 cm the control group and 0.80 cm the experimental group from the beginning to the end of program.

For lateral flexion, there was also no significant difference between two groups at any time of measurement both in left and in right directions. For right lateral flexion, the increases from the beginning to the end of program were 1.15 cm in the control group and 1.80 cm in the experimental group. For left lateral flexion, the increases from the beginning to the end of program were 0.74 cm in the control group and 2.06 cm in the experimental group. The experimental group had greater increases in left lateral flexion, however there was no significance compared with the control group.

From the literature review, most studies focused on the significant difference over time that attributable to the given interventions (101, 112, 113). However, the

clinical significance was still unknown or pre-specified. Therefore, it is difficult to determine whether how much the change of AROM could indicate the effectiveness in those interventions. In addition, low sensitivity was shown in the measures of AROM as a parameter of physical impairment (26). It represents that the change of AROM is not so much when observing over time while other parameters such as pain (VAS) and disability are greater in changes over time according to the interventions.

However, in this study, the post-hoc comparisons among various times showed significant differences in both right and left lateral flexion in the experimental group, in flexion in the control group, and mainly in lumbar extension in both groups. The better flexion AROM in the control group might be attributed to active stretching in forward bending. The therapist in this group frequently prescribed active forward bending in most cases or 76.36% of all cases because the physical therapist in the control group found the limitation in lumbar flexion from physical examination in active physiological movement.

The significant improvements in lumbar extension might be due to stretching exercise advised by the therapist in the control group. The therapist also encouraged her patients to perform active stretching in lumbar extension especially in patients that was found in decreased extension ROM. While, the therapist in the experimental group had given PA and transverse gliding mobilization in every case after the mobilization assessment was done. The PA mobilization is claimed as a relevant treatment in increasing lumbar extension, and transverse gliding mobilization in enhancing lateral flexion due to the proper plane and proper orientation of the facet joints (84, 94). Therefore, it is possible that the increases in lumbar extension and lateral flexion in the experimental group could be attributed to the mobilization. Anyhow, when the clinical significance is still unknown, thus the statistical significance might not be so appropriate to indicate the improvements of the patients. Therefore, the indications of the improvement should be done with care or should be considered together with other parameters such as pain or disability.

The indifferent results between two groups might be due to the subjects in both groups had no significant back stiffness. Although, from physical examination, the subjects in both groups had decreased flexion, extension, and lateral flexion comparing by the gradual increases after the baseline assessment, but, actually the subjects had no significant stiffness. Yet, the baseline data of lumbar flexion, extension, and lateral flexion in healthy subjects had not ever been collected especially in the methods of tape measure for the comparison with LBP patients. So there is no criterion to indicate significant stiffness. Therefore, there is no standard to determine whether the subjects had significant stiffness in this study. It awaits formal study of baseline data collection in the future. In addition, the subjects came into this study had the chief complaint of pain, rather than stiffness or decreased motion. Hence, the range of motion might not be a proper indicator for this study because it was not sensitive to detect the over-time changes or the actual changes was not related to range of motion.

5.4 Effects of Physical Therapy Treatments with or without Spinal Mobilization on Disability Index (modified ODQ)

The modified ODQ is a self-administered tool for assessing disability regarding to LBP which takes less than 5 minutes to complete. It consists of 10 items of questions pertaining to pain intensity and activities of daily living (ADL). Each item provides 6 statements that describe an increasing level of severity to a particular activity, which scored from 0 – 5 points. The raw scores of all items are gathered and multiplied by 2 to be a percentage of disability, the higher percentage the greater level of disability. By which the range of ODQ scores is defined: 0-20 minimal disability, 20-40 moderate disability, 40-60 severe disability, 60-80 crippled, 80-100 bed bound or symptom magnifier. Additionally, most researchers suggest that a range of 4-10 points is necessary to determine significant change (136-139). In addition, the ODQ is now used worldwide and is translated into many languages (56, 136-145).

For Thai version, it was translated by Sakulsriprasert and colleagues in 2006 (145). The process of development included formal cross-cultural adaptation and test-retest reliability. The results showed good reliability, the $ICC_{(2,1)}$ values ranged from 0.80-1.00 for individual items, and 0.98 for total scores. The Thai version modified

ODQ received permissions from original authors for both original version and modified version (56, 138).

From the results of this study, the baseline values of modified ODQ total scores were 23.60% and 21.12% for the control group and the experimental group respectively. According to aforementioned criteria, these total scores might represent that the subjects in both groups had moderate disability at the beginning. Then, the disability percentage significantly decreased at week 3 measurement and at the end of program in both groups without significant difference between two groups. Finally, at month 3 follow-up, the disability percentage remained stable as well as recorded at the end of program without any significant change. This finding seemingly reflected that the subjects in both groups had no increasing disability even though they reported no use of any interventions after the experiment. It was noted that some of them kept going on some active exercises such as personally-prescribed stretching and strengthening exercise as given by their therapists as well as during on the program. Regarding to this information, it might explain why the subjects in both groups had low recurrence rate of LBP, of which six from 25, or 24%, in the control group and three from 25, or 12%, in the experimental group reported the recurrence of LBP. According to the previous studies which engaged no interventions, it was reported 62-82% of recurrence rate with 3-12 months from many survey studies (4, 21, 146-148).

Compared to the measures of physical impairment such as AROM, disability and pain measures were much more sensitive (26). According to the results of this study, as well as pain measures, disability measures as derived by modified ODQ also showed good sensitivity. Besides that it was proved about the good sensitivity of modified ODQ (138), the overtime decreases of disability total scores might also represent the effectiveness of given physical therapy interventions in both groups as evidenced together with the decreases of pain intensity. The decreases of disability scores were apparent in every item such as pain intensity, personal care, lifting, sitting, and standing.

Considering the total scores, at the beginning, the control group reported the percentage of 23.60 and the experimental group showed the percentage of 21.12. At the end of program, the percentages of total scores reduced significantly, 7.84 for the control group and 4.48 for the experimental group. Eventually, at month 3 follow-up, the total scores between two groups were similar, 4.72 for the control group and 4.56 for the experimental group. Rasmussen-Barr et al (4) reported the total scores of ODQ at the baseline measurement as 18 % for stabilizing training (ST) group and 14 % for manipulative therapy (MT) group. The total score reduced significantly in the ST group at the end of program, as reported 9 %. While, there was no difference in the MT group at the end of program, as reported 12 %. The difference of the total scores at the baseline and end of program between this study and the previous study might be due to the difference of severity level of the patients and the treatments used. The previous study with less percentage of total scores of ODQ at the beginning might reflect that the subjects had less disability levels. In addition, the treatments were only stabilizing training or manipulative therapy, excluding physical modalities or other forms of physical therapy treatments. The present study showed greater reduction of the total scores might be due to the individually-assigned treatments for each individual, and all subjects were in acute phase, while the subjects in the previous study were in subacute and chronic. This result might reflect the better response after the treatments in patients with acute LBP. Another reason was that the higher total scores might allow the greater range of reduction. Therefore, it was wider for the total scores to get reduced by the interventions. So, the present study showed less total scores at the end of program and higher reduction after receiving interventions in both groups.

Especially, most of the subjects reported the greater scores in sitting and standing at the baseline. It is feasible that most of the subjects engaged with sedentary works that had a lot of standing and/or sitting activities for a long time in their daily livings that could be easily affected resulting in pain aggravation or functional disturbance. Therefore, it was very clear that most of the subjects rated higher scores in sitting and standing subscale items, and these two subscales also responded rapidly and clearly after the interventions as well. The plausible results might be due to the

exercise program assigned by the therapists. They had frequently asked their patients about work-related topics and then they prescribed some exercises that were considered individually-beneficial and self-performed for their patients. During the program, all subjects in both groups were regularly inquired about compliance and performance of their given exercises. The basic knowledge was given and the misunderstanding was adjusted by the therapists.

The better outcomes in both groups might be due to the total combinations of all interventions as evidenced in the present study. The addition of spinal mobilization in the experimental group might reflect that there was no superiority or greater advantage. Even though spinal mobilization was added in the experimental group, the subjects had no better outcomes over the control group. It might be because spinal mobilization had immediate effect in pain alleviation and promoting spinal mobility (84, 94). Anyhow, for overall improvement, the subjects might need some more interventions to suit their physical impairments or disability in the dimension of holistic approach. Spinal mobilization might serve as a beneficial intervention for pain alleviation, but some additional interventions such as strengthening or stretching exercise also played an important role in promoting the recovery of muscle strength, function and then the recovery from LBP (4). From this finding, it is exemplary that the individual physical examination and appropriate interventions might be beneficial in alleviating pain and minimizing disability.

5.5 Effects of Physical Therapy Treatments with or without Spinal Mobilization on Patient's Perception of Change

Measuring the changes over time, some parameters are frequently used in previous studies such as VAS scores for pain intensity, AROM, and outcome measures in various forms (4, 99, 101-103, 112, 113, 116, 117). However, those parameters might represent the outcomes of the specified treatment but might not relevantly reflect the exact change of the subjects' symptoms (26). Therefore, it is necessary to select another measure for detecting the change of the patients over time attributing to the interventions. Although there is no gold standard for measuring clinically relevant

change, it may be accepted that the patient's own perception of change gives a reliable assessment whether clinically significant change has occurred (26).

Patient's perception of change used in this study was a 100-mm VAS line divided into 2 parts, 50 mm representing worse outcome on the left side and 50 mm better outcome on the right, while zero number was at the midline representing no change. From the results, the VAS patient's perception of change indicated positive, or better, direction in both groups of subjects over time since immediately after the first treatment, as reported in Chapter 4. The immediate changes after the first treatment were 21 mm and 28.9 mm on right side for the control group and the experimental group respectively. And then, the positive scores of change also continually increased later on until the follow-up at 3 months in both groups. Anyhow, there was no significant difference when the comparisons were made between two groups at the same time of pairing. These indifferent results between two groups might reflect the effectiveness of the given interventions of both groups.

Before the study, it was expected the better outcome in the experimental group because of the effects of spinal mobilization in alleviating pain and then promoting normal function in LBP patients (84, 94). Anyhow, the results of this study might indicate that the addition of spinal mobilization might have no superiority in helping global changes perceived by the patients. One plausible explanation was about that the spinal mobilization has immediate effects which last no longer than 60 seconds after the treatment affirming by the previous experimental studies (86, 124, 126). In other words, the pain alleviation is possible after an application of spinal mobilization but immediate duration. However, the researchers expected more benefits of spinal mobilization and applied longer duration of treatment for expected better pain relief and then better change by using spinal mobilization techniques that concerned suitable for individuals. After 5 minutes of examination, the experimental therapist applied 5 minutes of treatment. While, Chiradejnant et al in 2002 and 2003 (112, 113), applied the spinal mobilization technique for 1 minute. The longer treatment duration in this study was planned to treat the specific problems of the subjects as practiced in clinical settings not as experimental trials.

According to the control group, as the reference, the result of change was as well as in the experimental group. This finding represented that the change of patient's symptoms was attributed to all of relevant treatments determined by the therapists after individual's physical examination.

From multiple comparisons of time, both groups showed significant increase in change from post-immediately to within week 3 and the positive changes still slightly increased later on. This finding represented that the peak of change in acute cases of LBP was within 3 weeks. The change could be observed not only immediately after the first treatment, but also the change still significantly increased after treatments within 3 weeks. And then the change slightly increased. This finding might confirm that the acute LBP patients had rapid responses to the interventions at the beginning phase of treatment.

There was no significant difference between at the end of program and month 3 follow-up in both groups. The indifferent results indicated that the improvement or better change in the patients still existed despite the patients reported no additional interventions or further treatments after the program.

5.6 Number of Visits and Recurrence Rate

Regarding the number of visits and the recurrence rate, although this study showed no statistical significance between two groups of both factors, the experimental group took trials less than the control group for the treatments. Ending up with similar outcomes between two groups at the end of program and at month 3 follow-ups, however, the median values showed that the experimental group spent only two times of trial while the control group took three times for the number of visits. Although without statistical significance, this study might support the benefits of addition of spinal mobilization in minimizing the duration of treatment. Together with the less recurrence rate, it also affirmed the strength of adjunctive spinal mobilization in more powerful to prevent the patients from getting recurrence of new

episode of LBP within 3 months from 24% without spinal mobilization to 12% with spinal mobilization.

5.7 Correlations between Patient's Perception of Change and Change Score of other Parameters

The objective of the correlation study was to determine the parameters that are most sensitive to change by conducting a correlation between patient's perception of change and other clinical parameters of this study namely, VAS pain intensity, AROM in flexion, extension, right lateral flexion, and left lateral flexion, modified ODQ total scores and separated items. By which, the raw data of change scores of all aforementioned parameters from all subjects in this study were included. The change scores of all parameters were from the reduction of the measured values at the end of program by their baseline values. Therefore, the positive or negative changes from time to time were then used for correlations with VAS patient's perception of change at the end of program. Then, r values from Pearson or Spearman were used to determine the level of sensitivity.

The technique of sensitivity study has been used in many studies (26, 116, 149, 150). Pengel and colleagues (26) studied the sensitivity of pain, disability, and physical impairment outcomes in patients with low back pain. The study population of their research consisted of 156 patients with subacute LBP, pain duration of 6 weeks to 3 months and aged 18-80 years. The researchers studied sensitivity by correlating change scores in each outcome with the global perceived effect scale, reported in Pearson r values. The global perceived effect scale ranged from -5 (vastly worse) to 5 (completely recovered), with 0 being unchanged. The results manifested that disability measures (Patient Specific Functional Scale, PSFS and Roland Morris Questionnaire, RMQ) and pain measures (Numerical Rating Scale, NRS) were more sensitive than physical impairment measures (backward bending, forward bending, left and right side bending, left and right SLR). Their results of Pearson r values were 0.5 for NRS pain intensity, 0.6 for PSFS, 0.5 for RMQ, 0.2 for most of active movements, and 0.1 for left and right SLR.

Comparing with the results of this study, the Pearson r values were 0.2 for VAS pain intensity, 0.24 for AROM flexion, 0.03 for extension, 0.27 for right lateral flexion, 0.26 for left lateral flexion, and with statistical significance only for modified ODQ total scores with r value of 0.30. While, Spearman r values were used for separated items of modified ODQ, the results ranged from 0.09-0.25 without statistical significance.

The results of Pearson r values manifested that modified ODQ had highest sensitivity than other parameters, anyhow only when the total scores were calculated. The separated items of modified ODQ showed low sensitivity and without significance. Therefore, it would be beneficial for assessing the change over time to recommend that the modified ODQ should be used with all items and calculated into total scores of percentage of disability rather than selecting only from some items for better sensitivity.

However, there are many ways of decision for using modified ODQ, namely, for modality effectiveness assessment, for patient's prognosis estimation, or for some specific activity measurement. Therefore, it depends on users or researchers whether how do they use and what do they study. If the users would like to use modified ODQ for measuring some specific item such as sitting or personal care, it is not needed to collect all items. While, if the users would like to assess the effectiveness of the treatments or modalities, or the change of the patients, it was suggested to collect all items and calculate into percentage of disability, with better sensitivity additionally.

In details, from the data of Spearman values of separated items of modified ODQ, it was shown that the item of personal care, standing, and sitting were more sensitive (Chapter 4). This finding might represent that personal care, standing, and sitting were more obvious and could be easily observed together with the global changes. In other words, the greater sensitivity meant that these activities were much involved in patients' daily life.

The results of this study corresponded to the study conducted by Pengel and colleagues in terms of high sensitivity in pain measures and disability measures. While, the correlation values of AROM of this study were similar to the values of physical impairment measures of Pengel et al. However, the Pearson r values of pain and disability measures of this study were slightly less than those of Pengel et al. It might be due to the difference of the age and symptom durations of study population. The study population of this study aged 30-50 years and all subjects were with acute LBP. While the previous study, the subjects aged 18-80 years and with subacute LBP. In the present study, the subjects were more homogenous than the previous study. This homogenous effect might be resulted in difficulty of sensitivity and correlation study, which would require more variety of clinical backgrounds, or more heterogeneity as evidenced by wider range of age group (18-80 years) and symptom durations (6 weeks – 3 months) in the study conducted by Pengel et al.

However, the results of correlation study might provide some clinical pictures of the change over time in patients with acute LBP. It should be interpreted the results with care and should be concerned the difference of the nature of various characteristics of the patients. Therefore, more studies pertaining to sensitivity or the changes should be done for further study. In addition, the parameter of patient's perception of change could be added as a parameter for clinical works or researches because it could be used to detect the change over time. Although there is no gold standard for measuring clinically relevant change, it may be accepted that the patient's own perception of change is reliable whether clinically significant change has occurred (26).

5.8 Comparisons of Subjects with Both Sides or Centralized LBP between the Control and the Experimental Groups

This small study besides to the main study aimed to scope the subjects regarding the location of pain that might attribute to the clinical reasoning in terms of treatments given. Therefore, the subjects with both sides of LBP or centralized LBP were chosen for comparisons in all parameters as done in the main study. The subjects with the painful location in only left or right side were excluded. This purpose of

selecting only subjects with both sides of LBP or centralized LBP was due to the similarity in spinal mobilization treatments given. According to the literature review (see also Chapter II) pertaining to selection of the technique of spinal mobilization explained by Maitland (84), the central PA mobilization technique is appropriate for central pain or the pain originated from both sides of the lumbar, while, the unilateral PA and transverse gliding techniques are more appropriate for one side painful location over another side (84). Therefore, this small study gathered the data of the subjects with both sides of LBP or centralized pain in the lumbar spine, the data were then analyzed statistically as shown in Chapter IV.

In both groups, seventeen subjects in each group met the criteria, therefore, the total number of subjects for statistical analysis was 34. The parameters of the study, same as the main study, consisted of VAS score for pain intensity, AROM flexion, extension, right and left lateral flexion, modified ODQ total scores, VAS patient's perception of change, and also the number of visits and the recurrence rate.

According to VAS score for pain intensity, the result showed the significant decrease of pain intensity over-time in within-group analysis accordingly since after the first treatment. The decreases still existed at week-1, end of program, and also at month-3 follow-up measurements in both groups. However, there was no difference between two groups at any time of measurements from between-group analysis. The pain intensity analysis was not different from the main study. This small study still found no significant difference between two groups. This evidence might indicate that the treatment of physical therapy treatments were therapeutic for patients with acute LBP even without spinal mobilization. However, the accumulative therapeutic effects from the combination of relevant treatments were responsible for the decrease of the pain intensity over-time for both groups. The results of this present study were actually preliminary. Yet, the exact therapeutic effects of other physical therapy modalities still seemed to be inconclusive, and it is very important to have more high-quality RCT studies for investigating the therapeutic effects of the other physical therapy modalities in research way (151). Although the most of physical therapy modalities awaits formal investigation for indicating their real effectiveness, but this present study used the

modalities considered necessary for treating specific problems found from physical examinations decided by experienced therapists with time consuming concerns.

Although there was no difference found between two groups, the experimental group presented a better trend in pain reduction as evidenced by the less pain level measured at post-immediately and week 1 compared to the control group. Even though the baseline data of pain intensity for the experimental group was higher than that of the control group, but the pain intensity at post-immediately and week-1 measurements for the experimental group were less. At week-1 measurement, the pain intensity in the experimental group was only 14.9 mm indicating the fast reduction in a week since the baseline data of 53.3 mm or 38.4 mm reduction. While, the week-1 measurement for the control group was 20.7 mm since the baseline 45.5 mm and post-immediately 22.1 mm. The week-1 value of the control group was still similar to its post-immediately value, and from the baseline data, the week-1 data represented 24.8 mm reduction in a week. The reduction of pain intensity at week 1 for the experimental group was nearly double to the control group. Although there was no statistical support for the better improvement in the experimental group over the control group, but there was a tendency towards the faster reduction in the experimental group.

According to AROM, the flexion seemed to be different to the main study because there was no any significant difference regarding within-group or between-group analysis, whereas the main study showed significant difference at month-3 follow-up measurement in the control group from the baseline data. These subjects with both sides of LBP or centralized LBP might have more stiffness compared to the subjects with only one side of LBP. The subjects with both sides of LBP or centralized LBP perhaps suffered from the stiffness in the lumbar region additionally to the muscular problems. The therapist in the control groups more frequently prescribed forward bending exercise for the control subjects (76.36%). This exercise seemed to be helpful in the main study, while in this small study seemed to be minimally therapeutic. As shown in the results (see also Chapter IV), the week-1 and the end-of-program measurements of AROM flexion were very similar to the baseline data in the

control group. Anyhow, at month-3 measurement, the AROM flexion of the control group was perhaps better from the baseline data seemingly. This increased value in AROM flexion of the control group at month-3 measurement might represent the compliance of the control subjects to perform the prescribed forward bending exercise after the end of treatment program affirming by the words of insistency given by the subjects at month-3 follow-up appointments. While, the stretching exercise was less prescribed in the experimental group (36.11%), it might be due to the subjects in the experimental group received spinal mobilization for the major treatment. The data of AROM flexion in the experimental group seemed to be better gradually from time to time. There was no difference in the experimental group over the control group at any time of measurement of AROM flexion because the spinal mobilization has the mechanical effects on tissue lengthening but the effect was immediate after the treatment (84). This improvement of AROM flexion as reported in both groups might indicate that the appropriate treatments rather than single treatment was necessary and the improvement was gradual and slow compared to pain intensity that was more sensitive to the given treatments.

AROM extension, this small study had the same tendency as of the main study towards increasing AROM extension over-time in both groups. There were significant improvement in AROM extension at week 1, end of program, and month-3 follow ups from the baseline measurement in both groups. But there was no significant difference between two groups at any time of measurement. The subjects in the control group were prescribed a stretching exercise in the manner of backward bending, while the central PA mobilization was given to the experimental subjects. The results might indicate the effectiveness of both stretching exercise and central PA mobilization in increasing AROM extension.

Regarding AROM right lateral flexion, there was a significant difference in within-group analysis but the post-hoc analysis showed no significant difference from time to time when the either group was calculated separately. The significant difference of within-group was found in overall or combined group consideration. Anyhow, AROM left lateral flexion; it seemed to be that only the experimental group

had better improvement as shown in significant increases of AROM at the end of program and month-3 measurements from the baseline data. This improvement in the experimental group was as well as that of the main study. Both the small and the main studies showed significant improvement of AROM left lateral flexion over-time while the control group did not. This significant improvement in AROM left lateral flexion and a tendency of improvement in right lateral flexion in the experimental group might indicate the effectiveness of spinal mobilization that has the mechanical effects in tissue elongation not only in one sagittal plane, but also the coronal plane or movement towards right or left lateral bending. Whereas, the control group showed no significant improvement in both AROM right and left lateral flexions. The data of the control group was perhaps served as a reference. The data in the experimental group might indicate the benefits of spinal mobilization in lateral bending.

The modified ODQ total scores reduced significantly in both groups as well as the main study. The dramatic change was found in both groups since the first measurement after the baseline measurement or at within week 3 and the reduction remained at the end of program and at month-3 measurement. As well as VAS score for patient's perception of change, the positive change or recovery from LBP was shown in both groups as well as the main study. The positive change was found even immediately after the first treatment, the control group 21.64 mm and the experimental group 28.17 mm. None of the subjects reported the negative change i.e., the symptoms became worse. The VAS scores increased significantly at within week 3, the end of program, and month-3 measurement compared to post-immediately measurement. The improvement of both groups as evidenced by the reduction in the modified ODQ total scores and the positive change in VAS patient's perception of change might represent the benefits of appropriate treatments with or without spinal mobilization. The experimental group was not better than the control group in terms of disability score (modified ODQ) or positive change. The results went in same way as the main study. It might be due to the sensitivity of these two parameters that could detect the change over-time rapidly, maybe the results represented that the appropriate physical therapy treatments given in both groups played an important role in minimizing disability and then promoting recovery.

The number of visits was not different to the main study, by which the medial values showed that both groups took two visits for the treatment program. And the recurrence rate was also very similar to the main study in both groups in terms of the proportion of the numbers of recurrent and non-recurrent subjects. These findings also affirmed the effectiveness of the physical therapy treatments in patients with acute LBP after the proper physical examinations were done.

5.9 Clinical Implications

This study was conducted in clinical settings and the procedure was comparable to clinical practices. Therefore, the procedure consisted of both physical examinations and treatments were given by assigned physical therapists according to pre-specified groups. Physical examinations were done individually by that therapist, and then the appropriate physical therapy diagnosis was made. Each patient was given proper treatments decided by the experienced therapist.

From the results, it was found that the subjects in both groups were beneficial from the treatments as reported in decreasing pain, increasing AROM, minimizing disability, and positive changes in recovery over time. Mainly, there was no significant difference between the control and the experimental groups in any parameters but significant differences were indicated for the over-time changes in each group.

This study was not conducted in laboratory settings or based on physiological approach, so, the results must be interpreted with caution if the readers would consider about physiological matters. Anyhow, the results could reflect the effects of physical therapy treatments with or without spinal mobilization especially in clinical settings. The experimental group although received spinal mobilization but they showed no advantage over the control group. This indifferent finding might be due to the subjects in this study had no critical joint stiffness, by which the therapeutic exercise could also offer similar benefits in promoting back mobility. Therefore, this study might manifest that the therapeutic exercise might be another choice for increasing AROM in patients with acute LBP. Anyhow, from the data of the number of visits and the recurrence, the

experimental group seemed better. The experimental group spent less trials of treatment and had lower recurrence rate compared with the control group.

Anyhow, the significance of this study was related to the results that spinal mobilization might not be so essential in patients with acute LBP. This explanation might support the effects of physical modalities such as ultrasound, massage, stretching exercise, and even spinal mobilization. The results from this study showed that the impairment or decreased AROM in the control group could also be corrected by stretching exercise as well as it was corrected by stretching exercise and spinal mobilization in the experimental group. The outcomes of AROM improvement between two groups were similar. So, it was interesting that stretching exercise might be good enough in increasing AROM, of which the stretching exercise is self-treatment that physical therapists may consider as a prescription for home program. Anyhow, stretching exercise might not be appropriate for the patients with joint stiffness because the stretching exercise is a general approach for back mobility, while spinal mobilization is claimed as a more specific technique for localized back mobility enhancement (84, 94). However, the effectiveness of spinal mobilization on joint stiffness awaits further investigations.

Considering the indifferent result between two groups, another plausible explanation might be due to the fast recovery and better response in acute phase of LBP (120, 121). Because of more frequent measurement, the changes in pain intensity could be detected in both groups after first treatment and week 1. This change affirmed the fast recovery in patients with acute LBP. In addition, from this study, it could be conclusive that the combination of all proper whether with or without spinal mobilization treatments after physical examination might be beneficial in patients with acute LBP in terms of minimizing pain intensity, increasing AROM, decreasing disability, and promoting recovery.

5.10 Further Study

For managing LBP patients appropriately or even building up clinical guidelines both locally or internationally, evidence-based studies are still needed (21). Therefore, it is challenging to increase high-quality evidence-based meta-analysis or randomized controlled/ clinical trials (RCT) about acute LBP studies. From the literature review, most of previous studies engaged in chronic LBP but very few in acute LBP studies. So, this study attempted to prove the effects of spinal mobilization as an adjunctive therapy to physical therapy treatments in patients with acute LBP. The results of this study showed no better outcomes in the experimental group over the control group in pain intensity, AROM in all measured directions, total scores of Thai modified ODQ, patient's perception of change, number of visits, and recurrence rate. Therefore, this study might indicate that there was no significance if the spinal mobilization is added in treatment program in patients with acute LBP.

However, the spinal mobilization technique is claimed as an effective therapy in minimizing pain intensity and increasing spinal mobility (84, 94). In addition, the spinal mobilization offers many specific techniques for specific spinal mobility approaches for the individuals who have joint stiffness. Therefore, it is interesting to recruit LBP patients with joint stiffness as defined by the therapists after physical examination. In addition, the recruitment of patients with chronic LBP is also interesting because it is postulated that the chronic LBP patients suffer from pain and decreased AROM because of the remodeling phase of the lesion which evidenced as stiffness (121). Thus it is possible that patients with chronic LBP may be beneficial from spinal mobilization together with physical therapy programs. While, there was no previous clinical study regarding the use of spinal mobilization in combination with physical therapy treatments in patients with chronic LBP in real clinical settings. So, the effects of spinal mobilization in patients with chronic LBP as an adjunctive therapy await formal investigations in the future.

CHAPTER VI
CONCLUSION

The purposes of this study were to compare the effects of physical therapy treatments with and without spinal mobilization reporting in the parameters of pain intensity, AROM, disability scores, patient's perception of change, and to study the correlations between the patient's perception of change and the change score of pain intensity, AROM, disability scores at the end of program. The study duration lasted up to 6 weeks maximally and was annexed by a follow-up at the third month after the baseline assessment. By which, the subjects between two groups were not different in age, weight, height, and BMI.

The first objective, the comparison between two groups, pain intensity at baseline measurement was 44.9 and 52.4 mm in the control and the experimental groups, respectively. The pain decreased significantly at immediately after the first treatment in both groups, and the decreases continued until the end of program. The experimental group seemed to be better in pain reduction as evidenced by the less pain level measured at post-immediately and week 1 from baseline data compared to the control group in both the main study and the small study of recruiting only both sides of LBP or centralized LBP subjects.

As well as AROM in flexion, extension, right and left lateral flexion, there was no difference between two groups at any time of measurement for all directions in both main and small studies. However, the significant increases of AROM extension were found from time to time in both groups. Whereas, AROM right and left lateral flexion significantly increased after the baseline measurement only for the experimental group at the end of program and month-3 follow up.

Modified ODQ total scores were 23.60 and 21.12 % at baseline measurement of the control and the experimental groups in the main study respectively. The total

scores decreased significantly at within week 3, end of program, and month-3 measurements compared to baseline data in both groups but no difference between two groups. Patient's perception of change showed positive changes over time in both groups with statistical significance. The full recovery was at 50 mm. At month-3 follow up, the scores were 39.9 mm or 79.8% of full recovery, and 43.5 mm or 87% of full recovery in the control and the experimental groups, while at immediately after first treatment were 21 and 28.9 mm, respectively. The improvements in both groups in terms of decreased modified ODQ total scores and positive change were similar in small studies.

The number of visits was counted according to the criteria of the study that the program lasted 6 weeks after baseline assessment or until the symptoms of LBP disappeared, or when the patients satisfied the outcome and would like to stop the treatment before 6 weeks. The termination of treatment was determined by the physical therapists together with the subjects. From the median values of the number of visits, the control group spent 3 trials of treatment, while the experimental group took only 2 trials of treatment. For recurrence rate within three months, the control group was 24% and the experimental group was 12%. The recurrence rate between two groups had no significant difference. The small study, the results were similar to the main study, both groups took 2 trials. There was no significant difference in the number of visits and the recurrence rate between two groups.

Another objective was to study the correlations between the patient's perception of change and the change score of pain intensity, AROM, modified ODQ total scores at the end of program. The results showed that only modified ODQ total scores and patient's perception of change had the highest Pearson r value with statistical significance, while individual items of modified ODQ had lower Spearman r values. Other parameters had no significant correlation, namely, VAS pain intensity and AROM all directions. The significant correlation of modified ODQ total scores might represent good sensitivity for detecting the change over time. This finding also supported the use of modified ODQ total scores in terms of clinical assessment and research.

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APPENDIX

APPENDIX A.1

CONSENT FORM

(หนังสือแสดงเจตนายินยอมเข้าร่วมการวิจัย)

วันที่.....เดือน.....พ.ศ. .....

ข้าพเจ้า……..... อายุ…..……ปี อาศัยอยู่บ้านเลขที่…..…..

ถนน.....….แขวง/ตำบล……..…..... เขต/อำเภอ…….....……

จังหวัด…….. รหัสไปรษณีย์.....….. โทรศัพท์…….....

ขอแสดงเจตนายินยอมเข้าร่วมโครงการวิจัย เรื่อง “ผลการรักษาทางกายภาพบำบัดโดยมีและไม่มีการขยับเคลื่อนข้อต่อกระดูกสันหลังในผู้ที่มีอาการปวดหลังส่วนล่างเฉียบพลัน”

โดยข้าพเจ้าได้รับทราบรายละเอียดเกี่ยวกับที่มาและจุดมุ่งหมายในการทำวิจัย รายละเอียดขั้นตอนต่างๆที่จะต้องปฏิบัติหรือได้รับการปฏิบัติ ประโยชน์ที่คาดว่าจะได้รับของการวิจัยและความเสี่ยงที่อาจจะเกิดขึ้นจากการเข้าร่วมการวิจัย รวมทั้งแนวทางป้องกันและแก้ไขหากเกิดอันตรายขึ้น ค่าตอบแทนที่จะได้รับ ค่าใช้จ่ายที่ข้าพเจ้าจะต้องรับผิดชอบจ่ายเอง โดยได้อ่านข้อความที่มีรายละเอียดอยู่ในเอกสารชี้แจงผู้เข้าร่วมการวิจัยโดยตลอด อีกทั้งยังได้รับคำอธิบายและตอบข้อสงสัยจากหัวหน้าโครงการวิจัยเป็นที่เรียบร้อยแล้ว ข้าพเจ้าจึงสมัครใจเข้าร่วมในโครงการวิจัยนี้

หากข้าพเจ้ามีข้อข้องใจเกี่ยวกับขั้นตอนของการวิจัย หรือหากเกิดผลข้างเคียงที่ไม่พึงประสงค์จากการวิจัยขึ้นกับข้าพเจ้า ข้าพเจ้าจะสามารถติดต่อกับ นายประเสริฐ สกุลศรีประเสริฐ ที่บ้านเลขที่ 129-131 หมู่ 6 ถ.เพชรเกษม ต.ท่าข้าม อ.สามพราน จ.นครปฐม 73110 โทรศัพท์ 0-9670-2916, 0-3428-7625 ได้ตลอด 24 ชั่วโมง

หากข้าพเจ้าได้รับการปฏิบัติไม่ตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย ข้าพเจ้าจะสามารถติดต่อกับประธานคณะกรรมการจริยธรรมการวิจัยในคนหรือผู้แทน ได้ที่สำนักงานคณะกรรมการจริยธรรมการวิจัยในคน ตึกอดุลยเดชวิกรม ชั้น 5 รพ. ศิริราช โทร (02)419-7000 ต่อ 6405

ข้าพเจ้าได้ทราบถึงสิทธิ์ที่ข้าพเจ้าจะได้รับข้อมูลเพิ่มเติมทั้งทางด้านประโยชน์และโทษจากการเข้าร่วมการวิจัย และสามารถถอนตัวหรืองดเข้าร่วมการวิจัยได้ทุกเมื่อ โดยจะไม่มีผลกระทบต่อการบริการและการรักษาพยาบาลที่ข้าพเจ้าจะได้รับต่อไปในอนาคตและยินยอมให้ผู้วิจัยใช้ข้อมูล

ส่วนตัวของข้าพเจ้าที่ได้รับจากการวิจัย แต่จะไม่เผยแพร่ต่อสาธารณะเป็นรายบุคคล โดยจะนำเสนอเป็นข้อมูลโดยรวมจากการวิจัยเท่านั้น

ข้าพเจ้าได้เข้าใจข้อความในเอกสารชี้แจงผู้เข้าร่วมการวิจัย และหนังสือแสดงเจตนายินยอมนี้ โดยตลอดแล้ว จึงลงลายมือชื่อไว้

ลงชื่อ.....ผู้เข้าร่วมการวิจัย/ผู้แทนโดยชอบธรรม/ วันที่.....

(.....)

ลงชื่อ.....ผู้ให้ข้อมูลและขอความยินยอม/หัวหน้าโครงการวิจัย/ วันที่.....

(.....)

ในกรณีผู้เข้าร่วมการวิจัยอ่านหนังสือไม่ออก ผู้ที่อ่านข้อความทั้งหมดแทนผู้เข้าร่วมการวิจัย คือ .....จึงลงลายมือชื่อไว้เป็นพยาน

ลงชื่อ.....พยาน/ วันที่.....

(.....)

APPENDIX A.2
PARTICIPANT INFORMATION SHEET
(เอกสารชี้แจงผู้เข้าร่วมการวิจัย)

ในเอกสารนี้อาจมีข้อความที่ท่านอ่านแล้วยังไม่เข้าใจ โปรดสอบถามหัวหน้าโครงการวิจัย หรือผู้แทนให้ช่วยอธิบายจนกว่าจะเข้าใจดี ท่านอาจจะขอเอกสารนี้กลับไปอ่านที่บ้านเพื่อปรึกษาหารือกับญาติพี่น้อง เพื่อนสนิท แพทย์ประจำตัวของท่าน หรือแพทย์ท่านอื่น เพื่อช่วยในการตัดสินใจเข้าร่วมการวิจัย

ชื่อโครงการ ผลการรักษาทางกายภาพบำบัดโดยมีและไม่มีการขยับเคลื่อนข้อต่อกระดูกสันหลังในผู้ที่มีอาการปวดหลังส่วนล่างเฉียบพลัน

ชื่อผู้วิจัย นายประเสริฐ สกุลศรีประเสริฐ

สถานที่วิจัย คลินิกกายภาพบำบัด ชั้น 1 อาคารสำนักงานมหาวิทยาลัยมหิดล เชิงสะพานสมเด็จพระปิ่นเกล้า โทรศัพท์ 0-2433-7098-9

โครงการวิจัยนี้ทำขึ้นเพื่อศึกษาถึงผลการรักษาทางกายภาพบำบัดโดยมีและไม่มีการขยับเคลื่อนข้อต่อกระดูกสันหลังในผู้ที่มีอาการปวดหลังส่วนล่างเฉียบพลัน ซึ่งจะมีประโยชน์ที่คาดว่าจะได้รับ คือ สามารถนำข้อมูลที่ได้จากการศึกษามาใช้เป็นแนวทางในการรักษาผู้ป่วยที่มีอาการปวดหลังส่วนล่างได้อย่างเหมาะสมและมีประสิทธิภาพมากยิ่งขึ้น

ท่านได้รับเชิญให้เข้าร่วมการวิจัยนี้เพราะ ท่านเป็นผู้ที่มีคุณสมบัติครบถ้วน ตามเกณฑ์ที่ผู้วิจัยกำหนดคือ ไม่มีบริเวณอาการปวดหลังที่เป็นเลยกว่าระดับก้นลงไปและไม่มีปัญหาของระบบประสาทร่วมด้วย และไม่มีความเสี่ยงต่อการรักษาด้วยวิธีการขยับเคลื่อนกระดูกสันหลัง

จะมีผู้เข้าร่วมการวิจัยนี้ทั้งสิ้นประมาณ 60 คน ระยะเวลาที่จะทำวิจัยทั้งสิ้น 3 เดือน

เมื่อท่านเข้าร่วมการวิจัย สิ่งที่ท่านจะต้องปฏิบัติ คือการเข้ารับการรักษาอย่างต่อเนื่องจนอาการปวดหลังหายไป หรือเป็นระยะเวลา 6 สัปดาห์

โดยท่านจะไม่มีความเสี่ยงใดๆที่อาจจะเกิดขึ้นเมื่อท่านเข้าร่วมการวิจัยในครั้งนี้

หากท่านไม่เข้าร่วมในโครงการวิจัยนี้ ท่านก็จะได้รับการตรวจเพื่อวินิจฉัยและรักษาอาการปวดหลังของท่านทางกายภาพบำบัดตามวิธีการที่เป็นมาตรฐาน โดยได้รับการประเมินอาการปวด ตรวจประเมินการเคลื่อนไหวของหลัง และได้รับการประเมินความสามารถในการทำกิจวัตรประจำวันอย่างครบทุกขั้นตอน

ในการศึกษาครั้งนี้ ท่านจะมีค่าใช้จ่ายตามปกติในการรักษาทางกายภาพบำบัด การวิจัยครั้งนี้ไม่มีค่าตอบแทน แต่ผู้ร่วมวิจัยจะได้ทราบรายละเอียดการตรวจประเมินอาการปวดหลังของท่าน

หากเกิดผลข้างเคียงที่ไม่พึงประสงค์จากการวิจัย ทางคณะผู้วิจัยจะยุติการวิจัยโดยทันทีและจะให้ท่านได้รับการรักษาที่เหมาะสมต่อสภาพการณ์นั้นๆ

หากมีข้อมูลเพิ่มเติมทั้งด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ ผู้วิจัยจะแจ้งให้ทราบโดยรวดเร็วโดยไม่ปิดบัง

ข้อมูลส่วนตัวของผู้เข้าร่วมการวิจัยจะถูกเก็บรักษาไว้ ไม่เปิดเผยต่อสาธารณะเป็นรายบุคคล แต่จะรายงานผลการวิจัยเป็นข้อมูลส่วนรวม ข้อมูลของผู้เข้าร่วมการวิจัยเป็นรายบุคคลอาจมีคณะบุคคลบางกลุ่มเข้ามาตรวจสอบได้ เช่น ผู้ให้ทุนวิจัย, สถาบันหรือองค์กรของรัฐที่มีหน้าที่ตรวจสอบ, คณะกรรมการจริยธรรมฯ เป็นต้น

ผู้เข้าร่วมการวิจัยมีสิทธิ์ถอนตัวออกจากโครงการการวิจัยเมื่อใดก็ได้ โดยไม่ต้องแจ้งให้ทราบล่วงหน้า และการไม่เข้าร่วมการวิจัยหรือถอนตัวออกจากโครงการวิจัยนี้จะไม่มีผลกระทบต่อการบริการและการรักษาที่สมควรจะได้รับแต่ประการใด

หากท่านได้รับการปฏิบัติที่ไม่ตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงนี้ ท่านจะสามารถแจ้งให้ประธานคณะกรรมการจริยธรรมฯ ทราบได้ที่ สำนักงานคณะกรรมการจริยธรรมการวิจัยในคน ตึกอดุลยเดชวิกรม ชั้น5 โรงพยาบาลศิริราช เบอร์โทร (02)419-7000 ต่อ 6405

ข้าพเจ้าได้อ่านรายละเอียดในเอกสารนี้ครบถ้วนแล้ว

ลงชื่อ ...../วันที่.....

(.....)

APPENDIX B.1
DATA COLLECTION FORM

PART 1 Patient History

Name……..……

Gender □ Male □ Female Date of Birth……../……/…….. Age (years)…….

Weight (kg) …….. Height (cm) ……. BMI (kg/m^2) ……..…..

Occupation ……...……

Address ……....

Telephone …… Mobile ……. E-mail address ……

Group □ Control □ Experimental

Subject code: C / E ……..

PART 2 Measurement Record Forms

Parameters	**Pre**	**Wk1**	**Wk2**	**Wk3**	**Wk4**	**Wk5**	**Wk6**	**Mo3**
VAS (mm) Pain intensity								
Flexion (cm)								
Extension (cm)								
Lt lat flex (cm)								
Rt lat flex (cm)								

Parameters	**Pre**	**Wk3**	**Wk6**	**Mo3**
Modified ODQ Pain intensity				
Personal care				
Lifting				
Walking				
Sitting				
Standing				
Sleeping				
Social life				
Traveling				
Employment				
Total Score				
VAS (mm) Patient's perception of change				

APPENDIX B.2
VISUAL ANALOG SCALE AND MODIFIED OSWESTRY LOW BACK PAIN DISABILITY QUESTIONNAIRE

B.2.1 100 mm Visual Analog Scale (VAS) for pain intensity

|_____|

ไม่ปวดเลย ปวดมากที่สุด

B.2.2 100 mm (-50, 0, 50) Visual Analog Scale (VAS) for patient's perception of change

|_____|_____|

อาการแย่ลงมากที่สุด ไม่มีการเปลี่ยนแปลง อาการดีขึ้นจนเป็นปกติ

B.2.3 Modified Oswestry Low Back Pain Disability Questionnaire in Thai

Cross-cultural adaptation of modified version Oswestry Low Back Pain Disability Questionnaire to Thai

Section 1: Translation of modified ODQ

Permission from the publisher

The modified ODQ was created by Fritz et al in 2001 and was published in Physical Therapy (Phys Ther), which holds the copyright of the modified ODQ. Therefore, the permission from the publisher is necessary before the beginning of the process of cross-cultural translation. The authors reported purposes and a process of cross-cultural translation to the publisher. The publisher appraised the purposes and process, and then permitted for cross-cultural translation.

Initial forward translations

Translators 1, 2 and 3 can speak both Thai and English, and are native speakers of Thai. Three translators independently produced initial forward translation of the modified ODQ. All translators were instructed to aim for conceptual rather than literal translation, and to keep the language easy to understand for individuals without the knowledge of technical terminology.

Synthesis of the translations

Each translation made by three translators were gathered and compared. Then, the approved version among three translators was made according to the consensus (see Appendix). However, the translation of some questions into Thai was difficult. For example, in item 4 (walking), the item described in terms of miles or yards would be unfamiliar to Thai people, then it was changed to kilometers or meters. In item 9 (traveling), the word “traveling” simply means a trip to somewhere or transportation, therefore in Thai version, the item of traveling was then clearly defined as transportation.

Back translation

A back translator was invited for back translation. The back translator is a native speaker of English (can speak both Thai and English). The back translator is not a medical profession but works in a company selling medical and physical therapy instruments. The back translator was blinded to original version of modified ODQ and then translated the approved Thai modified ODQ into English version.

Back translation approval

The back translation version was then thoroughly considered by the research team for all 10 items with 6 sentences of each. Compared to the original version of modified ODQ, the conceptual matters written in the back translation version have been approved. The meanings of back translation version are still comparable to the original version of modified ODQ. Therefore, this method has proved that the Thai modified ODQ contains items and sentences with unchanged meanings and concepts.

Section 2: Test-retest reliability of Thai version modified ODQ

A test-retest study was conducted to evaluate the reliability of the Thai modified ODQ for the patients with LBP. Forty patients with LBP, who came to outpatient clinic of the faculty of physical therapy and applied movement science, Mahidol University for physical therapy treatments, aged 40.1 ± 10.7 years, of which 20 patients with acute LBP (aged 40.3 ± 11.6 years) and 20 patients with chronic LBP (aged 39.9 ± 9.9 years), were recruited into the study. All participating subjects were during waiting for physical therapy interventions. The subjects had been interviewed about the area of symptoms and they were given the general purpose of the study.

Test-retest reliability was measured by comparing the results of the first and second administrations separated by a time interval of 20-30 minutes. In this study, the subjects were not informed whether they will be asked to administer the second administration to prevent them from recognition of the first response. Initially, the subjects were given general instructions of the Thai modified ODQ by the researchers, and the subjects were allowed to ask the researchers if they did not understand the items or descriptive sentences during responding the Thai modified ODQ. Then, one

of two trained researchers from random selection provided the Thai modified ODQ for the subjects to respond by themselves. After the first administration completed, all subjects were questioned pertaining to their symptoms 20-30 minutes. To confirm that the subjects would not recognize the first administration, the subjects would not be given the information of double administrations. And the subjects did not know whether they would be asked to respond the questionnaire again. Before the second administration, the subjects were subjectively inquired about the current status of LBP to make sure whether the pain intensity is still the same and the researchers asked the subjects to respond the questionnaire again. The subjects then did the second administration of the Thai modified ODQ. The responses from two administrations were collected for data analysis.

The results of test-retest reliability, the values of $ICC_{(2,1)}$ for both acute and chronic LBP groups (n = 40) ranged from 0.82 – 0.99, the test-retest reliability value of the total score was 0.98. The values of $ICC_{(2,1)}$ for acute LBP groups (n = 20) ranged from 0.85 – 0.99, the total score was 0.98. The values of $ICC_{(2,1)}$ for chronic LBP groups (n = 20) ranged from 0.80 – 1.00, the total score was 0.98.

Modified Oswestry Low Back Pain Disability Questionnaire[a] (ภาคภาษาไทย)

แบบสอบถามนี้ จัดทำเพื่อให้ผู้รักษาของท่านเข้าใจผลกระทบของอาการปวดหลังของท่านที่มีต่อชีวิตประจำวัน กรุณาตอบคำถามทุกข้อ โดยการขีด √ ด้านหน้าข้อความเพียงข้อเดียวที่จะบอกสภาพของคุณในวันนี้ได้ดีที่สุด เราทราบดีว่าท่านอาจจะรู้สึกว่ามี 2 ข้อความในข้อนั้นที่อาจจะตรงกับสภาพของคุณ แต่**กรุณาขีดเครื่องหมายในที่ว่างด้านหน้าข้อความที่ใกล้เคียงกับสภาพในปัจจุบันของคุณมากที่สุดเพียงข้อเดียว**

ระดับความเจ็บปวด

- ☐ ฉันสามารถทนอาการปวดได้ โดยไม่ต้องใช้ยาแก้ปวด
- ☐ อาการปวดไม่ดีเลย, แต่ฉันก็สามารถจัดการได้โดยไม่ต้องใช้ยาแก้ปวด
- ☐ ยาแก้ปวดทำให้ฉันหายจากอาการปวดโดยสิ้นเชิง
- ☐ ยาแก้ปวดทำให้ฉันหายจากอาการปวดได้ในระดับปานกลาง
- ☐ ยาแก้ปวดทำให้ฉันหายจากอาการปวดได้เล็กน้อย
- ☐ ยาแก้ปวดไม่มีผลต่ออาการปวดของฉัน

การดูแลตัวเอง (อาทิเช่น การทำความสะอาด, การแต่งตัว)

- ☐ ฉันสามารถดูแลตัวเองได้ตามปกติ โดยไม่ทำให้อาการปวดเพิ่มขึ้น
- ☐ ฉันสามารถดูแลตัวเองได้ตามปกติ แต่มันทำให้อาการปวดเพิ่มขึ้น
- ☐ มันเจ็บปวดในการดูแลตัวเอง และฉันก็ช้าและระมัดระวังตัวด้วย
- ☐ ฉันต้องการความช่วยเหลือ แต่ฉันก็สามารถจัดการธุระส่วนตัวส่วนใหญ่ได้
- ☐ ฉันต้องการความช่วยเหลือทุกวัน สำหรับธุระส่วนตัวเกือบทุกเรื่อง
- ☐ ฉันไม่แต่งตัว, ฉันทำความสะอาดด้วยความลำบาก, และฉันก็อยู่แต่ที่เตียงนอน

การยกของ

- ☐ ฉันสามารถยกของหนักได้โดยที่อาการปวดไม่เพิ่มขึ้น
- ☐ ฉันสามารถยกของหนักได้ แต่มันทำให้อาการปวดเพิ่มขึ้น
- ☐ อาการปวดเป็นอุปสรรคกับฉันในการยกของหนัก ขึ้นจากพื้น แต่ฉันก็สามารถจัดการได้ ถ้าของที่มีน้ำหนักมากนั้นถูกจัดวางให้สะดวกมากขึ้น (เช่นบนโต๊ะ)
- ☐ อาการปวดเป็นอุปสรรคกับฉันในการยกของหนัก แต่ฉันก็สามารถจัดการได้ ถ้าของที่มีน้ำหนักเบาถึงปานกลางนั้นถูกจัดวางให้สะดวกมากขึ้น
- ☐ ฉันยกได้แต่ของที่เบามาก
- ☐ ฉันไม่สามารถยกหรือถืออะไรได้เลย

การเดิน

- ☐ อาการปวดไม่เป็นอุปสรรคในการเดินไม่ว่าจะไกลเพียงใด
- ☐ อาการปวดทำให้ฉันเดินได้ไม่เกิน 1 ไมล์ (1 ไมล์ = 1.6 กิโลเมตร)
- ☐ อาการปวดทำให้ฉันเดินได้ไม่เกิน 1/2 ไมล์
- ☐ อาการปวดทำให้ฉันเดินได้ไม่เกิน 1/4 ไมล์
- ☐ ฉันสามารถเดินได้โดยใช้ไม้ค้ำยันหรือไม้เท้าเท่านั้น
- ☐ ฉันอยู่ที่เตียงเกือบตลอดเวลาและต้องคลานไปเข้าห้องน้ำ

การนั่ง

- ☐ ฉันสามารถนั่งบนเก้าอี้แบบไหนก็ได้ นานเท่าที่ฉันต้องการ
- ☐ ฉันสามารถนั่งบนเก้าอี้ที่ฉันชอบเท่านั้น นานเท่าที่ฉันต้องการ
- ☐ อาการปวดทำให้ฉันนั่งได้นานไม่เกิน 1 ชั่วโมง
- ☐ อาการปวดทำให้ฉันนั่งได้นานไม่เกิน 1/2ชั่วโมง
- ☐ อาการปวดทำให้ฉันนั่งได้นานไม่เกิน 10 นาที
- ☐ อาการปวดทำให้ฉันนั่งไม่ได้เลย

การยืน

- ☐ ฉันสามารถยืนได้นานเท่าที่ฉันต้องการโดยอาการปวดไม่เพิ่มขึ้น
- ☐ ฉันสามารถยืนได้นานเท่าที่ฉันต้องการแต่มันทำให้อาการปวดของฉันเพิ่มขึ้น
- ☐ อาการปวดทำให้ฉันยืนได้นานไม่เกิน 1 ชั่วโมง
- ☐ อาการปวดทำให้ฉันยืนได้นานไม่เกิน 1/2ชั่วโมง
- ☐ อาการปวดทำให้ฉันยืนได้นานไม่เกิน 10 นาที
- ☐ อาการปวดทำให้ฉันยืนไม่ได้เลย

การนอน

- ☐ อาการปวดไม่เป็นอุปสรรคต่อฉันในการนอนเต็มอิ่ม
- ☐ ฉันสามารถนอนได้เต็มอิ่มโดยการใช้ยาแก้ปวดเท่านั้น
- ☐ แม้ว่าเมื่อฉันทานยา ฉันก็นอนได้น้อยกว่า 6 ชั่วโมง
- ☐ แม้ว่าเมื่อฉันทานยา ฉันก็นอนได้น้อยกว่า 4 ชั่วโมง
- ☐ แม้ว่าเมื่อฉันทานยา ฉันก็นอนได้น้อยกว่า 2 ชั่วโมง
- ☐ อาการปวดทำให้ฉันนอนไม่หลับเลย

การเข้าสังคม

- ☐ การใช้ชีวิตในสังคมของฉันเป็นปกติ และไม่ทำให้อาการปวดของฉันเพิ่มขึ้น
- ☐ การใช้ชีวิตในสังคมของฉันเป็นปกติ แต่มันเพิ่มระดับความเจ็บปวดของฉัน
- ☐ อาการปวดเป็นอุปสรรคต่อฉันในการทำกิจกรรมที่ต้องออกแรงมาก (เช่น กีฬา, การเต้นรำ)
- ☐ อาการปวดเป็นอุปสรรคต่อฉันในการออกไปข้างนอกบ่อยๆ
- ☐ อาการปวดจำกัดการใช้ชีวิตในสังคมของฉัน ให้อยู่แต่ในบ้าน
- ☐ ฉันแทบไม่มีการเข้าสังคม เพราะอาการปวดของฉัน

การเดินทาง

- ☐ ฉันสามารถเดินทางไปได้ทุกแห่งโดยอาการปวดไม่เพิ่มขึ้น
- ☐ ฉันสามารถเดินทางไปได้ทุกแห่ง แต่มันทำให้อาการปวดของฉันเพิ่มขึ้น
- ☐ อาการปวดของฉันจำกัดการเดินทางที่เกิน 2 ชั่วโมงของฉัน
- ☐ อาการปวดของฉันจำกัดการเดินทางที่เกิน 1 ชั่วโมงของฉัน
- ☐ อาการปวดของฉันจำกัดการเดินทางของฉัน ให้เป็นการเดินทางระยะสั้นที่จำเป็นไม่เกิน ½ ชั่วโมง
- ☐ อาการปวดของฉันเป็นอุปสรรคต่อการเดินทางทั้งหมด ยกเว้นการไปพบแพทย์ / นักกายภาพบำบัด หรือโรงพยาบาล

การทำงาน / งานบ้าน

- ☐ งานบ้าน / กิจกรรมทางการงาน ของฉันไม่ทำให้เกิดอาการปวด
- ☐ งานบ้าน / กิจกรรมทางการงาน ของฉัน เพิ่มอาการปวดของฉัน แต่ ฉันยังคงสามารถทำงานที่ฉันต้องการทำทั้งหมดนั้นได้
- ☐ ฉันสามารถทำงานบ้าน / ภาระงานส่วนใหญ่ของฉันได้ แต่อาการปวดเป็นอุปสรรคต่อฉันในการทำกิจกรรมที่มีความเครียดทางกายเพิ่มขึ้น (เช่น การยกของ, การดูดฝุ่น)
- ☐ อาการปวดเป็นอุปสรรคต่อฉันในการทำสิ่งใดๆ ยกเว้นภาระงานที่เบา
- ☐ อาการปวดเป็นอุปสรรคต่อฉัน แม้แต่ภาระงานที่เบา
- ☐ อาการปวดเป็นอุปสรรคต่อฉันในการทำงานใดๆหรืองานบ้านประจำ

Source: Fritz JM, Irrgang JJ. A comparison of a modified Oswestry Low Back Pain Disability Questionnaire and the Quebec Back Pain Disability Scale. *Physical Therapy* 2001;81:776-788.

[a]Modified by Fritz & Irrgang with permission of The Chartered Society of Physiotherapy, from
Fairbanks JCT, Couper J, Davies JB, et al. The Oswestry Low Back Pain Disability Questionnaire. *Physiotherapy* 1980;66:271-273.

APPENDIX C
TEST-RETEST RELIABILITY OF BACK PAIN PARAMETERS MEASUREMENT

The purpose of this pilot study was to determine test-retest reliability of the research assistant in the parameters of VAS score for pain intensity, AROM in flexion, extension, right and left lateral flexion, modified ODQ total score, and VAS score for patient's perception of change. Ten subjects with acute nonspecific LBP who met the same inclusion criteria as used in the main present study, as reported in Chapter III, were engaged in the test-retest reliability study. For calculation of the test-retest reliability, Intraclass Correlation Coefficient ($ICC_{3,1}$) and standard error of measurement (SEM) were calculated. The SEM represents the reliability of the response which the less value reflecting the less error. The SEM values of VAS pain intensity, AROM all directions, ODQ total score, and VAS patient's perception of change, were also reported. Each parameter was measured one trial per administration; this study consisted of 2 administrations. The first and second administrations were separated by a time interval of 15 minutes. The subjects were informed about the general information of measurement but blinded about the times of measurement and the aims of test-retest reliability. The $ICC_{(3,1)}$, SEM, and raw data of the aforementioned parameters were reported (Table C.1 and Table C.2).

Table C.1 Test-retest reliability of the VAS score (mm) for pain intensity and AROM (cm) in flexion, extension, right lateral flexion (Rt. lat flex) and left lateral flexion (Lt. lat flex)

Subjects	VAS		Flexion		Extension		Rt. lat flex		Lt. lat flex	
	1st trial	2nd trial	1st trial	2nd trial	1st trial	2nd trial	1st trial	2nd trial	1st trial	2nd trial
1	72	72	5.5	6.0	6.0	6.0	20.5	22.0	20.5	21.0
2	29	24	4.0	4.0	4.0	4.5	21.0	23.0	23.5	22.0
3	26	39	6.0	6.0	1.0	1.0	15.0	15.5	14.0	14.5
4	79	80	6.0	6.0	1.0	1.0	18.0	20.0	20.0	19.0
5	24	20	6.0	6.0	1.5	1.5	17.5	17.5	16.5	16.0
6	27	23	4.0	4.0	0	0	21.0	21.0	21.0	20.0
7	18	17	2.0	2.5	2.0	1.5	17.0	16.0	18.0	17.0
8	62	59	5.0	5.0	2.5	2.0	18.0	19.0	20.0	21.0
9	65	72	3.0	4.0	1.0	1.5	14.0	15.0	16.0	15.0
10	26	22	3.5	3.5	0.5	1.0	10.0	11.0	16.0	17.0
$ICC_{(3,1)}$	**0.9718**		**0.9663**		**0.9795**		**0.9650**		**0.9431**	
SEM	**3.9899**		**0.2411**		**0.2538**		**0.6576**		**0.6539**	

Table C.2 Test-retest reliability of the modified ODQ (%) and VAS score (mm) for patient's perception of change

Subjects	Total score of modified ODQ		VAS score for patient's perception of change	
	1st trial	2nd trial	1st trial	2nd trial
1	24	28	8	8
2	6	6	8	8
3	8	8	7	13
4	18	18	0	0
5	18	18	13	12
6	38	40	26	24
7	52	50	20	13
8	16	18	25	22
9	14	18	8	12
10	18	18	33	29
$ICC_{(3,1)}$	**0.9901**		**0.9248**	
SEM	**1.3376**		**2.5778**	

APPENDIX D
RESULT OF THE PILOT STUDY

The purpose of this pilot study was to examine the effect of physical therapy treatments by comparing between treatments with and without spinal mobilization on pain intensity, AROM in flexion, extension, right and left lateral flexion, modified ODQ total score, and patient's perception of change. In this pilot study, control group underwent physical therapy treatments without spinal mobilization, and experimental group underwent physical therapy treatments together with spinal mobilization. Ten patients with acute nonspecific LBP participated in this pilot study. Subjects' characteristics are shown in Table D.1. The means for two groups on each parameter are revealed in the Figures D.1-D.7. Change score (wk1 post-treatment – pre-treatment) for two groups on each parameter are shown in Table D.2. The change score (end of program – pre-treatment) for two groups on each parameter are shown in Table D.3. Correlations between VAS score for patient's perception of change and other LBP parameters are shown in Tables D.4-D.5.

Table D.1 Characteristics of the subjects

Characteristics	**Control group (n = 5)**		**Experimental group (n = 5)**		**p-value**[a]
	Mean	**SD**	**Mean**	**SD**	
Gender (M / F)	3 / 2		3 / 2		-
Age (years)	45.60	4.50	38.40	6.14	0.068
Weight (kg)	65.80	11.25	67.40	10.08	0.819
Height (cm)	163.60	9.71	165.00	6.48	0.795
BMI (kg/m^2)	24.84	5.73	25.02	5.29	0.961

a = p-value from unpaired t-test

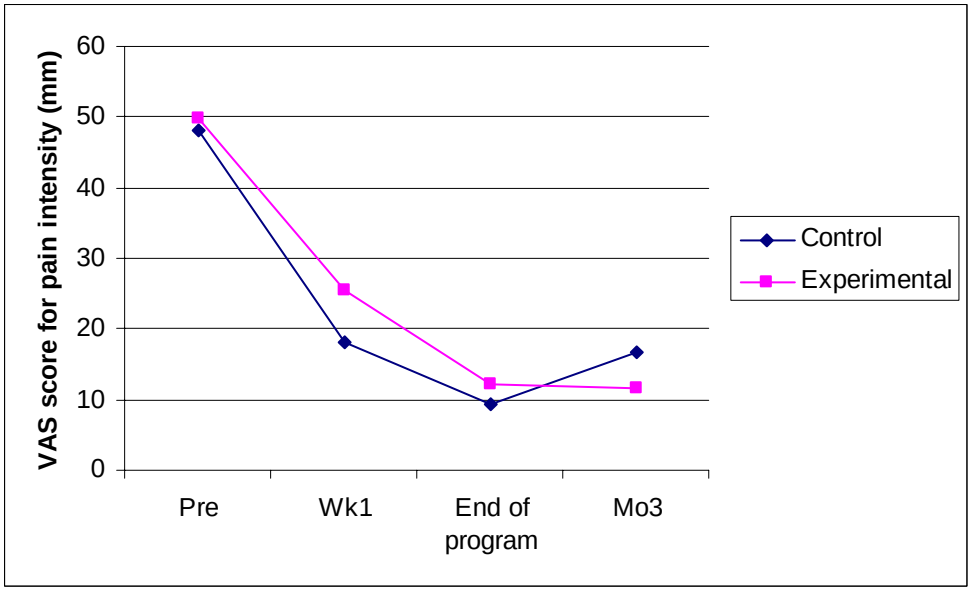

Figure D.1 Means of VAS score for pain intensity for control group and experimental group.

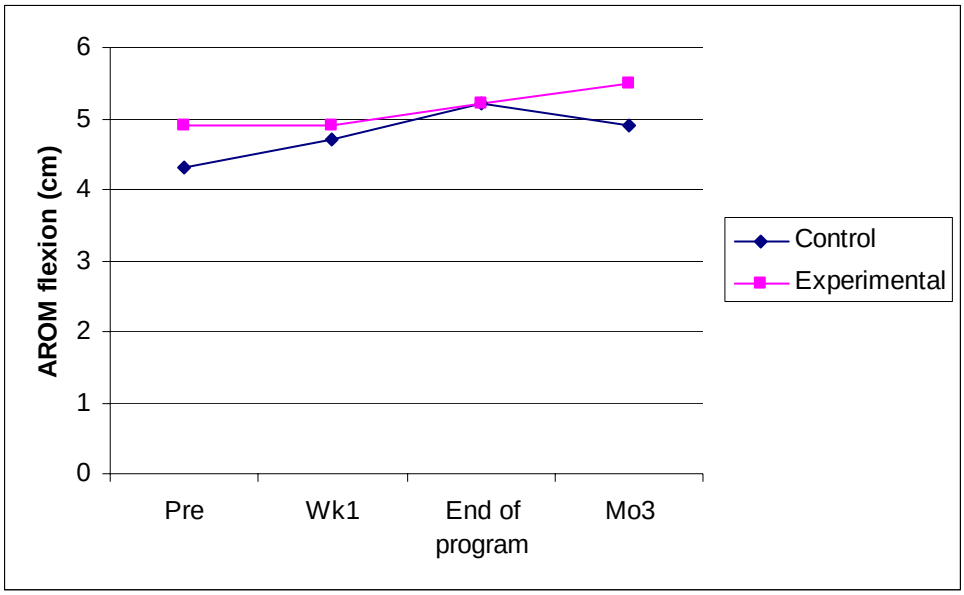

Figure D.2 Means of AROM flexion for control group and experimental group.

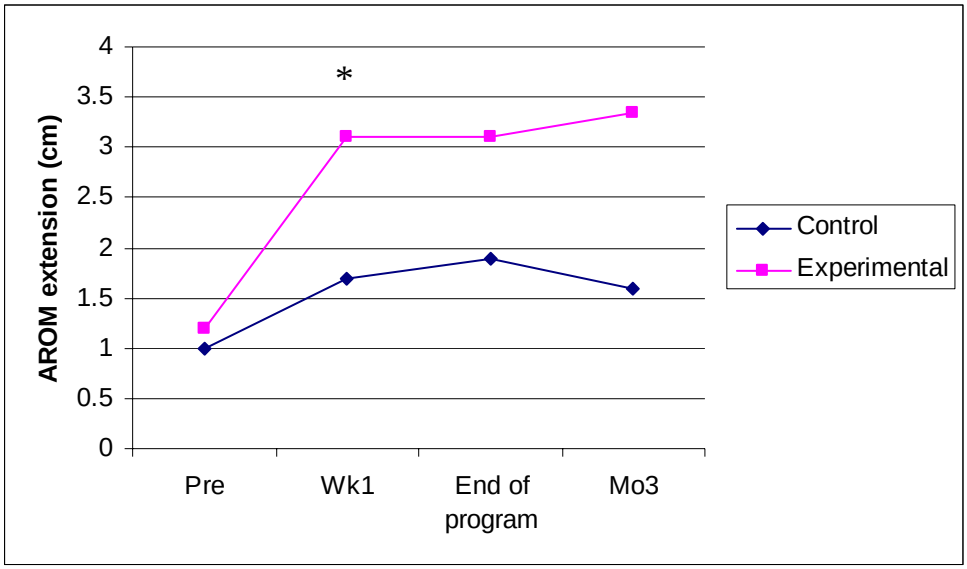

Figure D.3 Means of AROM extension for control group and experimental group (* denotes significant difference between two groups from Bonferroni post-hoc analysis).

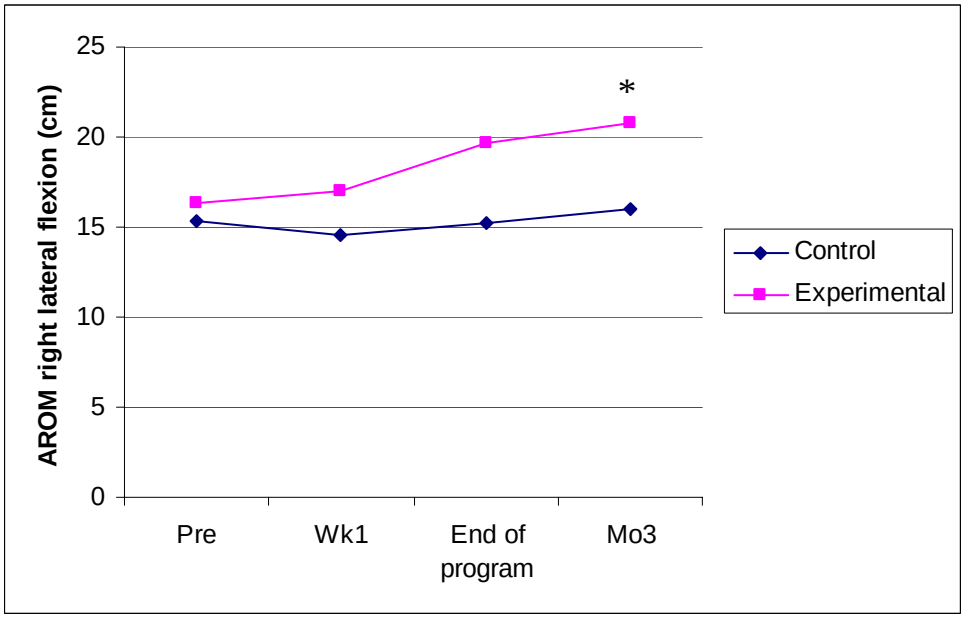

Figure D.4 Means of AROM right lateral flexion for control group and experimental group (* denotes significant difference between two groups from Bonferroni post-hoc analysis).

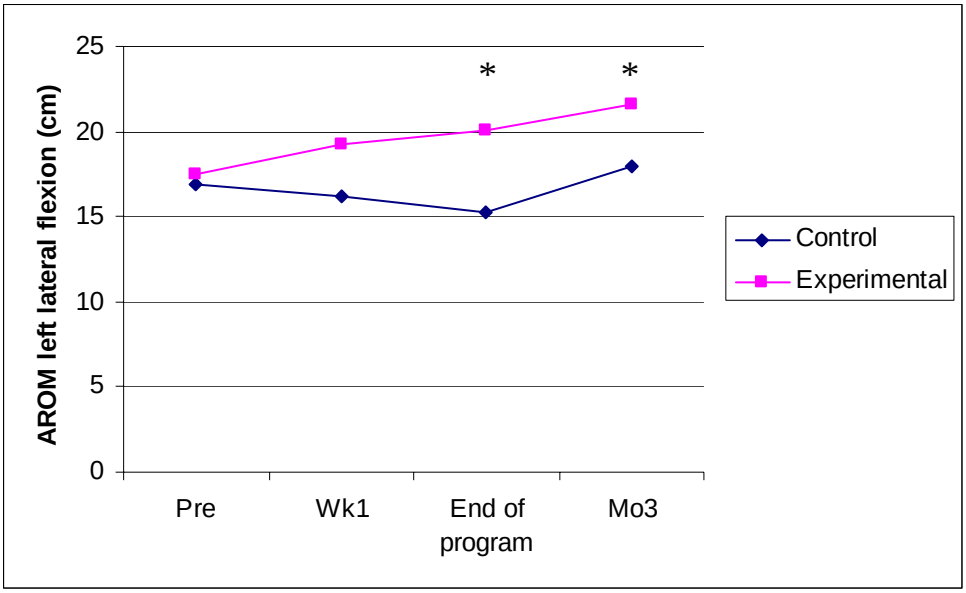

Figure D.5 Means of AROM left lateral flexion for control group and experimental group (* denotes significant difference between two groups from Bonferroni post-hoc analysis).

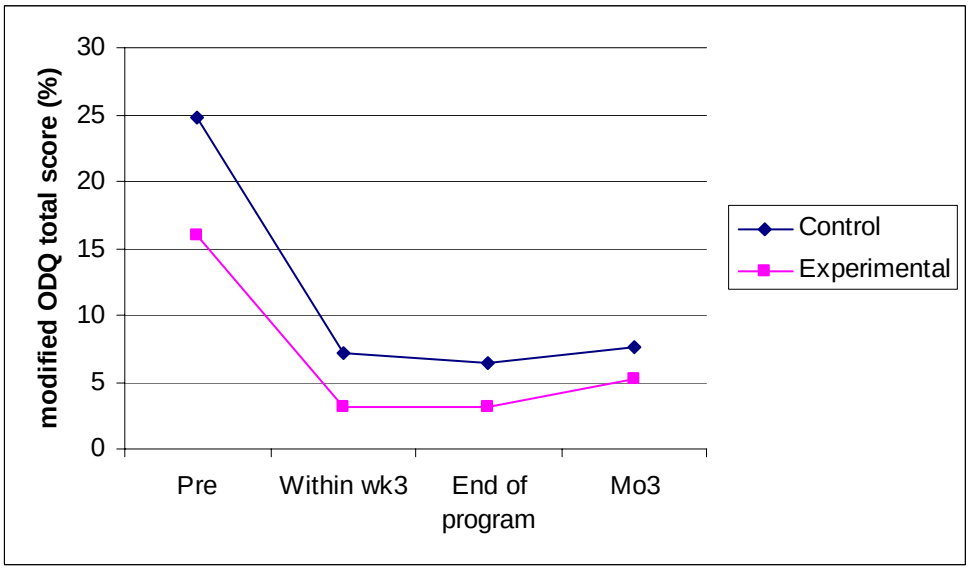

Figure D.6 Means of modified ODQ total score for control group and experimental group**.**

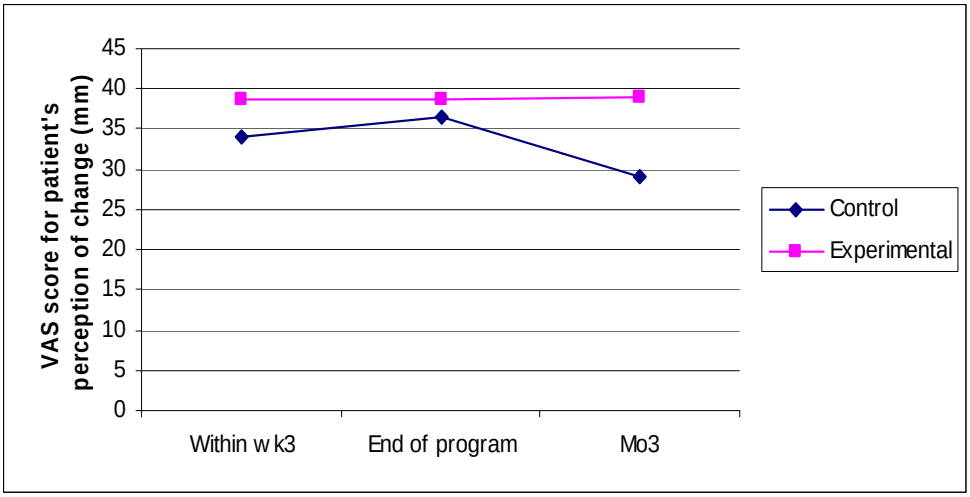

Figure D.7 Means of VAS score for patient's perception of change for control group and experimental group**.**

Table D.2 Change score (wk1 post-treatment – pre-treatment) for two groups

Parameters	**Control group (n = 5)**		**Experimental group (n = 5)**		**p-value**[a]
	Mean	**SD**	**Mean**	**SD**	
VAS pain intensity	-30.2	25	-24.2	14	0.652
Flexion	0.40	0.41	0	1.27	0.524
Extension	0.70	0.83	1.90	1.67	0.189
Rt. lateral flexion	-0.70	0.83	0.70	2.68	0.298
Lt. lateral flexion	-0.70	1.64	1.70	2.49	0.110

a = p-value from unpaired t-test

Table D.3 Change score (end of program – pre-treatment) for two groups

Parameters	**Control group (n = 5)**		**Experimental group (n = 5)**		**p-value**[a]
	Mean	**SD**	**Mean**	**SD**	
VAS pain intensity	-38.8	21.3	-37.6	18.2	0.926
Flexion	0.90	0.74	0.30	0.97	0.305
Extension	0.80	0.90	1.90	1.71	0.250
Rt. lateral flexion	-0.10	0.54	3.40	2.40	0.030 *
Lt. lateral flexion	-1.70	2.16	2.60	3.50	0.048 *
Modified ODQ total score	-18.40	11.78	-12.80	3.63	0.359

a = p-value from unpaired t-test

Table D.4 Correlations between VAS score for patient's perception of change and VAS score for intensity, AROM flexion, extension, right and left lateral flexion, modified ODQ total score (n = 10)

Parameters	**Pearson's Correlation**	**Sig (p-value)**
VAS pain intensity	-0.328	0.354
Flexion	0.175	0.629
Extension	-0.178	0.623
Rt. lateral flexion	0.324	0.361
Lt. lateral flexion	0.443	0.200
Modified ODQ total score	-0.271	0.449

Table D.5 Correlations between VAS score for patient's perception of change and individual items of modified ODQ

Parameters	**Spearman's Correlation**	**Sig (p-value)**
Pain intensity	-0.642	0.045 *
Personal care	0.338	0.339
Lifting	-0.313	0.379
Walking	-0.203	0.574
Sitting	-0.401	0.251
Standing	-0.182	0.615
Sleeping	0.364	0.301
Social life	0.038	0.916
Traveling	0.111	0.760
Employment	0.062	0.865

APPENDIX E
CALCULATION OF SAMPLE SIZE

The sample size for this study was calculated by using this equation

$$N = \frac{2S^2p\,[Z_{(1-\alpha/2)} + Z_{(1-\beta)}]^2}{(\mu_1-\mu_2)^2}$$

N = sample size for each subject group

S^2p = pooled variance, which is equal to $(S_1^2 + S_2^2)/2$, if $n_1 = n_2$

n_1 = number of subject of control group in the pilot study

n_2 = number of subject of experimental group in the pilot study

S_1^2 = variance of subject of control group in the pilot study

S_2^2 = variance of subject of experimental group in the pilot study

$Z_{(1-\alpha/2)}$ = Z-value when setting the confident level equal to 95% or significant level equal to 0.05 ($\alpha = 0.05$) = 1.96

$Z_{(1-\beta)}$ = Z-value when setting the power of testing equal to 80% ($\beta = 0.2$) = 0.84

$\mu_1-\mu_2$ = the difference of means of parameter between the control and the experimental group in the pilot study

From sample size calculation, the AROM extension is of concern for this study. Therefore, the sample size for this study, by using the aforementioned equation, is equal to

$$N = \frac{2S^2p\,[Z_{(1-\alpha/2)} + Z_{(1-\beta)}]^2}{(\mu_1-\mu_2)^2}$$

$$= \frac{2(1.87)[1.96+0.84]^2}{(0.80-1.90)^2}$$

$$= 24.23$$

APPENDIX F

RAW DATA OF THE PILOT STUDY

Table F.1 Characteristics of subjects

Subject	Gender	Age (yr)	Weight (kg)	Height (cm)	BMI (kg/m^2)
C1	F	45	76	153	32.46
C2	M	49	65	170	22.49
C3	M	38	65	177	20.74
C4	F	48	48	158	19.22
C5	M	48	75	160	29.29
E1	F	37	76	157	30.83
E2	M	36	64	165	23.50
E3	M	37	60	165	22.03
E4	F	49	80	163	30.11
E5	M	33	57	175	18.61

C = Subject in the control group, E = Subject in the experimental group

Table F.2 VAS score for pain intensity (mm)

Subject	Pre	Wk1	End of program	Mo3
C1	72	8	8	0
C2	27	1	1	0
C3	24	22	8	16
C4	53	40	24	48
C5	65	19	6	20
E1	26	4	4	0
E2	72	59	55	58
E3	50	18	0	0
E4	39	29	0	0
E5	62	18	2	0

Table F.3 AROM flexion (cm)

Subject	Pre	Wk1	End of program	Mo3
C1	3.5	3.5	3.5	3.5
C2	4.0	4.5	4.5	4.0
C3	6.0	6.5	7.0	6.5
C4	5.0	6.0	6.0	6.0
C5	3.0	3.0	5.0	4.5
E1	3.5	5.0	5.0	5.0
E2	5.5	5.5	5.5	5.5
E3	4.5	5.0	5.5	6.0
E4	6.0	4.0	6.0	6.0
E5	5.0	5.0	4.0	5.0

Table F.4 AROM extension (cm)

Subject	Pre	Wk1	End of program	Mo3
C1	1.0	1.0	1.0	1.0
C2	0	2.0	1.5	2.0
C3	1.5	2.0	2.0	1.0
C4	1.5	1.5	2.0	1.0
C5	1.0	2.0	3.0	3.0
E1	0.5	4.5	4.5	4.0
E2	1.0	4.0	4.5	5.0
E3	1.0	3.0	2.0	2.0
E4	1.0	1.5	1.5	1.2
E5	2.5	2.5	3.0	4.5

Table F.5 AROM right lateral flexion (cm)

Subject	Pre	Wk1	End of program	Mo3
C1	10.0	10.0	10.0	10.0
C2	21.0	20.0	21.0	16.0
C3	17.5	17.0	18.0	19.0
C4	14.0	14.0	14.0	17.0
C5	14.0	12.0	13.0	18.0
E1	10.0	12.0	12.0	20.0
E2	20.5	23.0	20.5	20.0
E3	18.0	19.0	23.0	24.0
E4	15.0	11.0	21.0	18.0
E5	18.0	20.0	22.0	22.0

Table F.6 AROM left lateral flexion (cm)

Subject	Pre	Wk1	End of program	Mo3
C1	15.0	13.0	13.0	15.0
C2	21.0	20.0	18.0	20.0
C3	16.0	18.0	18.0	18.0
C4	16.5	16.0	13.0	17.0
C5	16.0	14.0	14.0	20.0
E1	16.0	15.0	15.0	21.0
E2	20.5	24.0	19.5	21.0
E3	17.0	22.0	23.0	23.0
E4	14.0	14.0	20.0	19.0
E5	20.0	21.0	23.0	24.0

Table F.7 Modified ODQ total score (of 100 maximum)

Subject	Pre	Within wk3	End of program	Mo3
C1	46	12	12	12
C2	38	10	10	0
C3	18	6	6	16
C4	8	0	0	2
C5	14	8	4	8
E1	18	0	0	0
E2	24	12	12	24
E3	14	0	0	0
E4	8	0	0	2
E5	16	4	4	0

Table F.8 Modified ODQ individual items at pre-treatment session (of 5 maximum of each)

Subject	Pain intensity	Personal care	Lifting	Walking	Sitting	Standing	Sleeping	Social life	Traveling	Employment
C1	0	2	4	1	1	4	3	1	4	3
C2	5	1	1	0	2	1	5	2	1	1
C3	0	0	1	1	2	3	0	0	1	1
C4	0	0	2	0	0	1	0	0	0	1
C5	0	1	2	0	0	1	1	0	1	1
E1	1	0	4	2	0	0	0	1	0	1
E2	0	1	1	0	1	1	5	0	1	2
E3	1	0	1	0	2	2	0	0	0	1
E4	0	0	1	0	0	1	0	0	1	1
E5	0	0	0	0	2	0	0	2	1	3

Table F.9 Modified ODQ individual items at within-week3 session (of 5 maximum of each)

Subject	Pain intensity	Personal care	Lifting	Walking	Sitting	Standing	Sleeping	Social life	Traveling	Employment
C1	0	0	4	0	0	1	0	0	0	1
C2	0	0	0	0	1	1	0	1	1	1
C3	0	0	2	0	1	0	0	0	0	0
C4	0	0	0	0	0	0	0	0	0	0
C5	0	1	1	0	1	0	0	0	0	1
E1	0	0	0	0	0	0	0	0	0	0
E2	0	0	1	0	1	1	0	0	1	2
E3	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	0	0	0	0	0	0	0
E5	0	0	0	0	0	0	0	0	2	0

Table F.10 Modified ODQ individual items at end of program (of 5 maximum of each)

Subject	Pain intensity	Personal care	Lifting	Walking	Sitting	Standing	Sleeping	Social life	Traveling	Employment
C1	0	0	4	0	0	1	0	0	0	1
C2	0	0	0	0	1	1	0	1	1	1
C3	0	0	2	0	1	0	0	0	0	0
C4	0	0	0	0	0	0	0	0	0	0
C5	0	1	0	0	1	0	0	0	0	0
E1	0	0	0	0	0	0	0	0	0	0
E2	0	0	1	0	1	1	0	0	1	2
E3	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	0	0	0	0	0	0	0
E5	0	0	0	0	2	0	0	0	0	0

Table F.11 Modified ODQ individual items at 3-month follow up (of 5 maximum of each)

Subject	Pain intensity	Personal care	Lifting	Walking	Sitting	Standing	Sleeping	Social life	Traveling	Employment
C1	0	0	4	0	0	1	0	0	0	1
C2	0	0	0	0	0	0	0	0	0	0
C3	0	0	4	0	2	1	0	0	0	1
C4	0	0	0	0	0	1	0	0	0	0
C5	0	0	0	0	1	0	1	0	1	1
E1	0	0	0	0	0	0	0	0	0	0
E2	0	1	1	0	1	1	5	1	1	1
E3	0	0	0	0	0	0	0	0	0	0
E4	0	0	1	0	0	0	0	0	0	0
E5	0	0	0	0	0	0	0	0	0	0

Table F.12 VAS score for patient's perception of change (mm)

Subject	Within wk3	End of program	Mo3
C1	40	40	40
C2	44	44	50
C3	42	42	7
C4	15	15	15
C5	29	41	34
E1	47	47	48
E2	11	11	3
E3	50	50	50
E4	47	47	46
E5	39	38	48

Table F.13 Duration of treatment program (weeks), recurrence, and recurrence rate

Subject	**Duration of treatment program (wks)**	**Recurrence**	**Recurrence rate**
C1	1	No	60%
C2	2	No	
C3	2	Yes	
C4	3	Yes	
C5	4	Yes	
E1	1	No	20%
E2	2	Yes	
E3	2	No	
E4	3	No	
E5	4	No	

APPENDIX G

RAW DATA OF THE STUDY

Table G.1 Characteristics of subjects

Subject	Gender	Age (yr)	Weight (kg)	Height (cm)	BMI (kg/m^2)
C1	F	45	76	153	32.46
C2	M	49	65	170	22.49
C3	M	38	65	177	20.74
C4	F	48	48	158	19.22
C5	M	48	75	160	29.29
C6	F	42	52.5	145	24.97
C7	F	33	46	160	17.96
C8	F	34	55	156	22.60
C9	F	34	46	156	18.90
C10	F	32	48	162	18.28
C11	F	35	52	157	21.09
C12	M	40	85	165	31.22
C13	F	31	68	156	27.94
C14	M	39	65	172	21.97
C15	F	32	55	155	22.89
C16	F	31	56	155	23.30
C17	F	43	57	154	24.03
C18	F	36	48	155	19.97
C19	F	38	72	160	28.12
C20	F	44	46	153	19.65
C21	F	49	76	163	28.60
C22	F	36	55	158	22.03
C23	F	35	58	161	22.37
C24	F	41	64	165	23.50
C25	F	48	60	165	22.03

Subject	Impairment and location of pain	Nature of activity
C1	Strain of Paravertebral m., Lt. L4-5	Prolonged sitting
C2	Back dysfunction, centralized L1-5	Prolonged standing
C3	MPS of Paravertebral m., Lt. L1-5	Prolonged standing
C4	Back dysfunction, centralized L1-5	Prolonged sitting
C5	Tear of Lumbar fascia, Lt. L1-4	Household working
C6	MPS of Paravertebral m., both sides L1-2 and L4.5	Prolonged sitting
C7	MPS of Paravertebral m., both sides L1-2 and L5-S1	Prolonged sitting
C8	MPS of Paravertebral m., Lt. L1-2 and L3-5	Prolonged sitting
C9	Back dysfunction, centralized L1-5	Household working
C10	MPS of Paravertebral m., Lt. L1-2 and L3-5	Prolonged sitting
C11	Strain of Paravertebral m., both sides L1-3	Household working
C12	Back dysfunction, centralized L1-5	Prolonged sitting
C13	Strain of Thoracolumbar fascia, both sides T12-L2	Prolonged sitting
C14	Strain of Paravertebral m., both sides L2-3	Prolonged sitting
C15	MPS of Paravertebral m., both sides L4-5	Prolonged sitting
C16	MPS of Paravertebral m., both sides L2-3	Prolonged sitting
C17	Back dysfunction, centralized L1-5	Prolonged sitting
C18	Strain of Paravertebral m., Lt. L1-5	Prolonged sitting
C19	Strain of Paravertebral m., both sides L4-5	Prolonged sitting
C20	Strain of Paravertebral m., Rt. L4-5	Prolonged sitting
C21	Tear of Thoracolumbar fascia, both sides T12-L4	Household working
C22	Strain of Paravertebral m., both sides L4-5	Household working
C23	MPS of Paravertebral m., Rt. L1-2 and L3-4	Prolonged sitting
C24	Back dysfunction, centralized L1-5	Prolonged sitting
C25	Strain of Paravertebral m., both sides L2-5	Prolonged sitting

Subject	Gender	Age (yr)	Weight (kg)	Height (cm)	BMI (kg/m^2)
E1	F	37	76	157	30.83
E2	M	36	64	165	23.50
E3	M	37	60	165	22.03
E4	F	49	80	163	30.11
E5	M	33	57	175	18.61
E6	F	43	46	153	19.65
E7	M	44	60	162	22.86
E8	F	50	68	155	28.30
E9	F	42	64	159	25.31
E10	M	49	62	175	20.24
E11	M	38	75	168	26.57
E12	M	41	56	163	21.07
E13	M	45	65	170	22.49
E14	F	42	65	161	25.07
E15	F	32	71	170	24.56
E16	F	42	57	158	22.83
E17	F	39	85	151	37.27
E18	F	37	53	158	21.23
E19	F	30	87	165	31.95
E20	F	49	57	155	23.72
E21	M	32	58	174	19.15
E22	M	34	47	163	17.68
E23	M	42	64	159	25.31
E24	F	33	50	154	21.08
E25	M	32	85	168	30.11

Subject	Location of pain and impairment	Nature of activity
E1	Strain of Paravertebral m., both sides L1-5	Household working
E2	MPS of Paravertebral m., Rt. L4-5	Prolonged sitting
E3	MPS of Paravertebral m., Lt. L2-5	Prolonged sitting
E4	Strain of Paravertebral m., Rt. L5-S1	Household working
E5	Strain of Paravertebral m., Rt. L4-5	Prolonged sitting
E6	MPS of Paravertebral m., Rt. L1-2	Prolonged sitting
E7	Back dysfunction, centralized L4-5	Household working
E8	Strain of Paravertebral m., Lt. L4-5	Prolonged sitting
E9	MPS of Paravertebral m., both sides L4-5	Prolonged sitting
E10	Strain of Paravertebral m., Lt. L1-2 and L5-S1	Prolonged standing
E11	Back dysfunction, centralized L1-5	Prolonged sitting
E12	Strain of Paravertebral m., Lt. L1-5	Prolonged sitting
E13	Strain of Paravertebral m., both sides L2-5	Prolonged standing
E14	Back dysfunction, centralized L1-5	Household working
E15	Back dysfunction, centralized L1-5	Household working
E16	Back dysfunction, centralized L1-2	Prolonged sitting
E17	Back dysfunction, centralized L1-5	Prolonged sitting
E18	Tear of Lumbar fascia, both sides L2-5	Prolonged sitting
E19	Strain of Paravertebral m., both sides L2-3 and L4-5	Prolonged sitting
E20	Back dysfunction, centralized L1-5	Prolonged sitting
E21	Back dysfunction, centralized L2-5	Prolonged sitting
E22	MPS of Multifidus m., both sides L5-S1	Prolonged sitting
E23	Back dysfunction, centralized L1-5	Prolonged sitting
E24	Strain of Paravertebral m., both sides L4-5	Prolonged sitting
E25	Back dysfunction, centralized L1-5	Prolonged sitting

C = Subject in the control group, E = Subject in the experimental group

Table G.2 VAS score for pain intensity (mm)

Subject	Pre	Post-immediately	Wk1	End of program	Mo3
C1	72	48	8	8	0
C2	27	22	1	1	0
C3	24	12	22	8	16
C4	53	52	40	24	48
C5	65	58	19	6	20
C6	66	52	56	29	52
C7	70	22	22	22	1
C8	83	75	71	29	34
C9	30	9	31	5	5
C10	23	11	42	8	42
C11	38	13	24	12	24
C12	75	17	17	17	0
C13	70	27	13	13	20
C14	31	35	15	3	0
C15	22	4	15	3	40
C16	22	2	4	4	0
C17	10	3	3	3	0
C18	13	5	0	0	0
C19	49	26	11	11	20
C20	6	0	0	0	0
C21	44	19	19	19	0
C22	79	20	1	1	0
C23	63	46	49	23	7
C24	35	30	56	8	2
C25	53	24	24	0	0

Subject	Pre	Post-immediately	Wk1	End of program	Mo3
E1	26	9	4	4	0
E2	72	64	59	55	58
E3	50	27	18	0	0
E4	39	30	29	0	0
E5	62	38	18	2	0
E6	29	33	27	3	0
E7	18	5	1	0	0
E8	60	14	3	3	0
E9	35	19	18	6	0
E10	79	28	7	2	3
E11	45	24	22	3	1
E12	11	3	3	3	3
E13	21	2	2	2	2
E14	83	25	7	7	89
E15	54	11	0	0	0
E16	47	36	36	36	0
E17	91	67	14	6	0
E18	97	54	54	54	9
E19	59	0	0	0	0
E20	45	30	30	30	30
E21	63	19	43	43	1
E22	20	0	0	0	0
E23	41	0	0	0	0
E24	75	59	20	20	30
E25	87	12	3	3	10

Table G.3 AROM flexion (cm)

Subject	**Pre**	**Wk1**	**End of program**	**Mo3**
C1	3.5	3.5	3.5	3.5
C2	4.0	4.5	4.5	4.0
C3	6.0	6.5	7.0	6.5
C4	5.0	6.0	6.0	6.0
C5	3.0	3.0	5.0	4.5
C6	5	4	5	5.5
C7	6	2	2	8
C8	5	6	4.2	6
C9	3.5	7	3.5	5
C10	5	3.5	6	5
C11	10	7.5	8.5	10
C12	2.5	5.5	5.5	7
C13	5	6	6	6
C14	4.4	6.5	5.2	5
C15	5	3.5	5	5
C16	5.5	6	6	5
C17	6	5.5	5.5	6.5
C18	6.5	4.5	4.5	7
C19	5	5.5	5.5	5
C20	5	4.7	4.7	5
C21	5	6	6	5
C22	4	6	6	5
C23	6.5	6	4.9	7
C24	4.5	6	5.5	6.5
C25	4.8	2.5	2.5	5

Subject	Pre	Wk1	End of program	Mo3
E1	3.5	5.0	5.0	5.0
E2	5.5	5.5	5.5	5.5
E3	4.5	5.0	5.5	6.0
E4	6.0	4.0	6.0	6.0
E5	5.0	5.0	4.0	5.0
E6	4	4.5	6	5.5
E7	2	3	3	4.5
E8	6	6	6	6
E9	7	7	7	7
E10	3.5	3.5	6	5.5
E11	7.5	7.5	9	8.3
E12	5.5	5.5	5.5	5.5
E13	6	6	6	6
E14	6.5	7.5	6.5	7.5
E15	3.5	4	4	5
E16	6	6	6	6
E17	5.5	5.5	6	6.5
E18	4.5	4.5	4.5	4.5
E19	5.5	5.5	5.5	5.5
E20	4.7	5	5	1
E21	6	5	5	6.2
E22	6	6	6	6
E23	6	6	6	6
E24	6	6	6	6
E25	2.5	3	3	3

Table G.4 AROM extension (cm)

Subject	Pre	Wk1	End of program	Mo3
C1	1	1	1	1
C2	0	2	1.5	2
C3	1.5	2	2	1
C4	1.5	1.5	2	1
C5	1	2	3	3
C6	1	1.5	2	3
C7	3	3	3	3
C8	3	3	1.8	1
C9	0	1.5	3	1
C10	2	3	3	2.5
C11	5	6	6	6
C12	2	1	1	1
C13	1.5	3	3	3
C14	1.1	3	3	3
C15	2	2	2	2
C16	2	4	4	4
C17	2	3	3	3
C18	2.5	1.5	1.5	2
C19	1.5	4	4	4
C20	5	5	5	5
C21	0.5	0.5	0.5	1
C22	0.9	1.2	1.2	1
C23	0.5	0.5	1	2
C24	1	0.5	0.5	1
C25	1	2.5	2.5	2.5

Subject	Pre	Wk1	End of program	Mo3
E1	0.5	4.5	4.5	4
E2	1	4	4.5	5
E3	1	3	2	2
E4	1	1.5	1.5	1.2
E5	2.5	2.5	3	4.5
E6	4	4.5	2.5	3
E7	2	1.5	2.5	2.5
E8	2	2	2	2
E9	1	1.5	2	2
E10	1	1	1.5	1.5
E11	0	1	2.5	2.5
E12	3	3	3	3
E13	0.5	0.5	0.5	0.5
E14	1	2	1.5	1
E15	0.5	3	3	3
E16	1.5	1.5	1.5	1.5
E17	4	4	4.5	5
E18	0.5	0.5	0.5	1
E19	1.5	1.5	1.5	1.5
E20	0.5	2	2	1
E21	1	3	3	3.5
E22	2	2.5	2	2
E23	2.5	2.5	2.5	2.5
E24	2	2	2	2
E25	0.5	1	1	1

Table G.5 AROM right lateral flexion (cm)

Subject	**Pre**	**Wk1**	**End of program**	**Mo3**
C1	10	10	10	10
C2	21	20	21	16
C3	17.5	17	18	19
C4	14	14	14	17
C5	14	12	13	18
C6	12	13	13	13
C7	25	25	25	26
C8	20	21	22	18.5
C9	22	22	22	20
C10	19	21	21	20.5
C11	27	26	24	24
C12	19.8	22	22	22
C13	13	20	20	20
C14	23.5	25	27	27
C15	20	20	24	24
C16	18	18	18	18
C17	22.5	22	22	22
C18	14	17	17	17
C19	21	20	20	20
C20	27	27	27	27
C21	13	13	13	14
C22	14	19.5	19.5	20
C23	25	25	25	25
C24	15.5	17	17	17
C25	18.5	20.5	20.5	21

Subject	Pre	Wk1	End of program	Mo3
E1	10	12	12	20
E2	20.5	23	20.5	20
E3	18	19	23	24
E4	15	11	21	18
E5	18	20	22	22
E6	21	21.5	22	22.5
E7	17	16	14	18
E8	19.5	19.5	19.5	19.5
E9	18	18	21	21
E10	18	18	18	18.5
E11	23	23	27	27
E12	28	28	28	28
E13	26	26	26	26
E14	19.5	19.5	22.5	22
E15	23	29	29	30
E16	20.5	20.5	20.5	21
E17	18	23	26	26
E18	14	14	14	15
E19	19	19	19	20
E20	22	22	22	11
E21	20	22	22	22.5
E22	22	22	22	22
E23	25	25	25	25
E24	25	25	25	25
E25	20	24	24	24

Table G.6 AROM left lateral flexion (cm)

Subject	**Pre**	**Wk1**	**End of program**	**Mo3**
C1	15	13	13	15
C2	21	20	18	20
C3	16	18	18	18
C4	16.5	16	13	17
C5	16	14	14	20
C6	16	16	16	16
C7	22	22	22	23
C8	22	23	23	19
C9	21	21	21	21.5
C10	19	20	20	18.5
C11	25	25	27	25
C12	16.7	18.5	18.5	18.5
C13	14	20	20	20
C14	22	22	24	25
C15	23	24	24	24
C16	18	19	19	19
C17	23.5	24	24	24
C18	19.5	21	21	21
C19	20.5	20	20	20
C20	26	27	27	27
C21	15	15	15	16
C22	16	21.2	21.2	20
C23	25	22	23.5	25
C24	14	15	16	15
C25	19	22	22	22

Subject	Pre	Wk1	End of program	Mo3
E1	16	15	15	21
E2	20.5	24	19.5	21
E3	17	22	23	23
E4	14	14	20	19
E5	20	21	23	24
E6	23.5	23.5	24	24
E7	18	17.5	16	19
E8	21.5	21.5	21.5	21.5
E9	17	19	22	22
E10	16	16	16.5	16
E11	25	26	27	27
E12	29	29	29	29
E13	21	21	21	21
E14	21	21	21	23
E15	23	28	28	28
E16	21	21	21	21
E17	17	23	26	26
E18	16	16	16	16
E19	20	20	20	21
E20	21	21	21	15
E21	18.5	24	24	23
E22	22	22	23	23
E23	25	25	25	25
E24	22	23	23	23
E25	12	23	23	23

Table G.7 Modified ODQ total score (of 100 maximum)

Subject	**Pre**	**Within wk3**	**End of program**	**Mo3**
C1	46	12	12	12
C2	38	10	10	0
C3	18	6	6	16
C4	8	0	0	2
C5	14	8	4	8
C6	14	10	10	12
C7	12	12	12	2
C8	38	46	26	20
C9	32	0	0	8
C10	16	4	4	14
C11	10	8	8	10
C12	22	20	20	0
C13	26	6	6	0
C14	8	0	0	2
C15	6	0	0	2
C16	34	2	2	0
C17	0	0	0	0
C18	2	0	0	0
C19	50	14	14	6
C20	6	0	0	0
C21	34	12	12	0
C22	52	8	8	0
C23	8	4	4	4
C24	42	24	24	0
C25	54	14	14	0

Subject	Pre	Within wk3	End of program	Mo3
E1	18	0	0	0
E2	24	12	12	24
E3	14	0	0	0
E4	8	0	0	2
E5	16	4	4	0
E6	6	4	4	0
E7	52	4	4	6
E8	20	2	2	0
E9	6	0	0	0
E10	58	6	6	16
E11	18	10	10	8
E12	0	0	0	0
E13	6	0	0	0
E14	16	8	8	16
E15	16	0	0	0
E16	0	0	0	0
E17	58	12	12	6
E18	30	12	12	12
E19	28	10	10	0
E20	4	0	0	20
E21	44	12	12	0
E22	0	0	0	0
E23	22	2	2	0
E24	22	0	0	4
E25	42	14	14	0

Table G.8 VAS score for patient's perception of change (mm)

Subject	Post-immediately	Within wk3	End of program	Mo3
C1	14	40	40	40
C2	26	44	44	50
C3	12	42	42	7
C4	5	15	15	15
C5	8	29	41	34
C6	17	26	26	24
C7	29	29	29	48
C8	5	8	25	35
C9	9	45	45	45
C10	2.2	38	38	24
C11	2.9	31	31	26
C12	40	40	40	50
C13	35	41	41	40
C14	6	49	49	49
C15	9	40	40	40
C16	40	40	40	50
C17	40	40	40	50
C18	7	50	50	50
C19	17	36	36	40
C20	49	49	49	50
C21	28	28	28	40
C22	28	50	50	50
C23	14	35	35	41
C24	18	38	38	49
C25	18	46	46	50

Subject	Post-immediately	Within wk3	End of program	Mo3
E1	33	47	47	48
E2	8	11	11	3
E3	21	50	50	50
E4	7	47	47	46
E5	25	39	38	48
E6	8	47	47	50
E7	20	49	49	50
E8	34	48	48	50
E9	8	34	34	50
E10	30	46	46	40
E11	14	44	44	49
E12	38	38	38	50
E13	42	42	42	50
E14	33	44	44	9
E15	41	50	50	50
E16	10	10	10	50
E17	5	49	49	48
E18	40	40	40	43
E19	50	50	50	50
E20	50	50	50	30
E21	18	35	35	48
E22	14	50	50	50
E23	40	40	40	50
E24	17	32	32	35
E25	44	44	44	40

Table G.9 Duration of treatment program (trials) and recurrence LBP

Subject	Duration of treatment program (trials)	Recurrence	Subject	Duration of treatment program (trials)	Recurrence
C1	2	N	E1	2	N
C2	3	N	E2	4	Y
C3	4	Y	E3	4	N
C4	6	Y	E4	5	N
C5	8	Y	E5	8	N
C6	4	Y	E6	4	N
C7	1	N	E7	4	N
C8	8	N	E8	2	N
C9	6	N	E9	4	N
C10	4	Y	E10	4	N
C11	6	Y	E11	6	N
C12	1	N	E12	1	N
C13	2	N	E13	1	N
C14	4	N	E14	4	Y
C15	4	N	E15	2	N
C16	2	N	E16	1	N
C17	1	N	E17	4	N
C18	2	N	E18	1	N
C19	2	N	E19	1	N
C20	1	N	E20	1	Y
C21	1	N	E21	2	N
C22	2	N	E22	4	N
C23	3	N	E23	1	N
C24	4	N	E24	2	N
C25	2	N	E25	2	N

APPENDIX H

CERTIFICATE OF APPROVAL FROM ETHICS COMMITTEE

๒ ถนนพรานนก บางกอกน้อย กรุงเทพฯ ๑๐๗๐๐
โทร. (๖๖-๒) ๔๑๑-๑๔๒๙, ๔๑๑-๓๒๕๓
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Certificate of Approval
from
Ethics Committee Faculty of Medicine Siriraj Hospital, Mahidol University

SiEC COA No. 034/2005

Protocol Title	Effect of Physical therapy treatments with and without spinal mobilization in individuals with acute low back pain
SiEc Protocol Number	201/2547
Principal Investigator/ Affiliation	Mr.Prasert Sakulsriprasert / Department of Orthopedic Surgery Faculty of Medicine Siriraj Hospital, Mahidol University
Research site	Physical Therapy Clinic
Document Approved	- Protocol - Informed consent form - Participant information sheet - Principal Investigator : Curriculum vitae
Date of Approve	14 February , 2005
Date of Expiration	13 February , 2006

The aforementioned documents have been reviewed and approved by Ethics Committee,Faculty of Medicine Siriraj Hospital, Mahidol University, based on the Declarationof Helsinki.

Signature of Chairman .....
(Prof. Sumalee Nimmannit)

Signature of Dean .....
(Clin. Prof. Piyasakol Sakolsatayadorn)

Version 3 Effective date Dec 01, 2004

BIOGRAPHY

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