UNIVERSITY OF MIAMI

RANDOMIZED CLINICAL TRIAL COMPARING ACTIVE VERSUS PASSIVE APPROACHES TO THE TREATMENT OF RECURRENT AND CHRONIC LOW BACK PAIN

By

Brent D. Anderson

A DISSERTATION

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

Coral Gables, Florida

December, 2005

UNIVERSITY OF MIAMI

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<u>Randomized Clinical Trial Comparing Active Versus Passive Approaches to the Treatment of Recurrent and Chronic Low Back Pain</u>

Abstract of a dissertation at the University of Miami.

Dissertation supervised by Kathryn E. Roach, Ph.D., P.T.
No. of pages in text (206)

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additional analysis was conducted on the CLBP sub-population. Due to a small sample size and the impact of floor and ceiling effects on a number of outcome measures, it is impossible to draw firm conclusions from this study. A significant improvement was found in the Pilates group for back extension strength and SF-36 Vitality measures when compared to the massage group. Both massage and Pilates produced improvement in most other outcomes, however, with the exception of FSE, subjects who received Pilates improved more post intervention than subjects who received massage. A modest correlation was found between changes in psychosocial factors and changes in activity limitations. A weaker correlation was found between changes in physical factors and changes in activity limitations. The findings for the sub-analysis using CLBP subjects did not differ significantly from the findings for the whole group. Further research is warranted to better examine the effectiveness of Pilates as a treatment for CLBP.

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Dedication

To Del Anderson (my father), who always believed in me and supported my pursuit of higher education. Your support has been felt even though your presence has been greatly missed.

To Lizette, my eternal partner, without your constant support and love, this venture never would have realized.

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Mom, for your continual support and encouragement to finish.

Lizette, Nichole, Gabriel and Alina, for your patience and long suffering while daddy finished his doctorate. I love you.

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Glossary

Active Structures – Muscles and their role in stability of the spine.

Activity Limitation – Limitations in performing certain motions or maintaining certain postures or positions necessary for function.

Acute Low Back Pain – Activity intolerance due to lower back or back and leg symptoms lasting less than three months.

Behavioral Therapies - Therapies that address psychological modification through counseling and education.

Body Function – The physiological functions of body systems (including psychological functions).

Body Structure – The anatomical parts of the body such as organs, limbs and their components.

Catastrophising – Dwelling on the worst possible outcome of any situation in which there is a possibility for an unpleasant outcome.

Central Nervous System Modulation – A central modification of postural strategy integrating the organization of both local and global muscle systems, based on accurate anticipation of the work load

Chronic Low Back Pain – Activity intolerance due to lower back or back and leg symptoms lasting more than three months

Core Stability – Efficient recruitment of trunk musculature to control the position of the lumbar spine during dynamic movements.

Disability – An inability or limitation in performing socially defined activities and roles expected of individuals within a social and physical environment.

Discogenic Pain – Pain caused from fissures in the annulus (outer ring of the disc), usually described as non specific band across the back and gluteal region. Pain may spread to upper posterior and posterior lateral thigh. Often leading to bulging or herniated disc.

Disease – Something abnormal within the individual that gives rise to change in structure and functioning of the body.

Environmental Factors – The physical, social and attitudinal environment in which people live and conduct their lives.

Fear-Avoidance – Limitations in activity secondary to fear of repeated painful episodes.

Global Mobilizers – Muscles that generate torque to produce a range of movement, usually with a concentric contraction.

Global Stabilizers – Muscles that generate force to control ROM, usually with an eccentric contraction, to control movement.

Graded Physical Activities – Progressive training starting with low effort tasks and increasing to more demanding tasks as tolerance to exertion improves.

Handicap – A disadvantage resulting from an impairment or disability that limits or prevents fulfillment of a role considered normal for a particular age, sex, and socio-cultural factors.

High-Threshold Training – Conscious and volitional training to recruit and hold the contraction of the local stabilizers.

Impairments – Problems in body function or structure representing a deficiency or variation from normal, usually leading to a functional limitation.

Inert Structures – Biomechanical stability and mobility between the bone, ligaments, cartilage and fascia.

Local Stabilizers – Muscles that increase the muscle stiffness allowing for trunk stability and segmental control in the neutral zone.

Low Back Pain – A multifactorial condition that results in pain in the lower back or lumbar region.

Low-Threshold Training – Non-volitional contraction of the postural muscles to provide joint stiffness and awareness throughout movement.

Massage – The manipulation of the soft tissues of the body in order to promote mobility of fluid, structure and energy.

Mechanical Low Back Pain – Pain that results from damage to multiple structures and elements of the lumber spine.

Mind-Body Therapies – Therapeutic interventions that focus on producing a heightened awareness of the connectivity between the mind and body.

Neural Structures – Neuromuscular control, feedback mechanisms and hierarchical influence of muscle recruitment involved in the control of the spine.

Neutral Zone – A measure of spinal laxity in the vicinity of the neutral position

Participation – Activity specific to individual's lifestyle including work, recreation in family and community

Participation Restrictions – Restrictions that affect an individual's lifestyle, including work, recreation, family and community.

Personal Factors - The background of an individual's life. These may include age, sex, ethnicity, socio-economic status, demographics, belief models, self-efficacy, expectation, previous experience, culture, values and fears.

Pilates – A mind-body exercise program developed by Joseph Pilates during the early 1900s.

Recurrent Low Back Pain – Episodes of ALBP lasting less than three months duration but recurring after an intervening period of time without low back symptoms sufficient to restrict activity or function

Self-Efficacy – An individual's perception of ability to perform a task.

Spine Instability – The inability of the inert, active and neural control components to maintain the neutral zone of a spinal segment.

Chapter 1 - Introduction

Statement of the Problem

It has been estimated that 80% of the population will suffer at least one acute, disabling episode of low back pain (LBP) at some point during their lives (38); (37); (74). LBP is the second most common reason people seek the help of a physician (55). Approximately 20% of the individuals that suffer an acute episode of LBP will develop chronic LBP (CLBP) (106); (47). The 7-10% of individuals that will develop CLBP account for 75-90% of health care costs incurred for LBP (192). This results in an estimated $28 billion in productivity losses per year in the United States alone (192); (173) and an estimated total cost between $50 to 100 billion dollars annually (74).

Due to the severe socioeconomic impact of LBP, health care providers, insurance companies and industry struggle to find solutions for this epidemic. Current approaches include general exercise, neuromuscular re-education, behavioral therapies, medicinal treatments, manual therapies and complementary therapies. Although a number of intervention studies have been conducted, one treatment method cannot clearly be advocated over another (134). The purpose of this study was to compare the effectiveness of an active approach (Pilates) to that of a passive approach (massage) in improving the activity limitations and pain associated with CLBP and recurrent LBP (RLBP). The active approach was hypothesized as more effective because it offers the potential to change physical factors such as pain, strength and motor control as well as psychosocial factors such as self-efficacy and fear of re-injury. In addition, this study will utilize a modified version of the International Classification of Function and Disability (ICF) Model to categorize factors, interventions and outcome measures influencing CLBP and RLBP.

Study Population

This study focuses on patients suffering from CLBP and RLBP. CLBP was defined as LBP and leg symptoms lasting longer than three months. RLBP was defined as episodes of acute LBP (ALBP) and leg symptoms lasting less than three months duration interspersed with periods without pain (2). CLBP and RLBP were selected for this study because they occur in only a small percentage of the population and result in the majority of associated health care costs (173); (74); (192). In addition, there is a lack of research supporting one form of intervention over another for CLBP and RLBP (134).

Factors That Influence CLBP and RLBP

CLBP and RLBP are complex phenomena that can be influenced by many contributing factors. These factors can be divided into two categories; physical factors and psychosocial factors. Physical factors that are connected with LBP include muscular weakness, muscular imbalances, repetitive movement disorders, poor recruitment of deep abdominal muscles, inadequate motor control of the trunk stabilizing muscles and neuromuscular dysfunction (156); (170); (65), (73); (89); (91); (116); (102); (150). Lesions of inert structures associated with LBP can include disc lesions, ligament lesions, joint instabilities and bony abnormalities (e.g. osteophytes, stenosis and degenerative changes) (180); (43); (154); (155).

Psychosocial factors have also been found to play an important role in CLBP and RLBP (120); (67); (136); (201); (216). Psychological aspects of LBP include; depression, fear of movement, treatment expectation, self perception, locus of control and other personal factors (120); (67); (136); (201); (216). Social and demographic factors that may play a role in LBP include age, sex, race, socio-economic status, government programs, education, employment, support systems and community involvement (170); (56); (71); (125); (18); (60); (35).

Current literature demonstrates that some of the best predictors of outcome with CLBP and RLBP are psychosocial in nature (120); (67); (136); (201); (216); (14); (13); (70); (9). The perceived loss of control from pain, impaired expectations of performance and fear of re-injury, are all thought to influence function. Fear of re-injury (kinesiophobia) and catastrophising are both considered good predictors of functional outcome in CLBP (201); (216). This reiterates that disability associated with LBP has more to do with a perceived loss of control over self, rather than the pathology itself (161). Self-efficacy is the measure of perceived ability to perform a task (14). Lackner showed that individuals suffering from CLBP with low self-efficacy scores were significantly less likely to get better (120). He demonstrated that the predictability of outcome had a higher association with lack of control than pain perception (120). Although self-efficacy appeared to be a good predictor of outcome, it did not seem to be modifiable with behavior therapy (120). To date, the majority of clinical interventions do not seem to have a significant effect in changing psychological factors (120); (14).

Theoretical Model

The current health delivery model requires a paradigm shift from passive, non-integrated interventions to an active model of rehabilitation which is capable of addressing the physical and psychological factors affecting CLBP and RLBP. A holistic model including structural, psychological, functional, social, environmental and personal factors is required to better describe the dynamic and integrated relationships between these factors and how they influence outcome in CLBP and RLBP. The ICF model developed by the World Health Organization (WHO) is the most widely recognized integrated health model currently available (218). The ICF incorporates all pertinent factors including personal factors even though they have not included them in their classification system (220). Psychosocial factors play a large role in the rehabilitation of CLBP and RLBP. Ignoring these factors limits the practitioner's ability to successfully assess and treat the patient (14); (13); (9); (120); (216); (136).

For the purpose of this study, the investigator designed a three-dimensional representation of the ICF health model to allow the investigator to visualize the relationships among the different constructs of the ICF, including personal factors. The modified ICF model improves the graphic representation of the relationship among factors influencing LBP. The ICF definitions for activity limitations, pain limitations, physical impairments and psychosocial impairments are incorporated.

Interventions for Treatment of CLBP and RLBP

CLBP does not seem to spontaneously improve and patients with CLBP incur the majority of health care costs associated with LBP (173); (74); (192). There is little mentioned in the literature about RLBP and whether it should be categorized with CLBP or ALBP. There are a wide range of treatment options for CLBP and RLBP. These interventions can be categorized as either active or passive, as they relate to physical and psychological factors.

Active intervention passes the responsibility onto the patient to physically move, modify habits, strengthen and improve posture or flexibility through activities. It can also include modification to belief models, and auto perception of one's ability. Active interventions are designed to help the patients help themselves. Active interventions include general exercise, neuromuscular re-education and behavioral therapies. Active interventions for CLBP and RLBP are proven to be effective in varying degrees (134); (200). Variance in the impact of active interventions may be partially explained by inconsistencies in the outcome measures examined (134). In addition to improving physical function, active interventions appear instrumental in modifying important psychological factors (134). Active interventions which focus on the restoration of function and thereby influence psychological limitations regarding activities of daily living have been hypothesized to have the greatest impact on disability (120); (67); (201); (216); (14).

Passive interventions can be described as treatment rendered to the patient with little to no effort on the patient's part. Patients visit a practitioner with the expectation that the practitioner will cure them or make them feel better through palliative care. Psychologically, this creates a dependency on a practitioner, a treatment or a pill for wellbeing. Passive interventions include pharmacology, modalities (hot-packs, ultrasound, electric stimulation, infrared and ice), and therapeutic procedures (manipulation, massage and myo-fascial release). The most commonly prescribed treatments for RLBP and CLBP are passive and include pharmacological interventions, bed rest and treatments that do not emphasize patient participation (2). Many of the passive interventions have shown positive effects on ALBP (197); (11); (88). However, the interventions that are effective in the treatment of ALBP appear much less effective in the treatment of CLBP or RLBP (2); (134); (165).

The medical model for the treatment for CLBP and RLBP typically emphasizes short-term palliative care, focuses on treatment of pain symptoms and discourages self management (2). An alternative mode recommending active intervention and promoting a positive movement experience, where the patient is allows patients to gain confidence in their ability to move without pain. Theoretically a successful movement experience could help correct potentially harmful motor strategies and prevent the recurrence of LBP (134); (197). To compare active to passive interventions for CLBP and RLBP, a Pilates exercise program and therapeutic massage were selected as the treatment options.

The Pilates Method is an active intervention that is designed to improve strength, motor control, movement confidence and self-efficacy in subjects with CLBP. Some medical and allied health professionals have suggested that Pilates is an appropriate active intervention for rehabilitation of LBP (45); (42). One pilot study reported that 19 surgical candidates for low back pathologies avoided surgical intervention after 10 weeks of treatment and at six months post treatment maintained high self-efficacy scores and low disability and LBP scores (46).

The principles of movement incorporated into Joseph Pilates' method are consistent with approaches advocated in the literature (51); (168); (157); (166); (77); (78); (5); (12); (93). The original Pilates principles vary from school to school but include the following: concentration, coordination, centering, integration, fluidity and breath. Pilates incorporates not only a physically active component but also a mentally active component. Pilates provides an environment that can be graded in difficulty and progress toward functional activity with a focus on providing a positive movement experience without pain.

Therapeutic massage has been shown to be an effective passive intervention for LBP (75); (41); (42). Massage has been shown to provide short-term pain relief, decreased stress and reduced structural restrictions due to scar tissue of muscle, fascia, tendons and skin (40); (54); (188); (6). Massage has also been implicated in affecting psychological and psychoneuroimmunological factors (6). An estimated $18 billion dollars per year is spent every year on alternative heath practice, of which massage represents a large percentage (212). Massage has been shown to be one of the better passive interventions for LBP and is commonly selected as the control to active interventions for LBP studies (114); (75); (42); (40). There is stronger support in the literature for massage in the treatment of ALBP than CLBP. However, in many of the studies, massage has lacked clear definitions and descriptions (40). The lack of support for massage in CLBP may be due to poorly structured research (40). Because of its support in the literature and widespread use, therapeutic massage was chosen as the passive intervention for this study.

Purpose

The purpose of this study was to compare the effectiveness of an active approach (Pilates) to that of a passive approach (Massage) in improving the activity limitations and pain associated with CLBP and RLBP. The active approach was proposed as more effective because it offered the potential to change both physical factors such as pain, strength and motor control, as well as psychosocial factors, such as self-efficacy and fear of re-injury.

Specific Aim 1: Compare the effectiveness of Pilates to massage in treating CLBP and RLBP.

Hypothesis 1: Subjects who receive Pilates will demonstrate a greater improvement in activity limitation than subjects who receive massage.

Hypothesis 2: Subjects who receive Pilates will demonstrate a greater improvement in pain than subjects who receive massage.

Hypothesis 3: Subjects who receive Pilates will demonstrate a greater improvement in physical factors than subjects who receive massage.

Hypothesis 4: Subjects who receive Pilates will demonstrate a greater improvement in psychosocial factors than subjects who receive massage.

Specific Aim 2: Examine the relationship between changes in activity limitation and pain and physical factors and between changes in activity limitation and pain and psychological factors.

Hypothesis 5: There will be a relationship between the change in activity limitation and pain and the change in physical factors.

Hypothesis 6: There will be a relationship between the change in activity limitation and pain and the change in psychosocial factors.

Chapter 2—Review of Literature

Socioeconomic Consequences of LBP

LBP continues to be one of the largest healthcare problems in the Western industrialized world. It affects an estimated 80% of the population and it is the second most common reason people seek the help of a physician (55); (82); (47); (46); (203). Of the 80% of individuals who suffer from LBP, it is estimated that 20% will develop CLBP (106); (47). The CLBP population accounts for 75-90% of health care costs for LBP (106); (66).

In the United States, CLBP has generated direct health care costs in the range of $18 billion annually (211); (58). According to a recent study on how CLBP affects productivity in the United States labor force, it was observed that the prevalence of CLBP in employees was approximately 22% and it increased for older individuals, women and persons with other chronic disease. Research by the Department of Labor showed that in 1996, the average productivity losses per worker per year due to CLBP were $1,230 for male workers and $773 for female workers. The difference in lost wages between men and women may be explained by differences found in average incomes. The productivity loss related to CLBP came to approximately $28 billion the United States (173).

Physiological Consequences of LBP

Pain is considered one of the primary consequences of low back pathology and often results in activity limitations (203); (198); (133). The exact mechanism of how pain influences disability is controversial. Literature supports perception of pain as a major predictor of disability (120). Studies also show that fear of repeated painful episodes will limit activity (204); (216); (9). In the literature, this is referred to as fear-avoidance. It appears that when an individual has multiple episodes of LBP, movement and pain become synonymous and lead to altered movement strategies (204); (129). These faulty movement strategies may increase the likelihood of the individual developing future episodes of LBP and may have a significant psychological effect on the individual as it pertains to their perceived ability to return to daily activities

Research has found that perceived pain scores demonstrated a strong correlation with disability measures (204); (119). Other studies have shown that psychosocial measures, such as self-efficacy (one’s perception of ability to perform a task), are more effective than pain as a predictor of disability (120). However, activity limitation seems to be the best indicator of disability (120). Patients demonstrate activity limitation due to psychological impairments (e.g. pain perception, fear-avoidance and low self-efficacy), physical impairments (e.g. weakness, endurance and structural integrity), environmental and social factors.

Permanent disability has become one of the greatest concerns in the labor industry (173); (139); (210). Individuals who suffer from LBP and perceive an inability to return to work no longer participate in their normal work activities, social activities and potentially develop a serious psychological, as well as physical disability (216); (119). Because of this connection between pain, activity limitation and disability, it is often recommended that interventions for CLBP should target pain and activity limitations as well as physical and psychological limitations to decrease the likelihood of permanent disability and return patients to work.

Categories of LBP

LBP is multifactorial and may be a result of a mechanical insult to the inert and active structures of the spine (164); (43). These lesions can include discogenic pain, facet lesions, ligament sprains, muscle and tendon strains and trauma to the bone (e.g. fracture or stress fractures). Discogenic pain can be caused from fissures in the annulus (outer ring of the disc), that lead to a bulging or herniated disc. Herniations can be a painful experience due to innervation of the outer ring of the annulus and due to chemical-related pain of the proteoglycan (an enzyme of the nucleus pulposus) that acts like an auto-irritant to the surrounding structures. The herniations can also cause an irritation to the dura (the connective tissue sheath surrounding the spinal cord and nerve roots) that can result in pain or put pressure on the spinal cord or nerve root causing radicular symptoms in the lower extremity. Radicular symptoms can include weakness, pain, change in reflexes, loss of sensation and decreased proprioception. The majority of acute lesions seem to resolve independently over time and even the more serious pathologies of the spine do not always lead to CLBP (47).

LBP can also be a result of chronic degenerative disease processes including stenosis, osteoporosis, degenerative disc disease, spondylolisthesis, spondilysis and other arthritic processes (43); (7); (110); (143). Other influencers of LBP may include deficient sleep, fatigue, physical deconditioning or psychosocial problems and conflicts. These factors regularly alter the patient's perception, behavior and reporting abilities (17). Mechanical LBP, degenerative disease or other influencers of LBP can all develop into ALBP, CLBP or RLBP.

According to the New Zealand Guidelines for Physiotherapy, ALBP is described as activity intolerance due to lower back or back and leg symptoms lasting less than three months (2). CLBP is defined as activity intolerance due to lower back or back and leg symptoms lasting more than three months (2). RLBP is described as episodes of ALBP lasting less than three months duration but recurring after an intervening period of time without low back symptoms sufficient to restrict activity or function (2). No specific time period is suggested for the symptom free period in RLBP (2).

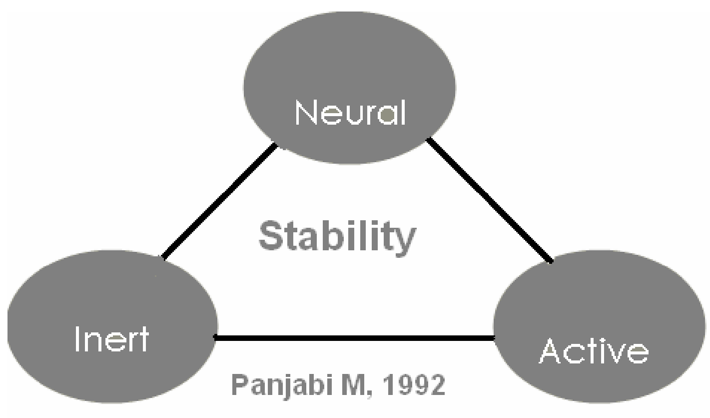
Von Korff et al. defined CLBP as being back or back and leg pain that is present at least half of the days of a 12-month period (202). He also defined RLBP as LBP present on less than half the days of a 12-month period, occurring in multiple episodes over the period of a year (202).

For the purpose of this study the investigator has chosen the New Zealand Guideline's for LBP due to the comprehensive and concise definitions of ALBP, CLBP and RLBP offered. Much of the available research does not differentiate between CLBP and RLBP. It was assumed that the literature categorized them together and referred to them as CLBP. For the purpose of this paper, and to maintain consistency, if a reference is made to CLBP it is because there was no mention of RLBP in the research.

Normal Structure and Function of the Lumbar Spine

A healthy spine can be defined as a balance between stability and mobility, dependent on the activity load. Spine mobility provides a stable foundation for movement and increases the functional range of motion (ROM) of the extremities. Stability and function is facilitated by a balance between inert structures, active structures and the neural control of those structures. Panjabi was the first to describe this triad (Figure 2.1) (154); (155).

Figure 2.1 - Panjabi's Model for Stability 1992



The inert component of Panjabi's model pertains to the biomechanical stability and mobility between the bone, ligaments and fascia. Normal biomechanics of the lumbar spine provide for weight-bearing as the primary purpose. The wide and thick bodies of the vertebrae and the facets increase the stability of the spine. The discs act as the front leg of a tripod and their purpose is to absorb shock and distribute force. The facets or zygapophyseal joints, in the back act as the back legs of a tripod. Synovial joints that articulate allow flexion and extension of the vertebral segments, lateral flexion or side-bending in the frontal plane and a limited amount of rotation in the horizontal plane. This limitation is due to the sagittal alignment of the lumbar vertebral facets. The average amount of rotation at the lumbar spine is three to five degrees per vertebral segment (193). The lumbosacral aspect of the spine consists of five motion segments and ideally should distribute forces through the segments. The ligaments of the spine, in a healthy vertebral segment, provide the stability to the disc, the facets and the spinous and transverse processes of each segment. Each of these ligaments contains mechano-receptors responsible for the proprioception of the spine.

The active component of Panjabi's model consists of muscles and their role in stability of the spine. The muscles primarily responsible for trunk stability are the deep local stabilizers, which are type I muscle fibers and are tonic in nature (147). Muscles that are classified as local stabilizers include: the transversus abdominus (TA), mulitifidus, pelvic floor, diaphragm and the internal abdominal oblique (IAO) and external abdominal oblique muscles (EAO) (160); (147); (169); (168); (217); (82); (116); (140); (176); (190); (222); (25); (152); (151). The IAO and TA muscles attach anteriorly to the ribs and pelvis. Posteriorly these muscles attach to the middle layers of the thoracolumbar fascia (LDF) (160); (82); (140); (102). Since the LDF attaches to the transverse and spinous processes of the lumbar spine, contraction of the IAO and TA increases tension in the LDF and the Rectus Abdominus Sheath, thereby creating a circumferential, supportive corset effect for the lumbar spine, resulting in an increase in intra-abdominal pressure (82); (190). A recent study showed that the contraction of the diaphragm and TA provides a mechanical contribution to the control of spinal inter-vertebral stiffness, where stiffness represents segmental control within the neutral zone (99). By maintaining a dynamic contraction of the local stabilizers, the lumbar spine can be maintained in a safer optimal position during superimposed limb movements (179); (77); (78).

Panjabi categorized the stabilizing muscles of the trunk into three groups: local stabilizers, global stabilizers and global mobilizers (44). Local stabilizers are muscles that allow for trunk stability and segmental control in the neutral zone. Global stabilizers are muscles that generate force to control ROM, usually with an eccentric contraction, to control movement. Global mobilizers are muscles that generate torque to produce a range of movement, usually with a concentric contraction. Comerford and Mottram devised a table for comparison between the three muscle groups (Table 2.1) (44).

Table 2.1 - The function and characteristics of the three classes of muscle

	Local Stabilizer	**Global Stabilizer**	**Global Mobilizer**
Function & Characteristics	Increase muscle stiffness to control segmental motion	Generates force to control ROM	Generates torque to produce range of movement
Examples	TA, multifidus, post. fascicles of psoas major	Oblique abdominal, spinalis, gluteus maximus	Rectus abdominus, iliocostalis, piriformis
Activity Dependence	Activity is independent of direction of movement	Activity is direction dependent	Activity is direction dependant
Activity Continuity	Continuous activity	Non-continuous activity	Non-continuous activity

The neural component of Panjabi's model involves neuromuscular control, feedback mechanisms and hierarchical influence of muscle recruitment involved in the control of the spine. The local stabilizers tend to be low-threshold active muscles that recruit according to the amount of load or the anticipation of load that occurs with an activity and provide postural support (102).

Core stability is a commonly misinterpreted term that is often inappropriately taught using high-threshold training. High-threshold training consists of conscious and volitional training to recruit and hold the contraction of the local stabilizers. Low-threshold postural muscles fire at such a low-threshold that activation is usually unconscious. Non-volitional contraction of the postural muscles provides joint stability and awareness throughout movement, particularly in the neutral zone (167); (102); (77); (78). A recent study that identified normal anticipatory firing of the TA, IAO, EAO and multifidi showed that some of the local stabilizers consistently fired in intervals of less than 50 milliseconds in healthy subjects (102). This 50 millisecond interval is too fast for a volitional contraction to occur. Therefore, high-threshold training may not be appropriate in the treatment of low-threshold motor dysfunction (77).

The neural control of the deep stabilization muscles has been referred to as central nervous system modulation (77); (78). Central nervous system modulation can be defined as a central modification of postural strategy integrating the organization of both local and global muscle systems, based on accurate anticipation of the work load (77) ; (78). This efficient, low-threshold muscle recruitment is thought to be initiated by anticipation of work load (102).

Anticipation is built on previous experiences, perceptions and the expectation of ability to perform a task and leads into the integration of psychosocial factors that influence normal spine movement. The central nervous system modulation theory suggests that therapists should select interventions that address movement strategies with normal activities rather than maximal threshold training and recruitment of postural muscle groups.

Normal strategy and activation of these muscles are crucial to the health of the spine. If the neural control element is faulty in the Panjabi triad, then the active elements (muscles) will not be able to protect the inert structures (bones and ligaments) from the forces of normal activity. This organization is developed through movement experiences throughout life. Faulty, compensatory movements due to injury, habits of daily living or genetic predisposition can disrupt the normal organization of movement and lead to pain and disability (3).

Physical Factors Related to LBP

Impairments of the Inert Structures

Lesions to the inert structures such as ligament and capsular sprains, disc fissures and herniations and stress fractures, are all factors that contribute to CLBP and RLBP (149), (128). Ligamentous or capsular deformities increase accessory motion (joint laxity), decrease stability and increase potentially harmful shear forces. Panjabi defined spinal instability as the inability of the inert, active and neural control components to maintain the neutral zone of a spinal segment (154); (155). Neutral zone was shown to increase with inter-segmental injury and inter-vertebral disc degeneration (156). The effects of disc degeneration can lead to a mechanical compromise of neural structures (nerve roots, spinal cord and dura) which can result in CLBP. The loss of proprioceptive feedback from the ligaments, capsules and disc can result in directional instabilities and sometimes a permanent loss in mechano-receptor feedback to the central nervous system (161). The permanent loss in proprioception of the inert structures of the spine can result in a structural instability and permanent damage to the mechano-receptors. The lack of structural stability that results requires a heightened neuro-muscular awareness to protect the structures of the spine from harmful forces. If this neuro-muscular awareness is decreased, the spine becomes vulnerable to insult, injury and pain.

Impairments in Active Structures

Impairments in low back musculature have been implicated as a contributing factor in CLBP and RLBP**.** Muscular weakness of deep local stabilizers has been shown to be a factor related to LBP (156). Muscular imbalances have been associated with regional pain syndromes due to the increased susceptibility of the spine to harmful forces when the relationship between agonist and antagonist muscle is disrupted (181); (1). Pain associated with repetitive movement disorders have been shown to cause pain inhibition of the muscle fibers and result in CLBP (65). Patients with CLBP have been shown to fatigue early and have sub-optimal recruitment of the IAO, EAO and TA (167); (77); (78). It has been found that the multifidus muscle does not recover spontaneously on remission of painful symptoms (97). The disruption of localized muscle support to the spine may be one reason for the high recurrence rate of LBP (97).

Dysfunction occurs in all three muscle groups when the spine is injured (Table 2.2). The local stabilizers are inhibited because of pain, decreasing proprioceptive feedback from the muscle spindle fibers. The pain can be a result of trauma to either the inert or active structures. Pain further causes spasms of the global mobilizers. The spasms in the global mobilizers often cause more pain. Movement causes stress to the lesion, leading to further inhibition and additional spasms, which eventually contribute to CLBP (Table 2.2). The active structures are impaired directly from trauma or inhibited neurologically secondary to local trauma. In addition, the active structures contribute to neural control impairment through the lack of feedback from muscle spindle fibers of the inhibited local stabilizers (22).

Table 2.2 - Dysfunction in Three Muscle Classes (44)

Local Stabilizer	**Global Stabilizer**	**Global Mobilizer**
Reacts to pain and pathology with inhibition	Poor control of excessive ROM	Reacts to pain and pathology with spasm
Poor segmental control	Poor eccentric control	Overactive low-threshold, low load recruitment
Local inhibition (inefficient low-threshold recruitment)	Global imbalance	Global imbalance

Impairments in Neural Structures

Inadequate motor control of the trunk stabilizing muscles and neuromuscular dysfunction have also been identified as contributing factors to CLBP (102); (150); (116). This involves the strategy of movement before, during and after the trauma. There are three categories that seem to affect strategy:

congenital factors, compensatory movements and poor functional habits (4). Each of these can lead to faulty motor strategies that can predispose an individual to injury or slow down recovery. Some faulty motor strategies can directly cause repeated insult to the lesion, preventing the lesion from healing.

Congenital defects like scoliosis, leg length discrepancies, cerebral palsy and other defects can result in abnormal motor strategies of the spine. Postural deformities can create excessive and damaging forces to the inert structures. Faulty motor strategies can include over-recruitment of the quadratus lumborum ipsilaterally or inhibition of the deep stabilizers due to active insufficiency. The impaired or absent activity of the trunk stabilizing muscles can either predispose or contribute to micro-trauma of the spine (156); (102).

Pain produced comensation patterns are not always unhealthy. A healthy compesation to pain might include pain inhibition of certain muscle groups that can allow the lesions to heal The patient who reacts appropriately to the spasm and the pain inhibition might belong to the 80% of LBP patients who spontaneously improve and gradually return to regular activity. In some LBP patients, there appear to be unhealthy compensation patterns following trauma. These patterns might be related to anticipation of pain, fear of pain associated with movement or belief that movement must occur in spite of the pain (216); (119). It is thought that this faulty compensatory strategy creates an abnormal movement pattern in an attempt to preserve segmental stability (149).

Poor movement and postural habits are another possible factor leading to faulty motor strategies. Sometimes faulty movement strategies lay dormant and do not pose a problem until after a trauma. Poor posture due to daily habits like computer use, driving and sitting at a desk, can place sheer forces on structures that prevent healing because they repeatedly stress the injured structure. This repetitive micro-trauma can create persistent pain often leading to CLBP or RLBP (62).

Psychosocial Factors Related to LBP

CLBP and RLBP are complex problems with distinct neurophysiologic, cognitive, and emotional components (120). Due to the multi-factorial nature of CLBP, it cannot accurately be understood as simply the product of noxious peripheral input. Physiologically, perceptions of pain control influence levels of catecholamine and endogenous opioids, which in turn, affect perceived pain and related distress (15). Psychologically, a sense of loss of control over pain augments perception of pain intensity, demoralization and negative emotional reaction to nocioceptive stimulation (69). Weak convictions of pain self-control are associated with physical disability (115). This reiterates that disability associated with LBP has more to do with a perceived loss of control over self, rather than the pathology itself (161). Disability can be defined as a problem of physical performance (120). The perceived loss of control from pain, impaired expectations of performance and fear of re-injury, are all thought to influence function. The New Zealand Guide mentioned four psychological factors that must be considered as consistent predictors of poor outcome in patients with CLBP (2):

- the presence of a belief that back pain is harmful or potentially severely disabling
- fear-avoidance behavior and reduced activity levels
- a tendency toward depressed moods and withdrawal from social interaction
- the expectation that passive treatment(s), rather than active participation, will help

The psychological constructs above have been organized into two major categories, self-efficacy/expectation and fear-avoidance (kinesiophobia). Both of these constructs represent the beliefs, values and previous experiences that affect perception of ability or disability that may influence CLBP and RLBP.

Self-Efficacy/Expectation

There are two models of self-efficacy that can influence CLBP, a pain self-efficacy model and a functional self-efficacy (FSE) model. The pain self-efficacy model stresses the perceived expectations regarding a patient's ability to cope with pain during functional activities (120). Pain self-efficacy has more to do with the individual's judgment about their ability to cope with or manage pain. Patients with confidence in their ability to tolerate or control pain are thought to utilize more effective pain coping skills than their counterparts with low pain self-efficacy (9). The cognitive processes thought to influence function are believed to be associated with outcome expectancies such as pain, catastrophising and fear of reinjury (120). Because disability has more to do with a problem in physical performance, a performance specific or FSE model may be more appropriate for understanding psychological influencing factors in CLBP (120).

FSE refers to confidence judgments regarding the ability to execute or achieve tasks of physical performance (120). Human motivation research has demonstrated that individuals' who see themselves as capable of accomplishing behavioral tasks tend to strive toward more challenging goals, exert more effort in goal attainment, persist longer in the face of aversive stimuli, and experience less distress than their counterparts with weak beliefs about their performance capabilities (13); (114). Because the correspondence between pain and function is modest, a shift in focus from pain specific self-efficacy expectations to FSE expectations appears to better account for physical performance decrements in CLBP (120).

Research demonstrated that the FSE measure was a better predictor of a LBP patient's ability to successfully execute a lifting task than the perceived pain control measures or psychological distress (120). If an individual has the expectation or belief that they are capable despite the pain, the patient is more likely to perform a given motor task. It can be hypothesized that FSE is therefore associated with activity limitations, physical impairments and psychological impairments.

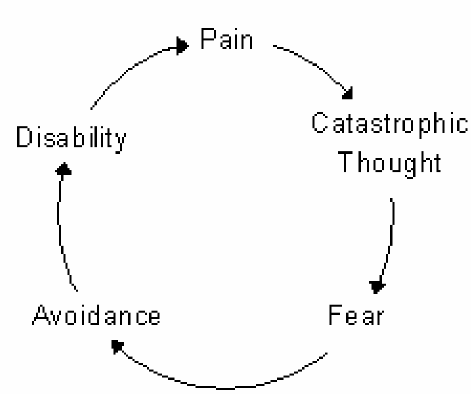
Fear-Avoidance

Fear of re-injury (kinesiophobia) and catastrophising are both considered good predictors of functional outcome in CLBP (201); (216). These findings are consistent with the cognitive-behavioral perspective that addresses maladaptive interpretations of bodily sensation. Fear-avoidance can be described as the catastrophic misinterpretation of innocuous bodily sensations, including pain.

These people are likely to become fearful of pain and follow two patterns. First, pain-related fear is associated with avoidance behaviors and the avoidance of movement and, in particular, physical activity. Avoidance also means withdrawal from rewarding activities such as work, leisure and family. Second, pain-related fear is associated with increased bodily awareness and pain hyper-vigilance. Hyper-vigilance, depression and disuse are known to be associated with increased pain levels and might exacerbate the painful experience (186).

Research shows that fear-avoidance is highly associated with the risk of developing CLBP (186); (48); (216); (201). According to research, it can be hypothesized that fear-avoidance involves both physical and psychological factors. When an individual expresses greater fear-avoidance, the therapist may expect increased pain, activity limitations and physical impairments. In one study, fear-avoidance and locus of control (self-efficacy) accounted for 71% of the reduction in disability after controlling for pain intensity, age and sex (216). Vlaeyan et al. explained the fear-avoidance cycle using the following chart (Figure 2.2) (201):

Figure 2.2 – Fear Avoidance Cycle



When a patient becomes caught in this fear-avoidance cycle, it is hypothesized that they become more susceptible to developing CLBP (201).

Behavioral modification integrated with graded physical activities is the currently suggested method for treating the psychosocial component of LBP (85); (86). The graded physical activity must provide a positive movement experience without pain. The pain-free movement experience is thought to reduce catastrophic thought and change the paradigm to a healthier perception of movement and function. The progression through the graded program returns the individual to functional daily activities, including work and recreation (201). McCracken et al. made the recommendation that patients with high fear-avoidance may require psychological treatment prior to their entry into physical therapy programs (136).

Self-efficacy and fear-avoidance appear to influence LBP and, in particular, have been shown to have a strong correlation with CLBP. These psychological constructs deserve greater attention when researching the assessment and treatment of CLBP and potentially RLBP.

Health Models

Due to the complexity of LBP, it is useful to have a model to explain the relationships between the influencing factors affecting CLBP and RLBP. In addition, a tool to evaluate the effectiveness of the interventions performed and present the outcome of the assessed measures was required.

Over the past 25 years, an evolution occurred regarding classification systems for disabilities and conceptual models used in the delivery of healthcare. The World Health Organization (WHO) developed a disability classification model in 1980 known as the International Classification of Impairments, Disabilities, and Handicaps (ICIDH) (219). The ICIDH model was divided into four sub-groups: disease, impairment, disability and handicap. The aim of the model was to classify disease, its effects on the body, its effect on functional activities (e.g. standing, walking, reaching and eating) and to determine the level of disability (handicap) as it pertained to their ability to interact with the environment and society. Physical therapy focused on the later three categories. Assessment and treatment did not directly address treatment of the disease, rather it dealt with impairments and disabilities.

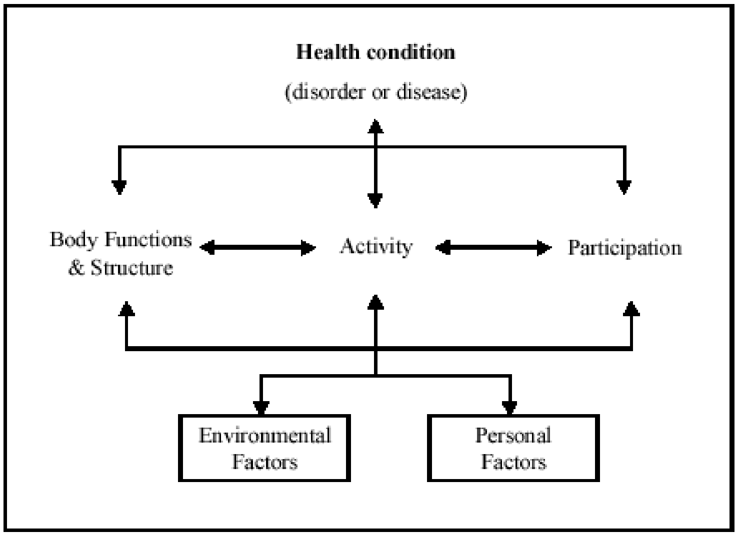
The word handicap was defined as “a disadvantage resulting from an impairment or disability that limits or prevents fulfillment of a role considered normal for a particular age, sex, and socio-cultural factors” (219). The ICIDH suggested that societal disadvantages, which prevented them from participating in normal roles of life, were due to limitations of the individuals. The ICIDH did not consider the possibility that disadvantages might be a result of societal limitations and not limitations of the individual.

Due to the advocacy of more politically correct language, the term handicap lost favor as a classification. The Nagi model was presented at the Institute of Medicine in 1991 by Pope and Tarlov and was revised in 1997 in a report titled Enabling America (158); (27). The Nagi model was a revision of the late ICIDH model, changing the language to eliminate handicap and better define disability. Disability was defined in the new Nagi model as an inability or limitation in performing socially defined activities and roles expected of individuals within a social and physical environment (158); (27). While the Nagi health model improved upon the definition of handicap and disability, it continued to place the limitation in societal activities on the individual.

It was not until 1997 that the National Center for Medical Rehabilitation Research (NCMRR) added the concept of societal limitations. These limitations were defined as restrictions attributable to social policy and barriers (structural or attitudinal) which limit fulfillment of roles and deny access opportunities that were associated with full participation in society. This definition of societal limitations started to place some of the responsibility on society to make the community accessible to individuals with physical and psychological limitations.

The WHO more recently developed the International Classification of Functioning, Disability and Health Model (ICF). The over-all aim of the ICF model was to provide a unified, standard language and framework for the description of health and health-related states. This was another major paradigm shift from identifying disability to identifying health states. Health states could include a larger spectrum from states of functional limitations to states of activity and participation. The ICF model allowed for a more holistic classification of the individual’s health, incorporating many of the components found in previous models and expanding the model. Components of the ICF model included: body functions, body structures, impairments, activity/activity limitations, participation/participation restrictions, environmental factors and personal factors (Figure 2.3).

Figure 2.3 – ICF Health Model



Body Functions

Body functions are the physiological functions of body systems (including psychological functions). These physical and psychological impairments are measurable and objective and are often the measures identified in a medical examination. In a physical therapy examination these measures may include ROM, strength, girth, inflammation, reflexes, sensation, blood pressure, heart rate, endurance and vital capacity (218).

Body Structures

Body structures are the anatomical parts of the body such as organs, limbs and their components. Structure includes skeleton, muscle, connective tissue systems and neurological systems. In physical therapy these are often measures of postural alignment, joint mobility and stability, soft tissue mobility and stability (218).

Impairments

Impairments are problems in body function or structure representing a deficiency or variation from normal, usually leading to a functional limitation. Structurally, a poorly aligned posture can potentially lead to a limited ROM of a joint, restricting normal movement and strength. Impairments by definition are measurable and objective in nature. Not all impairments lead to functional or activity limitations. This classification process allows the practitioner to prioritize interventions based on limitations caused by impairments. This includes both physiological and psychological impairments (218).

Activity/Activity Limitations

Activity limitations in performing certain motions or maintaining certain postures or positions are common in people who suffer from LBP. These limitations, as they pertain to LBP, can consist of limitations in walking, squatting, lifting, prolonged sitting, standing and repeated movements like bending, reaching and twisting. Activity limitation can be considered a major determinate of health, according to the ICF model, and its outcome is influenced by physical and psychosocial impairments (218).

Participation/ Participation Restrictions

Participation pertains to the individual's lifestyle, including work, recreation, family and community. A person's type of employment can determine the participation restrictions. If an individual's job consists of heavy labor; a small strain might result in the inability to participate in work-related activities, where the same lesion for a sedentary job might have much fewer limitations. These restrictions can also apply to activities of daily living including hygiene, community locomotion and more advanced participation in recreational activities. Hence, the limitation in activities is often associated with specific tasks that are limited due to impairments and the participation restrictions are dependent on the individual's lifestyle and the demands it places on the task limitations (218).

Participation restriction is similar to the definition of disability in the Nagi model where these limitations are more dependent on societal limitations than the individual's. An individual who requires a wheelchair is limited in many of his daily activities based on the availability of easily accessible structures facilitating locomotion and function in the community. This factor also takes into consideration the societal demands the individual places on self. If an individual is involved in activities and roles that require greater function than another individual with the same impairments, then their limitations will be perceived as greater due to the increased societal demands (218).

Environmental Factors

Environmental factors pertain to the physical, social and attitudinal environment in which people live and conduct their lives. This portion of the ICF is still being developed. The factors are external to an individual's participation as a member of society, the performance of activities of the individual or on the individual's body function or structure. Environmental factors, according to the WHO, are designed to function at three different levels: individual, services and systems. Individual applies to the immediate personal environment of the individual, including physical and material features of the environment, as well as direct personal contact with others such as family, peers and strangers. Familial support, assistance at home and modifications to homes all affect perceived health (219). Services apply to formal and informal social structures and services in the community or the local setting which includes work environment, community activities, government agencies, transportation services and informal social networks (219). Systems apply to the over-arching approaches and systems that exist in a culture or subculture. This can include laws, regulations and both formal and informal rules, attitudes and ideologies. Expectations of government assistance, worker's compensation, compensation models for personal injury and cultural tendencies towards health all have a great influence on one's perception of health (219).

Personal Factors

Personal factors are the background of an individual's life. These may include age, sex, ethnicity, socio-economic status, demographics, belief models, self-efficacy, expectation, previous experience, culture, values and fears. Personal factors are not classified in the ICF. However, they are included to show their contribution, which has an impact on the outcome of various interventions. Personal factors may strongly influence the cause of CLBP and RLBP (170); (125); (18); (60); (35). Due to the high propensity for contextual factors to influence LBP, it is necessary to consider the contribution of personal factors to the perception of health and to continue to develop and expand the ICF model to include these factors (219).

Table 2.3 demonstrates the differences and similarities between the three health classification models. The two greatest evolutions were the acceptance of activity limitations, due in part to societal limitations and the expansion from the disability model to the health model.

Table: 2.3 - Disability and Health Classification Model Comparison

ICIDH 1980 (WHO)	Nagi Model 1991	ICF Model 2002
Disease: Something abnormal within the individual; etiology gives rise to change in structure and functioning of the body.	**Active Pathology:** Interruption or interference of normal bodily processes or structure.	**Health Condition:** Disorder & disease affecting normal bodily function or structure
Impairment: Any loss or abnormality of psychological, physiological, or anatomical structure or function at the organ level.	**Impairment:** Anatomical, physiological, mental or emotional abnormalities or loss.	**Body Functions:** The physiological functions of body systems (including psychological functions). **Structures:** Anatomical parts of the body such as organs, limbs and their components. **Impairments**: Problems in body function or structure as a significant deviation or loss
Disability: Any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.	**Functional Limitations:** Restriction or lack of ability to perform an action or activity in the manner or range considered normal, which results from an impairment.	**Activities:** Pertain to the individual's lifestyle, including work, recreation, family and community. **Activity Limitations**: Difficulties an individual may have in executing activities
Handicap: A disadvantage resulting from an impairment or disability that limits or prevents fulfillment of a role considered normal for a particular age, sex, and socio-cultural factors.	**Disability:** An inability or limitation in performing socially defined activities and roles expected of individuals within a social and physical environment.	**Participation:** Lifestyle chosen by individual. **Participation Restrictions:** Problems an individual may have in life situations
	Societal Limitation: (NCMRR) Restrictions attributable to social policy and barriers (structural or attitudinal) which limits fulfillment of roles and denies access opportunities that are associates wit full participation in society.	**Environment and Social:** The physical, social and attitudinal environment in which people live and conduct their lives **Individual:** Familial, home, assistance, immediate environment. **Services**: Government transportation, services that impact accessibility **Systems**: Overarching constructs culturally, government, litigation, etc.
		Personal: Age, sex, ethnicity, socio-economic, demographic, culture, belief models, values and fears

The ICF model was the most appropriate model for this study due to the expanded classification system. Although the ICF mentions the influence of personal factors, it does not currently measure or classify personal factors. Personal factors include many factors that have been shown to have a significant impact on CLBP and RLBP (219). Because of the large psychological component associated with LBP, personal factors are expected to play a large role in identifying successful interventions for CLBP and RLBP.

Interventions for the Treatment of LBP

Interventions for treatment of CLBP and RLBP can be placed into two categories, active and passive. Active interventions include general exercise (strength, endurance and group), neuromuscular re-education (motor control) and behavioral therapies. Passive interventions include manipulation, mobilization, massage, acupuncture, pharmaceutical and surgery. Although a number of intervention studies have been conducted, one treatment method for CLBP or RLBP still cannot clearly be advocated over another (134) (200); (197).

The New Zealand Guidelines Group suggests that treating CLBP as if it were a new episode of ALBP can result in the perpetuation of disability. The New Zealand Guide does not categorize RLBP as to whether it will respond more like ALBP or CLBP. In addition, treatments traditionally used with ALBP are less effective for treatment of CLBP (2). This is especially true when health providers adhere to the following (2):

- They rely on a narrow medical model of pain and emphasize short-term palliative care with no long-term management plan.
- They discourage self care and fail to instruct the patient in self management.
- They sanction disability and do not provide interventions that will improve function.
- They over-investigate and perpetuate belief in the “broken part hypothesis”.

The broken part hypothesis is defined by a natural tendency for some patients to search for a diagnosis that justifies their behavior as being disabled. LBP patients with similar limitations might not perceive themselves to be disabled if they did not perceive a lack of control associated with their condition (108). According to the New Zealand Guidelines, a successful intervention would influence locus of control.

Active Physical Interventions

There are many types of active physical interventions utilized in rehabilitation, post-rehabilitation and fitness. For the purpose of this study the physical interventions are grouped into two categories, general exercise and neuromuscular re-education.

General Exercise

General exercise can be defined as a non-specific conditioning program that includes endurance training, strengthening and group exercise. Studies have shown that general exercise improves functional activity levels in subjects with CLBP (192); (200); (199); (34); (72). The evidence for improved functional outcomes (decreased activity limitations) with general exercise interventions for CLBP and RLBP are limited. This is due, in part, to poor scientific methodology used in some studies and because of the complexity of CLBP and RLBP (134). Some studies have found that general exercise and movement-related therapies have a positive effect on the CLBP and RLBP populations (200); (199); (131); (192); (126). Other studies found support the premise that general exercise is better than no exercise at all (200); (192); (34). However, there is no agreement as to which type of exercise is most appropriate.

Strengthening of specific trunk muscle groups is a common treatment approach for CLBP and RLBP (89); (131); (95); (36). One study showed that specific exercises that strengthen muscle, enhance performance and limit loading of the spine, significantly reduced the risk of injury exacerbation (138). In a recent review of 54 randomized controlled trials examining treatments for LBP, 16 articles were included that looked at general exercise. All 16 studies showed a positive effect for exercise in the treatment of LBP. Ten of the studies retained their positive effect (improved disability scores) at follow-up (124). The best results were found for protocols that included a combination of exercise, education and behavioral counseling (138).

Another study suggested that less expensive group exercise produced similar outcomes as therapist guided exercise programs and could greatly relieve the financial burden of CLBP (134). Long-term results suggested that specific exercise therapy, in addition to medical management and resumption of normal activity, may be more effective in reducing LBP reoccurrences than medical management and normal activity alone (95). A few studies have shown that intense dynamic exercises of the back, in particular back extension exercises (McKensie extension exercises), showed significant decrease in pain if the program continued for longer than 2-3 months (132); (36).

Aerobic conditioning is another type of general exercise used to treat CLBP and RLBP. One study compared aerobics, conventional physical therapy (which included modalities, remedial strengthening exercises and stretching techniques) and trunk muscle conditioning using machines. This study showed similar outcomes for all interventions but there was a better retention of benefits at 12 months for both trunk conditioning and aerobics compared to conventional physical therapy (135). Another study examined the relationship among performance, disability, self-efficacy, pain and aerobic capacity with CLBP. The results indicated that aerobic capacity demonstrated a weaker relationship with CLBP than the other four measures (68). Because aerobic exercise is often taught in groups, the socialization effect of exercise might have a greater impact on CLBP than the cardiovascular work itself.

In addition to aerobic conditioning, group exercise sessions can be found for strengthening, yoga, Pilates, meditation and many other types of therapy. Group exercise is defined as more than one person performing similar tasks lead by a single instructor or therapist. Group exercise that focuses on back strengthening exercises was shown to be just as valuable as conventional therapy (passive modalities and procedures) and much more cost-effective (72); (200); (141). Group exercise was found to be beneficial with CLBP and is becoming an increasingly more researched intervention because of its cost-effectiveness. In addition to the physical benefits received from group exercise classes, it has also been suggested that group classes might also affect the psychosocial factors that are thought to influence CLBP and RLBP (72); (200); (135).

Neuromuscular Re-education

Trunk stabilization is more specific than general strength training. It focuses on the strengthening of the deep stabilization muscles and has been suggested as an appropriate intervention for CLBP (168); (111); (44); (149). A licensed rehabilitation professional normally conducts this type of intervention. Studies show that specific trunk stabilization exercises in patients with LBP can influence psychosocial measures including Locus of Control, the Mental Health Inventory (MHI) and the Sickness Impact Profile (SIP) (171); (151); (89). Other studies also show that long-term results are better with specific exercise therapy than general medical management (pharmaceuticals and bed rest) (95). Specific stabilization exercises may be more effective in reducing CLBP and RLBP than general medical management and non specific activity (e.g. walking program or general conditioning in a gym) (97); (95); (96).

Direction specific stability and load training was shown to be more effective in functional outcome measures than non-directional specific stabilization programs (127). This is the integration of Panjabi's model. When there is a directional instability of the inert structures, neural muscular retraining seems to be more beneficial when it is performed with directional conditioning and stresses. This type of training requires more skill because the practitioner must be able to assess directional instabilities and address global trunk stabilization.

Low-threshold training of the diaphragm, abdominal muscles and pelvic floor to maintain the correct intra-abdominal pressure in relation to the anticipated work load was shown to improve spine stability (147). Research supports the integration of deep abdominal stability training in returning functional movements and higher level activities of daily living to patients with CLBP and RLBP (150); (152); (149); (151).

Trunk stabilization exercises focus on increasing the strength of specific target muscles (e.g. multifidi, TA, pelvic floor musculature), where interventions focusing on motor control emphasize facilitating functional movement strategy and correcting faulty motor patterns. Improved motor control, where there is efficient organization of the low back muscles and accurate anticipation of the load to be placed on the low back, may provide better protection to the inter-vertebral disks from the harmful effects of sudden loads(44); (149). Richardson et al. (1992) stated that the emphasis in spine rehabilitation needs to focus more on coordination and less on actual strength or muscle torque, insinuating that isolated volitional strength of a postural muscle is not as valuable as coordinated integration of the postural muscles (167); (168). Since the majority of postural muscles are low-threshold with sub-conscious activation, movement-based therapies might have a greater impact in the treatment of CLBP and RLBP (102); (101).

Central nervous system modulation is an approach that takes into account pain inhibition and its effect on deep stabilizing muscles of the back (172). Low-threshold training was shown to be more effective than high-threshold training of trunk musculature in treatment of CLBP (44); (77). The perception of ability to perform a task may improve and an accurate anticipation of the load associated with the exercise (normal neuromuscular organization) can occur by modulating the feedback of pain. An intervention that focuses on successful pain-free movement and correct anticipation of load incorporates low-threshold training of deep stabilizers and may be able to return normal neuromuscular organization (44); (77); (78). Graded activity programs emphasize regaining function through safe movement without pain (126). This type of training may be able to more effectively correct the faulty movement strategies found in CLBP and RLBP and enhance optimal segmental spinal control (149).

The primary focus of graded activity is to train deficient local stabilizers, beginning at the first stage of motor learning, the cognitive stage. This usually consists of isolation training of local stabilizers (e.g. TA, IAO, pelvic floor muscles, and multifidi) in non-threatening positions with a large base of support. Isolation training inhibits the premature contraction of global stabilizers (e.g. rectus abdominus, external oblique, erector spinae and quadratus luborum) in a neutral zone. The second stage of motor learning is the associative stage, where the focus is placed on refining a particular movement pattern. This entails specificity training which trains local stabilizers to function normally during activities like standing, sitting, squatting, rolling over and quadruped position.

Specificity training occurs again at sub-threshold levels. The third stage is referred to as the autonomous stage where a low degree of attention is required for the correct performance of a motor task (149); (184). Graded activity programs were shown to be successful interventions that were able to restore function and return CLBP patients to work (126). This may be due to the ability of graded activities to address all stages of motor learning, re-training faulty activation patterns and movements.

Many therapists who specialize in spine care incorporate the cognitive stage of motor learning by teaching their patients the isolation of local stabilizers. The majority of therapists may get to the associative stage, but many are not able to get to the autonomous stage of motor learning with activities of daily living (ADL's) for patients with LBP (149). Theoretically, this inability to restore autonomous normal activity is a possible factor leading to the development of CLBP or RLBP. Incomplete rehabilitation (never arriving at the autonomous stage), might also be due to other limiting factors such as lack of insurance, insufficient health care systems or lack of interest or resources on behalf of the patient.

Active Psychological Interventions

CLBP is a complex problem that requires attention to multiple factors including pain, activity limitation, physical impairments and psychosocial factors. Research suggests that exercise programs alone, though better than inactivity, are not as effective as interventions that address psychological and physiological factors that influence CLBP and RLBP (85); (134); (108). A Cochran review of interventions for CLBP concluded that while physical rehabilitation is an important component of rehabilitation for CLBP, psychological rehabilitation should also be included in order to minimize disability and improved daily functioning (171). Active psychological interventions can be separated into two categories: behavioral modification therapies provided alone and integrated models of therapy that incorporate exercise, neuromuscular re-education and behavioral modification.

Behavioral Therapy

Behavioral therapies (BT) address psychological modification through counseling and education. Literature has shown that BT and psychological interventions can be beneficial for treatment of CLBP and RLBP (67); (136); (85); (200). A study that compared BT to physiotherapy for treatment of CLBP showed improvements for both groups, but the group treated with a combination of physiotherapy and BT had the greatest improvement in daily function (171); (144); (92). By addressing fears, faulty expectations and poor perceptions of ability to function in society, patients who suffer from CLBP appear to be able to better handle normal ADL's. One study showed that while psychosocial measures (self-efficacy and fear-avoidance scales) seemed to be strong predictors of outcome, BT did not seem to have a strong effect on altering these measures (120). Literature appears to support BT when combined with therapeutic exercise and physiotherapy in the treatment of CLBP and RLBP, but not when it is utilized alone (200); (85).

Integrated Intervention Models

Multidisciplinary teams that work with chronic pain populations usually include physicians, anesthesiologists, psychiatrists, psychologists, physical therapists, recreation therapists and sometimes complementary practitioners. A multi-disciplinary team approach that includes movement re-education has been shown to be effective for the treatment of CLBP and RLBP (85); (87). A review of multidisciplinary rehabilitation interventions for CLBP suggests that intensive, multidisciplinary, bio-psychosocial rehabilitation with functional restoration reduces pain and improves function in patients with CLBP (85). Less intensive interventions did not show improvements to a clinically relevant degree (85). The intensive programs usually incorporate a full-time program or live-in program that is of a shorter duration compared to traditional outpatient multidisciplinary programs. Intensive programs that demonstrated successful functional outcomes included physical exercise, BT, counseling and education.

A Cochran review that that examined multidisciplinary and intensive therapy for CLBP showed that intensive therapy, when accompanied by a functional restoration focus, decreased pain and improved function (85). The functional restoration focus is built around the patient's perception of ability to be restored to performance and function in their society. This functional focus relates directly to FSE, which measures a patient's perception of ability to perform specific tasks. Studies show that patients with a low FSE are more likely to be disabled (108); (119).

Programs that included patient education, discussion, role playing and feedback combined with physiotherapy were able to better address physiotherapy goals for patients with CLBP (19). The New Zealand guidelines for CLBP included a focus on functional restoration with less emphasis on pain relief or palliative care (2). Another study showed that while the integrated model was shown to be effective, it is not regarded as curative (23). This reinforces the idea that all impaired systems that could potentially influence CLBP must be addressed. Counseling, education and therapy by itself, when a serious structural defect is present, will not be curative. However, not all structural defects of the spine result in LBP and disability, which indicates that additional pathologies are involved.

The multidisciplinary team approach, though effective, has proven to be costly (195); (196). While the expense may be prohibitive, a preliminary screening that can assess impairment in multiple contexts (physical, psychological, social and functional) might provide a more cost effective integrated treatment approach yielding improved outcomes.

The Pilates Method

The Pilates method was selected as the active intervention for this study. Pilates was reported anecdotally to provide a positive outcome for individuals who have failed to recover with traditional interventions, including but not limited to physical therapy, exercise, acupuncture, pharmacology, surgery and rest (44); (42). Some of this success has been attributed to the assistive environment that is unique to Pilates, the training of the core musculature, (e.g. TA, IAO, multifidus, pelvic floor and diaphragm) and a heightened awareness of the connectivity between the mind and body (mind-body connection) (44); (46). There is little research available that pertains to the effect of Pilates in patients that suffer from CLBP or RLBP. An unpublished pilot study that examined the effectiveness of Pilates to treat patients with CLBP looked at 19 subjects scheduled for low back surgery. Subjects participated in a Pilates exercise program for ten weeks. Following the 10 week intervention period, a significant improvement, where $p \leq 0.05$, in Rolland Morris, Functional Self-Efficacy, SF-36 and FABQ was found (46). At 8 months post-Pilates intervention, all subjects were still in the upper seventieth percentile for outcome measures and had not required surgery (46).

German-born Joseph H. Pilates developed his unique method of physical and mental conditioning in 1923. In the early 1930s and 1940s, popular dance artists and choreographers, such as Martha Graham, George Balanchine and Jerome Robbins, embraced Pilates' exercise method. As highly conditioned performers, dancers often suffered from injuries that resulted in long recovery periods and the frequent inability to achieve peak performance. The Pilates method encouraged movement early in the rehabilitation process with non-destructive forces. This early movement intervention without pain could theoretically hasten the healing. This coincides with Mannion's study where successful movement experiences without pain were correlated with successful physical and psychosocial outcomes (133).

Within the rehabilitation setting, most Pilates exercises are performed on several types of apparatus (Figure 2.4). The apparatus regime evolved from Pilates' original mat work, which often proved difficult as a result of the effect of gravity on the body (Figure 2.5). On the apparatus, springs and gravity are used to assist an injured individual to successfully complete movements that otherwise would be limited (Figure 2.6). Ultimately, by altering the spring tension or increasing the challenge of gravity, an individual may be progressed towards functional movement. The Pilates Environment consists of equipment used by Pilates practitioners including: the Reformer, Cadillac or trapeze table, chair, ladder barrel and mat.

Figure 2.4 – Pilates Equipment

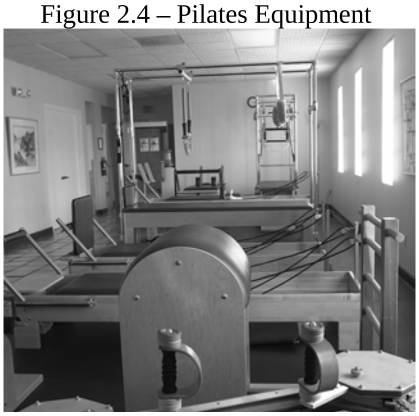


Figure 2.5 – Pilates Mat Work

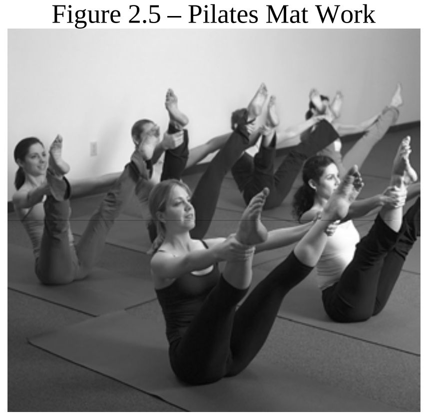
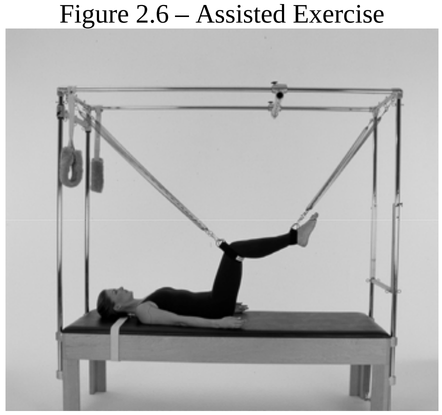


Figure 2.6 – Assisted Exercise



The Pilates method was also built on principles of movement. Pilates and his successors built the methodology with eight basic principles to guide the work he referred to as Contrology. They consisted of concentration, control, precision/coordination, isolation/integration, centering, flowing movement, breathing and routine. The original eight principles have been modified into six movement principles that have greater practicality in a rehabilitation environment and have supporting literature with a stronger scientific basis (97). The six modified principles (breathing, core control, efficiency of movement, spine articulation, alignment and movement integration) are described in greater detail below.

Breathing

In the Pilates technique breathing is utilized to facilitate spine stability and mobility depending on the desired movement sequence. Inhalation can facilitate spine extension and resist forces of spine flexion. Exhalation can facilitate spine flexion and resist forces of spine extension.

Breath is a facilitator for stabilization and mobilization of the spine and extremities (100); (99). Faulty breath patterns can be associated with complaints of pain and movement dysfunction. Pilates movements create an environment whereby breath facilitates the efficiency of air exchange, breath capacity and thoracic postural changes. A rigid thoracic spine might correlate with cervical and lumbar pathologies. The Pilates approach to breathing varies depending on which school of Pilates is examined, but one thing in common is that breath is an integral part of each exercise (157).

Core Control and Axial Elongation

Core control represents the neural control of the trunk musculature that successfully organizes the spine and pelvis according to the anticipated load while moving. Axial elongation is the alignment of the head, spine and pelvis that facilitates correct joint spacing and provides optimal ranges of motion with minimal risk of injury.

Studies demonstrate that the TA, IAO, EAO, multifidus and diaphragm are key organization muscles of movement in healthy individuals and are often lacking in individuals with LBP (168); (166); (167). For this reason, Joseph Pilates' original teachings referring to the powerhouse are becoming quite popular among rehabilitation specialists around the world. The powerhouse is defined as being the connection between the upper torso and the pelvis, creating the source of power in movement, particularly rotational forces. In a motor control model, this includes the relationship between the TA, IAO, EAO, pelvic floor and diaphragm and is often referred to as core-stabilization (44); (77); (78). This principle of stabilization has increased therapists' interest in Pilates as a rehabilitation procedure. Motor control studies and theories of trunk organization and stabilization indicate that sub-threshold contraction of local and global stabilization muscles provide a safe movement to perform ADL's (160). Control of the trunk has been related to a balance of stiffness between muscles to provide efficient control of dynamic posture (181).

To produce efficient movement, the image of axial elongation, a lengthening of the spine along the vertical axis, is used to organize the spine into an optimal orientation. This elongation avoids working or resting at the end of range, which can place undue stress on the inert and contractile structures of the trunk and extremities (77); (78). The proper neuromuscular organization of spine and extremities theoretically provides a more optimal alignment for performance of sport and leisure activities. It appears clinically, that when a patient has the ability to reorganize their strategy of spine movement and movement of the extremities in conjunction with the spine, power is better distributed and less likely to introduce harmful forces to inert and active tissues of the spine. Pilates' exercises are thought to facilitate trunk organization at a subconscious level, allowing the individual to explore and assimilate a more efficient control of the trunk. The subconscious organization of the core thought to occur in Pilates training warrants further investigation.

Efficiency of Movement

Efficiency of Movement is utilized to decrease unwanted or unnecessary muscle contraction that tend to interfere with healthy movement. The head, neck and shoulders becomes indicators of the ease and adaptability that an individual demonstrates when acquiring new movement or correcting faulty movement patterns. This principle can be applied to functional movement skills (e.g. sit to stand, walking, reaching) as well as performance skills (e.g. golfing, throwing, running).

The visual assessment of tension and posture within the head, face, neck, and shoulder girdle in relation to the thoracic spine and trunk are good indicators of efficient movement organization. Many restrictions and unnecessary stresses can occur in this area. The excessive recruitment of antagonist muscles is obstructive to the desired movement and significantly decreases the efficiency. For example, a protracted shoulder, due to poor postural alignment, interferes with normal biomechanics of the glenohumeral joint in elevation, placing the joint at risk of injury.

The benefits of this principle are increased ROM, energy conservation and minimizing the risk of lesions to cervical, shoulders and spine. Lesions usually occur at the end of ROM. Increasing the available ROM and improving coordination of the scapulothoracic joints, will decrease the likelihood of experiencing destructive forces to the shoulder, lumbar, thoracic and cervical spine.

<u>Spine Articulation</u>

The ability to move the spine segmentally greatly increases fluidity while performing movement. Increased segmental mobility of the spine theoretically decreases unwanted stress and sheer of the spinal segments and increases efficiency and flow of movement. Rehabilitation of the spine in the Pilates environment further increases the relevance of the above principle.

When clinicians assess the mechanism of a spine pathology, it is common to identify the lesion by hyper-mobile segment, where in Pilates it has been suggested that hyper-mobility is often secondary to a lack of movement in a neighboring segment or joint. One theory yet to be tested is that a greater distribution of mobility through-out the entire spine will decrease potentially harmful forces on the hyper-mobile segments, often responsible for pain (38).

There is currently little research in this area due to limitations in technology and the invasive risk required to measure intra-discal pressure in healthy subjects. More research is warranted to investigate the relationship between movement and force in the spine, as more cost effective, less invasive instrumentation is developed. Segmental movement of the spine, theoretically reduces stressful forces from causing micro and macro traumas to the hyper-mobile segment. Dack et al. showed in an unpublished pilot study that following one session of Pilates, healthy subjects had a significant increase in overall forward bending, an increase in motion of less mobile segments, and a decrease in motion of the previously measured hyper-mobile segments (51). However, a Metracom device was used to measure changes in mobility and proved to be unreliable causing the data to be contaminated.

The study by Dack et al. suggested that in healthy subjects hypo-mobility was a result of neuromuscular control and not structural limitations. The above study does not take into consideration structural abnormalities that might exist in LBP patients; however the change in neuromuscular control might explain a portion of the success claimed by the Pilates community when working with LBP. Theoretically, by changing the movement strategy in the spine to a more distributed movement reducing sheer force of the hyper-mobile structures, LBP patients may start to feel better and move with less pain even though the structural lesion is still present or visible with imaging.

One invasive study, Brown et al., was the first to perform intra-operative stiffness measurements of the spine segments to predict satisfaction post-surgery between those with increased hyper-mobility and those that demonstrated increased segmental stiffness. He concluded that the intra-operative measure did not predict clinical results after lumbar spine surgery (30); (31); (29). According to the study, data was not originally collected for research, possibly accounting for the lack of statistical significance.

Alignment

The Pilates principle of alignment is utilized to optimize the static and dynamic posture of the body. Dynamic alignment includes the arthrokinematics of the joints referred to as bone rhythms. Proper alignment of the posture provided for balanced and efficient movement of the body. Alignment of the body and mind are purported to facilitate clear thinking and greater emotional clarity.

Alignment and posture are concepts often incorporated in the field of rehabilitation. Postural organization can significantly decrease energy expenditure in daily activities. Faulty alignment in the extremities and the spine can be the source of decreased ROM, early fatigue of muscle groups, abnormal stresses on inert structures and faulty movement patterns that can be potentially harmful (12); (93). Postural alignment, according to one study, significantly relieved patients of chronic headaches (137). Postural alignment and postural muscle recruitment organizes differently for individuals suffering from LBP (121); (118). Most importantly performance is greatly enhanced through dynamic alignment, especially with high demand sports and singing (12); (64); (182).

Movement Integration

The Pilates principle of movement integration summarizes all of the principles above and integrates the many factors that influence the successful organization of a movement. It theoretically draws from the systems theory. According to Shumway Cook, movement organization is influenced by the individual, the task and the environment (5). The individual is composed of three factors cognition, action and perception. Tasks, according to Shumway Cook, consist of attributes that are inherent in the task. These attributes consist of: 1) mobility, defined as a base of support moving under the mover (e.g. bicycle, kayak, walking or running); 2) stability, defined as activity on a non moving structure (e.g. sitting, standing or lying down); and 3) manipulation, regarding the degree of fine motor versus gross motor activity or repetitive tasks versus open ended tasks (184). In addition, the environment in which the tasks are performed can greatly influence the success of movement organization (5); (184).

Pilates provides an environment that can be modified for each of the factors associated with movement organization. Movement assistance, changing base of support, stabile versus mobile surfaces, foreign and familiar environments are all possible modifications within the Pilates environment to provide a successful movement experience without pain. The five tools according to one school of Pilates are as follows (4); (5):

1. Modify the base of support.
2. Decrease the center of gravity.
3. Shorten the length of the levers.

4. Vary the degree of assistance (spring tension).

5. Progress from a foreign environment to a familiar environment.

These five tools allow the therapist to facilitate motor changes of the trunk quickly, while giving ownership of the newly acquired movement to the patient or client.

This is only one interpretation of the Pilates method, with the purpose of understanding its application in the field of rehabilitation. These principles are not globally accepted by all Pilates schools. When the Pilates method is used for rehabilitation, it requires that the practitioner possess critical reasoning skills and the ability to manipulate the environment to meet the needs of the patient.

The Pilates method utilizes principles that could be effective in the treatment of CLBP and RLBP. The Pilates requirement that patients participate in the treatment on a mental level is designed to increase awareness of the body and its organization.

Pilates programs often move from exercises performed using equipment to exercises performed in a real world environment. Pilates programs are progressed under supervision to facilitate pain free movement and restoration of function. If participants are able to perform functional activities without pain in the context of the Pilates program, they may feel more confident in performing those activities in their daily lives. Thus it could be hypothesized that an active intervention such as Pilates should improve strength and flexibility, decrease pain and activity limitations and improve confidence in ability to move in patients with chronic or recurrent LBP.

Passive Interventions

Passive interventions can be defined as treatments where the patient does not have an active physical or mental role in their care. Passive interventions may include manipulation, acupuncture, massage, medicinal, therapeutic ultrasound, electrical stimulation, ice and heat. Treatment for ALBP often consists of the above interventions and are beneficial in reducing pain and speeding up healing (11); (88). According to a Cochran review of Randomized clinical trials by van Tulder et al., there is limited research as it pertains to the long-term effect of passive interventions for the treatment of CLBP and RLBP (197); (199). Passive interventions were organized into two groups, medicinal (pharmaceutical and homeopathic) and manual therapies (e.g. manipulation, mobilization, massage, acupuncture).

Medicinal

Pharmaceutical interventions are considered a standard intervention and are typically prescribed prior to any other intervention by physicians. Prescriptions normally consist of non-steroidal anti-inflammatory drugs (NSAIDs) and are often augmented by muscle relaxants (39). Long-term care studies show that drugs have not been very effective with treatment of CLBP. A Cochran review that looked at different randomized trials that pertain to drug interventions for CLBP found that NSAIDs are effective for short-term symptomatic relief in ALBP. Another study confirmed that NSAIDs were beneficial for ALBP but not for CLBP (39). In a Cochran review of literature, NSAIDs and muscle relaxants were found to be effective for ALBP, while manipulation, back schools, and exercise were found to be effective for CLBP (199). Drug intervention is outside the scope of this study, however, most patients that have suffered CLBP continue the use of some form of pain medication or muscle relaxant (39).

Holistic medicinal therapies include naturopathy, Chinese medicine and other herbal medicine including Willow Bark, Devil's claw, glucosamine sulfate and chondroitin sulfate. These holistic medications have been used clinically for centuries but are poorly researched for the prevention and acute treatment of LBP (41).

Manual Therapies

The number of Americans who receive alternative therapies has skyrocketed in the past decade, with an estimated $27 billion spent annually on acupuncture, chiropractic, massage, homeopathy and other non-traditional therapies (212). Manipulation is defined as a passive movement of any kind. According to chiropractors and manipulative therapists, manipulation is associated with a high velocity, low amplitude thrust that takes place before the patient can prevent it (130). Studies disagree as to the benefits of manipulation for the treatment of CLBP and RLBP. Studies that support manipulation tend to examine ALBP populations (11); (88) or examine manipulation accompanied with stabilization exercises. Manipulation combined with exercise was found to be more effective in reducing pain intensity and disability than the physician consultation alone for LBP (145); (70); (148). Another study supports the combination of exercise and spinal manipulation in the treatment of LBP when compared to other conservative treatments, however this study showed a decreased benefit over time (193).

Other research found that manipulation was not beneficial with CLBP (57); (42); (79); (10). One of the most recent studies showed that manipulation compared to McKenzie method had similar effects and was only marginally better than patients who received educational pamphlets (42). Studies on manipulation in the treatment of LBP have been poorly designed and require further investigation (57).

Therapeutic Massage

Therapeutic massage was selected as the passive intervention for this study and has been suggested as having a mechanical, reflexive, physiological psychological and psychoneuro-immunological (Table 2.4) (54); (188).

Table 2.4 - Therapeutic Effects and Outcomes of Massage (6)

Effect	Description	Example
Mechanical**	Effects are caused by physically moving the tissues by compression , tension (stretch), shearing bending, or twisting	Increase lymphatic return Mobilized bronchial secretions
Reflex**	Functional change is mediated by nervous system	Sedation or arousal Facilitation of skeletal muscle contraction/relaxation
Physiological**	Involves a change in biochemical body processes	Improved modeling of connective tissue Reduced muscle spasm
Psychological	Effect occurs in the mind, emotions, or behavior	Improved social interaction Improved physical self-image
Psychoneuro-immunological	Altered feeling state is accompanied by changes in hormone levels or immune function; this term emphasizes that “mere” feelings states like relaxation represent complex multi-system phenomena	Decreased anxiety and cortisol levels Improved T-cell function
**Each massage technique produces a variety of effects and outcomes that are achieved through multiple mechanisms of operation that occur simultaneously.* ***Effects may be local, occurring only on the site of manipulation, or general, occurring throughout the body.*		

Therapeutic massage can be divided into six categories: superficial reflex techniques, superficial fluid techniques, neuromuscular techniques, connective tissue techniques, passive movement techniques and percussive techniques (Table 2.5) (6). The descriptions of the various massage techniques help to identify what specific techniques are thought to work on which body systems. The complex nature of CLBP includes such factors as structural impairments, neurological pain pathways and structures, central modulation and interpretation of pain and perception of abilities to perform tasks.

Table 2.5 - Classification of Massage Techniques (6)

Superficial reflex techniques	These techniques engage only the skin and produce reflex effects, such as counterirritant analgesia, but no mechanical effects.
Superficial fluid techniques	These techniques engage skin, superficial fascia, and subcutaneous fat down to the investing layers of the deep fascia. They produce mechanical effects on superficial lymphatic and possibly the venous circulation.
Neuromuscular techniques	These techniques engage muscle and the tissues it contains. They affect the function of the contractile element, hydration of connective tissue, and lymphatic return and may also produce complex reflex effects.
Connective tissue techniques	These techniques engage superficial and deep layers of connective tissue. They mechanically affect the hydration, extensibility, and modeling of connective tissue and may also produce complex reflex effects.
Passive movement techniques	These techniques produce substantial tissue or joint motion without effort on the part of the client. They engage multiple tissues and structures and have wide-ranging effects on fluid flow, connective tissue, and the neural control of muscle tone
Percussive techniques	These techniques deform and release tissues quickly. They engage different tissues, depending on the force with which they are applied. They are used primarily in cardiopulmonary rehabilitation to mechanically assist bronchial drainage and airway clearance. They may also produce useful reflex neuromuscular effects.

Some of the literature supports therapeutic massage as a viable intervention for LBP, especially when combined with other active interventions and education (24); (75). Preyde M. (2000) found that “comprehensive massage therapy (soft-tissue manipulation, remedial exercise and posture education combined) was significantly more effective treatment than the soft-tissue manipulation by itself in sub acute LBP as it pertained to measures of pain and function (162).

When compared to other complementary therapies (acupuncture and manipulation), massage showed marked improvement in functional outcome measures (75); (41); (42). Konig A. et al. (2003) showed contrary evidence that acupuncture was superior to conventional massage (no description of what conventional massage was given) as it pertained to increasing ROM in the cervical spine immediately following treatment and one week post (117). When massage was compared to manipulation in a population of subjects with sub-acute LBP, results indicated that after three weeks subjects receiving manipulation showed greater improvement in flexion and pain, while the massage group had the best extension strength and endurance. None of the findings were found to be significant (159).

Massage may reduce the costs of care and be more effective for the treatment of persistent LBP than acupuncture or spinal manipulation (41); (42); (40). Evidence has suggested that massage has a positive effect to decrease pain, Increase ROM, facilitate healing of connective tissue, reduce stress and influence emotional states with CLBP patients (159).

Pain Control

Massage has been described as an effective treatment to disrupt the pain cycle by inducing mechanical and reflex effects (107); (123). The theory that endogenous opiates, β–endorphins and β-lipotropin, are released during massage, as they have been found to do with exercise, has not been consistently demonstrated (53). However, in a later study Kaada and Torsteinbo showed a moderate increase of 16% in β-endorphin levels lasting approximately 60 minutes after a 30 minute massage (113). Decreases in pain whether from mechanical, chemical or the combination of both theoretically may account for the temporary relief often experienced after massage.

Another study looked at the delayed onset of muscle pain after working out and found that massage was effective in alleviating delayed onset of muscle soreness by approximately 30% and reducing swelling, however no effects on muscle function were found (221); (159). No description of the massage technique was given.

Increase ROM

Crosman et al. showed that soft tissue work combining effleurage, pétrissage and friction massage showed an increased range of motion immediately following the treatment. However, there appeared to be minimal long-term effect from a single massage (49). Evidence supported a unique style of massage to increase hamstring flexibility. The technique combined classical massage with long and short stroke techniques during eccentric loading of the hamstring muscle. The study demonstrated a significant increase in hamstring flexibility in healthy male subjects when compared to classical massage alone and to a control group (103). Another study compared a Cyriax approach of transverse tissue massage (TTM), which would fall under the connective tissue massage category, to conventional therapy (diathermy, hot packs, strentching and a home exercise program) for patients with adhesive shoulder capsulitis, Results indicated a significant improvement in the TTM group when compared to the conventional therapy group (84). Van den Dolder P.A. and Roberts D.L. (2003) found that massage around the shoulder was effective in improving range of motion, decreasing and pain and increasing function in patients with shoulder pain. No rationale for the results were given and the technique was not defined

(194). When massage was compared to stretching, stretching was found to affect all muscle groups tested and was superior to massage (214).

Soft Tissue Healing

Healing is though to take place in soft tissue injuries through alignment of the connective tissues and blood supply, which carries enzymes and protein factors that facilitate tissue mending. Massage has been defined as an appropriate intervention for the treatment of connective tissue lesions (163); (50). The literature supports that movement, whether mechanical or intrinsic, helps facilitate realignment of the collagen and healing of soft tissue fibers (76); (83); (122). Theoretically, connective tissue techniques and passive movement techniques would be the most appropriate to facilitate a change to the healing tissue.

Evidence suggests that massage increases blood circulation and flow as much as 50% (205). An increase in serum enzymes has also been demonstrated in response to massage, but felt they were released in response to trauma from the massage to the muscle cells (8). In other research it was found that pétrissage did not significantly increase blood flow, but percussion did improve blood flow, possibly due to the muscle contractions following rapid percussion to the muscle fibers (104). Other studies found that there was increased circulation in the immediate areas of massage (90) but increased circulation over the entire body has no been shown (183). The increased blood flow seems to occur locally with deep tissue massage (connective tissue) or percussive techniques. The literature does not support massage as a mode of increasing circulation systemically.

Relaxation and Change in Emotional State

Traditionally, massage has been thought to reduce stress through relaxation. One important study explored the effect of exercise and massage on positive mood (213). Results indicated that massage repeatedly demonstrated positive effects with mood states including: anger, fatigue, depression, anxiety and confusion. In opposition, another study compared mood profiles and the Perceived Exertion Feeling Scale in six elite athletes and found no significant difference (61).

Hernandez-Reif et al. (2001) found evidence for improved ROM and reduced pain. The study also provided evidence that there was a decrease in stress hormones, an increase in serotonin and dopamine, decreased depression and anxiety and lastly improved sleep patterns effected by CLBP (94).

Massage was thought to influence the autonomic nervous system by increasing the para-sympathetic activity (191). Another study showed just the opposite, that sympathetic activity increased due to massage (16). This could possibly be due to whether the massage technique is perceived as being relaxing or painful.

Massage has served as the control group for a number of studies examining the effectiveness of active interventions. However, according to a few authors, massage is not clearly defined or adequately described in most of these control studies (40); (33). Because of the lack of control, it is difficult to know which type of massage is being performed, for how long or with what skill level (novice, proficient or expert).

As it pertains to a rehabilitative modality for treatment of CLBP there continues to be a lack of supporting evidence in its long term benefits and warrants further investigation.

Summary

CLBP and RLBP continue to be a large and complex problem for society. They have considerable costs to industry, the health care industry and the individual. This study will utilize the New Zealand Guidelines for Physiotherapy definition of CLBP and RLBP. CLBP is defined as LBP and associated leg pain that last greater than three months and RLBP is defined as recurrent episodes of LBP and associated leg pain that last less than three months duration.

Multiple influencing factors of CLBP and RLBP include physical factors (inert structures, contractile structures and neural control) and psychosocial factors (fear of re injury, decreased self-efficacy, social and environmental). Current classification models of disability lack some of the psychological and holistic factors that influence CLBP and RLBP. The WHO’s current ICF model was the most comprehensive health model available. The ICF model was modified to provide a three-dimensional graphic representation to examine the relationship between pain, activity limitation, physical impairments and psychosocial impairments.

Active and passive interventions were defined and categorized to facilitate the study. A review of literature found support for active and passive interventions in the treatment of LBP. However, active interventions have been shown to be more effective for the treatment of CLBP and RLBP. Active therapy programs that focus on pain-free restoration of function have been able to modify both physiological and psychological factors that influence CLBP and RLBP (134). Differences in the effectiveness of various interventions on LBP seem to have been associated with the acuity of LBP. An integrated model that included passive and active interventions, both physical and psychological, had the greatest impact on functional outcome measures (91). This integrated model proved to be expensive and has not been shown to be cost effective in the long term (114); (85); (134).

To compare the effectiveness of active versus passive interventions for the treatment of CLBP and RLBP, Pilates and therapeutic massage were selected. Pilates, an active complementary therapy, and massage, a passive complementary therapy, were evaluated for their impact on pain, activity limitations, physical impairments and psychosocial impairments. Table 2.6 compares the two interventions for CLBP and RLBP selected for this study.

Table 2.6 - Classification of Interventions

	Pilates	**Massage**
Historical	Complementary	Complementary
Nature of intervention	Active	Passive
Physical Factors	Inert, active and neural control	Inert and active tissues
Psychological Factors	Internal locus of control	External locus of control
Intention of Practitioner	Positive movement experience without pain	Reduce pain

Chapter 3 – Methods and Measures

Design

This study was a single-blinded, randomized, controlled clinical trial comparing an active intervention (Pilates) to a passive intervention (massage) for subjects suffering from CLBP and RLBP, measured in terms of pain, activity limitation, physical factors and psychological factors.

Subjects

Inclusion Criteria

Subjects were eligible to participate in this study if they met the following inclusion criteria:

- Subjects must have had a history of CLBP or RLBP diagnosed by a physician within the last six months
- Subjects must have completed treatment for CLBP or RLBP by a physician or a physical therapist within the past 60 days
- Subjects must have been dissatisfied with their current LBP (as measured by a score below a 3 out of 5 on the symptom satsifaction scale)
- Subjects must have been between the ages of 18-65 years

Exclusion Criteria

Subjects who were unable to complete the instruments secondary to cognitive deficits or language barriers were excluded from the study. Subjects were also excluded from the study if they were currently suffering from any of the following co-morbidities:

- Clinical presentation suggestive of serious pathology (organic or neoplastic)
- Significant weakness of the lower extremities
- Previous spine fusions, stenotomies and other compromising surgery
- Systemic illness
- Pregnancy
- Recent abdominal surgery
- Symptoms/evidence of cauda equina compression
- Acute nerve root compression
- Neurological/muscular degenerative disorders
- Concomitant health problems that would preclude exercise
- Severe joint limitations due to degenerative changes that would preclude weight-bearing exercises of the upper or lower extremities

In addition, subjects were excluded from the study if they met any of the following criteria:

- Eligible for social security disability benefits
- Currently involved in a civil litigation
- Currently resolving a worker's compensation claim
- Narcotic Addiction
- Currently receiving therapeutic massage or Pilates lessons

Recruitment

Volunteers were recruited from the patient populations of local clinicians which included physicians, surgeons and therapists who treat LBP in the Miami and South Miami region. These clinicians were provided the inclusion and exclusion critieria for the study in order to pre-sceen potential subjects and given information sheets containing the contact information for the study to handout to eligible patients. Clinicians were encouraged to refer patients who had completed a standard course of treatment but continued to suffer from symptoms related to LBP.

Potential subjects who contacted the study received an automated answering service that asked for their phone number and contact information. A research assistant followed up with each of the volunteers. The research assistant administered the telephone interview and screening form (Appendix II) to verify that volunteers met the inclusion and exclusion criteria for the study. Qualified volunteers were asked to schedule an initial appointment to have their baseline measures taken.

Outcome Measures

The modified ICF model was divided into three categories 1) activity and pain limitation, 2), physical factors and 3) psychosocial factors (Figure 2.2). These categories are taken directly from the ICF model. The physical factors relate to body structures, psychosocial factors relate to body functions and activity and pain limitation relate to activity and participation limitations. Several outcome measures were selected to measure each of the constructs in the modified ICF model (Table 3.1).

Table 3.1 – Outcome Measures Related to the Modified ICF Constructs

Activity Limitation/Pain	Physical Factors	Psychosocial Factors
Oswestry	Lower Abdominal Strength	Functional Self-Efficacy
MBI Disability	Back Extension Strength	General Self-Efficacy (GSE)
MBI Pain	Lumbar and Thoracic flexion ROM	Expected Re-Injury/Pain Scale
SF-36 Bodily Pain	Side Kick Test/Motor	SF-36 Vitality

Activity Limitation/Pain Measures

The Oswestry LBP Scale

The Oswestry LBP Scale is an 11 item self report index that evaluates activity level as it pertains to LBP. The first item on the Oswestry is a visual pain scale with a range from “0” (no pain) to “10” (unbearable pain). The remaining ten items ask subjects the degree that various daily activities are limited by pain. Each question has a possible score between “0” (no pain with activity) to “5” (unable to do the various activity secondary to the pain). Total scores are calculated by adding the individual item scores. The higher the Oswestry score, the greater limitation in activity level. Scores can range from zero to 60. The Oswestry has been widely used as a measure of LBP related disability and has demonstrated the ability to detect change in subjects with LBP (52); (177); (178); (189); (59); (26).

Miami Back Index

The Miami Back Index (MBI) is a 22-item, self report index that consists of a 14-item disability subscale and an 8-item pain subscale. The test-retest reliability of the MBI is high and it has been validated against the Oswestry in previous studies (175); (174). While the Oswestry is focused on questions examining the influence of pain during specific activities, the MBI is designed to evaluate both pain and disability associated with low back dysfunction. The MBI is administered in the form of two separate questionnaires, the disability sub-scale and the pain sub-scale.

Miami Back Index Disability Sub-Scale

The MBI disability sub-scale (Appendix XI) consists of 14 questions with a visual analogue scale ranging from “0” (no difficulty with the task) to “10” (unable to perform or needs help). The disability sub-scale includes activities such as the ability to fall asleep, climb stairs, or walk. It is calculated by adding the scores for all of the questions answered and dividing that number by the total possible points for questions answered. This provides a score that ranges between zero to 100 percent, where the higher the score, the greater the subject’s activity limitations. The MBI disability sub-scale, unlike pain scales, looks at subjects’ perception of their ability to do the activity and does not make the assumption that it is related to pain.

Miami Back Index Pain Sub-Scale

The MBI pain sub-scale (Appendix XII) assesses the severity of perceived pain associated with various activities. This sub-scale has eight questions and uses a visual analogue scale that ranges from “0” (no pain) to “10” (worst pain imaginable). The pain scale is scored the same way as the disability sub-scale, where scores for the index are added together and the total score is divided by the total possible score, based on the number of items successfully answered.

The score is reported as a percentage from zero to 100, where the higher the score, the greater the perception of pain limiting activity.

<u>The SF-36 Health Status Survey</u>

The SF-36 Health Status Survey (Appendix IX) was developed as part of the Health Insurance Experiment (HIE) conducted in the 1970's. This project involved an extensive application of psychometric theory to health status surveys. Short versions of the surveys were developed because a number of subjects refused to complete the entire health survey (209); (28). A 20-item short form (SF-20) was developed for use in older, sicker populations and a 36-item short form (SF-36) was developed for use in younger, healthier populations (209). The SF-36 includes sub-scales that represent eight important health constructs that had been identified by previous studies (208). Each of the eight health constructs included a physical and mental health component and was divided into four measures: behavioral functioning, perceived well-being, social and role disability and personal evaluations (Table 3.2) (207).

Table 3.2 - Summary of SF-36 Survey Construct

		Physical				Mental			
Scale	Label	Function	Well-being	Disability	Pers. Eval	Function	Well-being	Disability	Pers. Eval.
Physical Functioning	PF	X							
Role-Physical	RP			X					
Bodily Pain	BP		X	X					
General health	GH				X				X
Vitality	VT		X				X		
Social Functioning	SF			X				X	
Role-Emotional	RE			X				X	
Mental Health	ME					X	X		

The SF-36 was not designed to be a classification or diagnosis tool but was intended to measure an individual's health status as it pertains to physical and mental health problems. This study utilized the following SF-36 subscales: physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH) and vitality (VT).

Table 3.3 - SF-36 Survey: Item abbreviations PF, RP, BP, GH, VT

Scale	Item	Abbreviated Item Content
Physical Functioning	3a	Vigorous activities, such as running, lifting heavy objects, strenuous sports
	3b	Moderate activates, such as moving a table, vacuuming, bowling
	3c	Lifting or carrying groceries
	3d	Climbing several flights of stairs
	3e	Climbing one flight of stairs
	3f	Bending, kneeling, or stooping
	3g	Walking more than a mile
	3h	Walking several blocks
	3i	Walking one block
	3j	Bathing or dressing
Role—Physical	4a	Limited in the kind of work or other
	4b	Cut down the amount of time spent on work or other activities
	4c	Accomplished less than would like
	4d	Difficulty performing the work or other activities
Bodily Pain	7	Intensity of bodily pain
	8	Extent pain interfered with normal work
General Health	1	Is your health: excellent, very good, good, fair, poor
	11a	My health is excellent
	11b	I am as healthy as anybody I know
	11c	I seem to get sick a little easier than other people
	11d	I expect my health to get worse
Vitality	9a	Feel full of pep
	9e	Have a lot of energy
	9g	Feel worn out
	9i	Feel tired

The SF-36 Pain Sub-Scale

The SF-36 BP sub-scale (Appendix IX) is one of the eight sub-scales contained in the SF-36 Health Status Survey. The BP sub-scale consists of two questions (Table 3.3). The first question deals with intensity of bodily pain and has six responses that range from “none” to “very severe”. The second question in the BP sub-scale asks how much pain has interfered with work and daily activities over the past four weeks. This question has five response options that range from” not at all” to “extremely”. A total score was calculated for BP by adding the two scores together. The SF-36 scoring guideline rectify any inverted items and provides a total, where the higher the score, the less impact pain has on the subject’s perceived health.

Physical Measures

Physical measures (Appendix IV) in this study were selected from standard measures of strength and flexibility of the spine currently utilized in clinical settings. Six of the seven tests are standard low back strength and flexibility measures with established reliability. The seventh is a new measure that is designed to assess the ability to stabilize the lumbar spine while moving the lower extremities.

Lower abdominal strength

Lower abdominal strength was measured using a bilateral straight leg raise (SLR) lowering task (206); (63); (142); (20). The subject was positioned supine on a solid surface. One of the subject’s greater trochanters was aligned with the axis of rotation of a goniometer. The examiner placed one hand under the subject’s back in a position to note loss of contact with the supporting surface. The subject raised both lower extremities to 90 degrees while the low back maintained contact with the supporting surface. The subject then slowly lowered both lower extremities. The examiner noted and recorded the angle, in degrees, of the legs at the point that the subject's back lost contact with the supporting surface. The lower the angle of the SLR the stronger the subject's lower abdominal control. Scores ranged from zero to 90 degrees.

Back extension strength

Back extension strength was measured using a modified Sorenson endurance test (105); (146); (20). The subject was positioned prone on a solid surface with their trunk off the edge of the platform to the lever of the ASIS. The subject's feet and ankles were secured in place with a ladder. The subject was asked to place both hands behind their head and raise their trunk to a position horizontal to the floor. Verbal cueing was given as necessary to assist the subject in maintaining the appropriate position. The time, in seconds, that the horizontal position was maintained (up to 240 seconds) was recorded. The greater the amount of time the subject was able to maintain the position the greater the subject's back extension muscle endurance.

Lumbar and Thoracic Flexion Range of Motion

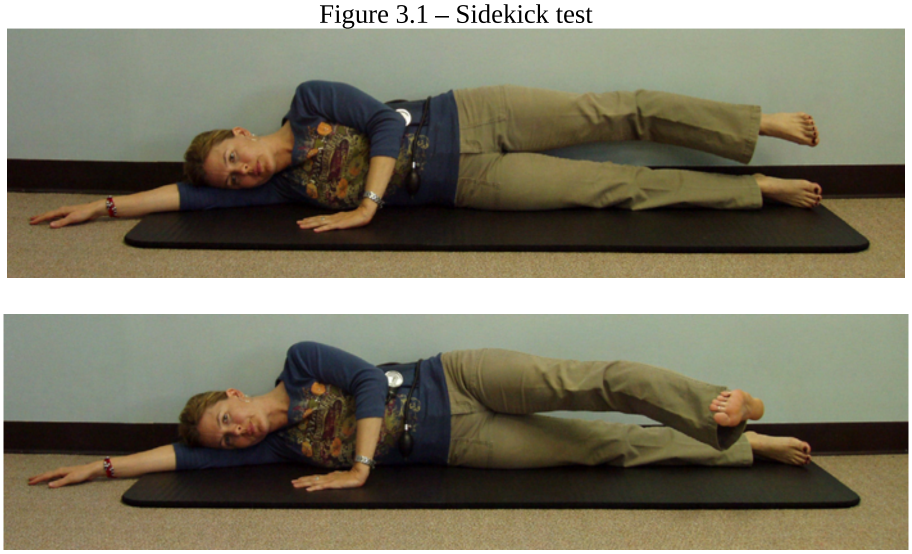
Lumbar and thoracic flexion ROM were determined with the Modified Schodber method (215); (105); (32); (63). The subject stood with their feet shoulder width apart. A horizontal line was drawn between the posterior, superior iliac crests, approximating the top of the sacrum. Additional marks were placed along the midline of the subject's back, 10 cm above and 5 cm below the first mark. The subject then flexed the trunk forward to the limit of motion. The distance between the highest and lowest marks was measured in standing and forward flexion. The difference between the two measures was calculated to give the amount of lumbar spinal flexion available. A similar procedure was utilized to determine thoracic spine ROM. The distance between the thoracic-lumbar junction and the first thoracic spinous process was measured in both standing and forward flexion to give the amount of thoracic spinal flexion available.

Motor control /Side Kick Test

The motor control /side kick test is a new test that was developed for this study. The test compares a passive SLR to an active SLR in side-lying. The side kick test was included to measure a subject's ability to stabilize their spine while moving their lower extremity into flexion. There is no validity or reliability data available for this test. Even with its limitations the test might provide basic and important information as it pertains to trunk stability.

Subjects were placed in side-lying, against a wall, with a sphygmometer between the lumbar spine and the wall. Subjects supported their head with their inferior arm extended in front of them. The superior arm supported the body with the hand in front of their chest. The superior greater trochanter was positioned directly vertical to the inferior greater trochanter. Subjects were asked to elevate the superior leg four to six inches off of the lower leg and to flex their hip with the knee extended, without loosing the neutral position of the pelvis. The ROM of the superior limb's hip flexion was recorded using a goniometer. The researcher monitored the sphygmometer while the subject flexed the superior limb to make sure that there was no more than 5 mm Hg displacement. If the pressure rose above 5 mm Hg, the subject was asked to stop and the goniometric measure taken. The greater the angle, in degrees, the more the subject was able to control spine stability and hip mobility (Figure 3.1). This required complex organization of the core muscles and lower extremity. If the subject under-recruits the core musculature, the leg will be over-bearing and cause the subject to loose their balance. If the subject over-recruits their core stabilization muscles, there will be carry over into the lower extremities and limit the ROM in the lower extremity.

Figure 3.1 – Sidekick test



Psychosocial Measures

Psychosocial outcomes were obtained through a self report questionnaire. This questionnaire consisted of the following scales: General Perceived Self-Efficacy (GSE), FSE, Fear of Re-Injury and the SF-36 Vitality sub-scale.

<u>The General Perceived Self-Efficacy Scale</u>

The GSE Scale (Appendix VI) by Ralf Schwarzer and Matthias Jerusalem is a ten question psychometric scale that is designed to assess self-beliefs in coping with difficult demands in life. The score for each question ranged from “1” (not at all true) to “4” (exactly true). The scores are added and divided by ten to produce an average score where the higher the score, the more positive the subject’s perception of ability. The GSE has been used in many psychological studies to assess the belief that one’s actions are responsible for successful outcomes (109).

The Functional Self-Efficacy Scale

The FSE scale (Appendix VII) is a 15 question psychometric scale that is designed to assess a subject’s self beliefs pertaining to their ability to perform a specific task. The FSE used a visual analogue scale referred to as a “Confidence Scale”. The score for each question ranged from “10” (not certain at all) to “100” (very certain). Subjects marked “N/A” for items that were not applicable. Of the questions answered, a total score was calculated and divided by the total possible score. This provided a score that ranged between zero to 100 percent, where the higher the score, the more confident the subject perceived their ability to accomplish the task. The tasks ranged from reaching to climbing stairs and lifting. In one study, higher scores on the FSE were correlated to higher performance of spinal function, using standardized behavioral measures of load lifting (120).

Expected Re-Injury/Pain Scale

The Expected Re-Injury/Pain Scale (Appendix VIII) is a 15 question psychometric scale that was designed to assess a subject’s perception of possible re-injury. The Expected Re-Injury/Pain scale is similar to the FSE scale and uses a visual analogue scale that ranges from “10” (very low possibility of re-injury) to “100” (very likely chance of re-injury). The Expected Re-injury/Pain Scale is a companion scale to the FSE scale and is a reliable measure of pain-related fear and kinesiophobia (fear of movement) (187); (48); (201).

The SF-36 Vitality Sub-Scale

The SF-36 Vitality sub-scale (Appendix IX) is a sub-scale of the SF-36 Health Status Survey and consists of four items that measure perceived energy levels and fatigue. The four questions have six responses ranging from “1” (all the time) to “6” (none of the time). The first two questions are designed in a positive context and the second two questions are written in a negative context. The SF-36 scoring guidelines rectify inverted items, providing a total where a higher score depicts a higher perception of vitality and energy.

Procedures

Each subject was screened through a phone interview, consented, measured at baseline and randomly assigned to either the active (Pilates) or passive (massage) intervention group. Interventions lasted six weeks, followed by a post-test measurement. Subjects agreed to a six and twelve month follow-up.

Screening

Potential subjects were asked over the telephone a battery of questions to determine if they met the inclusion/exclusion criteria for the study. Subjects had to commit to hour long sessions, two times per week for a period of six weeks.

Once a potential participant qualified for the study they were scheduled to be consented and assignment to a group.

Consent

Subject consent was taken in a one on one interview. The therapist that performed the consenting process reviewed the consent form with the subject, asked if there were any concerns or questions that pertained to the study and asked for the subject's signature. The consenter witnessed the subjects' signature and original copies were kept on file.

Randomization

Randomization occurred following the signing of the consent form. The subject was asked to draw one slip of paper from an envelope with an equal number of assignments for Pilates and massage. The slip of paper contained both the group and ID number assigned to the subject. After successful assignment to an intervention group, the subject was scheduled for baseline measurement with therapist blinded to the subjects' group assignment. Scheduling of Pilates classes and massages were performed by the Pilates instructor or massage therapist.

Baseline Measures

A physical therapy student was responsible for taking baseline physical measures and overseeing the written questionnaire. The student was trained by the principle investigator (PI) and kept blind to the subjects' intervention assignment. Training consisted of approximately four hours where the student practiced all the physical tests on the PI and then demonstrating the tests on another PT student while the PI observed. In addition, the student was educated on all of the written questionnaires and was instructed to make sure all of the measures and scales were complete and legible for data entry. Demographic data (Appendix III) on weight, height, recreational activities, smoking, general health problems and marital status were also obtained at the time of baseline measurement.

Interventions

Within one to two weeks of baseline measurement, the intervention treatments were started. The Pilates group met two times per week for six weeks and received a 50 minute Pilates Allegro class each session. A 50-60 minute class is standard in the Pilates industry. The teacher of the class was instructed to keep a personal attendance record for each subject and to make notes of any special concerns or complaints experienced by the subject. The class was designed to progress within the subjects' tolerance and to provide a positive movement experience without pain.

The massage therapist contacted the massage intervention subjects and scheduled the entire series of massages. Massages were 30 minute in length (61); (123), two times per week for six weeks. Massage was limited to the area between the gluteal folds and the head.

Post-Test Measures

Subjects were post-tested within seven days after they completed the last intervention session. Post-test measures were administered by the same physical therapy student examiner that performed the baseline measures. The student examiner was blinded to the group assignments of the subjects. The post-test measures included the same measures of activity and pain limitations, physical measures and psychosocial measures that were performed in the baseline measurement.

A six month and one-year follow up questionnaire was developed for this study. This information is not part of this current study.

Active (Pilates) Intervention Group

The Pilates Allegro Reformer (Figure 3.2) is a piece of equipment that evolved from the original Pilates Universal Reformer. The Reformer was the first piece of equipment designed by Joseph Pilates to aid students in their ability to perform the Pilates Mat exercises. The Allegro Reformer was later designed to offer Pilates equipment work in a group setting. The original group setting was taught on the floor and was known as “Pilates Mat”. The Pilates Reformer classes offered an assisted group class for those unable to perform the Pilates Mat exercises.

The Allegro Reformer classes consisted of six positions and up to 13 exercises with limitless variations to each exercise. Each exercise position was designed to progress the subject through a graded strengthening and awareness program specific to CLBP and RLBP. Each of the Pilates principles were integrated into the class. The exercises are presented by position and are defined by the primary objectives, expected benefits and modifications required. Photographic depictions are presented to provide an example of each of the basic exercises.

Supine

Classes begin with subjects in a supine position. This was the least challenging of positions with the largest base of support and the lowest center of gravity. The supine position was used to teach basic concepts of trunk organization, breath control and basic alignment. The following exercises are performed in supine.

Footwork is a simulated squatting exercise with various foot positions (weight bearing on heels or on metatarsal heads, legs in external rotation or internal rotation, feet together or wide apart) in supine (Figure 3.2).

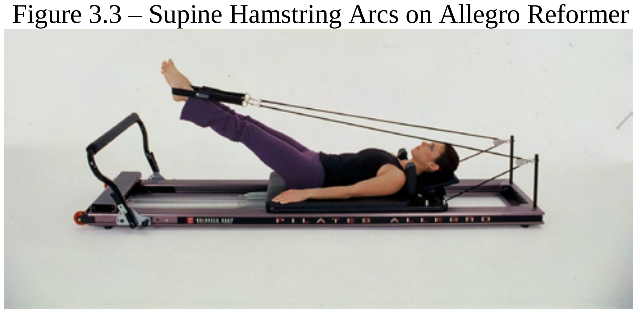
Figure 3.2 – Supine Footwork on Allegro Reformer

Breath was incorporated into the exercise (inhalation while bending knees, exhalation while straightening legs) to help facilitate trunk stabilization and core control during the movement. Awareness of alignment of the spine and lower extremities and the organization of the shoulder girdle and the head was facilitated by using verbal and tactile cues. The springs helped to assist hip disassociation and encourage stabilization of the pelvis and spine. The participants were thereby able to practice squatting strategy in a safe environment with proper biomechanics.

Modifications were implemented for participants with severe forward head posture by raising the head rest or adding a small pillow behind the head. The height and position of the reformer footbar were adjusted to accommodate each participant’s leg length and flexibility.

Hamstring Arcs are a core stabilization exercise that allows the legs to rise and lower with the assistance of the foot straps and springs (Figure 3.3).

Figure 3.3 – Supine Hamstring Arcs on Allegro Reformer

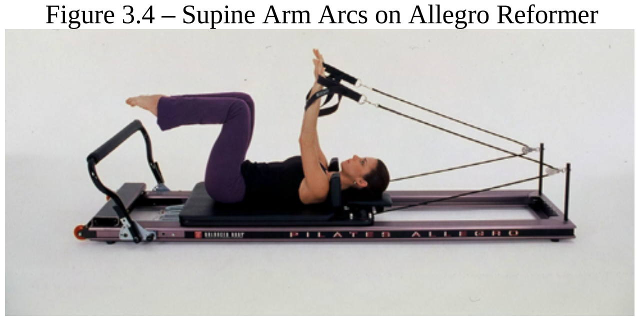


The primary objective was to challenge hip disassociation while stabilizing the pelvis in neutral. This exercise included the principle of breathing, inhaling while flexing the hips and exhaling while extending the hips, to facilitate core control. The spring assisted environment allowed the participants to perform many repetitions with less risk of fatigue and increased attention to alignment, coordination and movement integration. Additional benefits expected from hamstring arcs included increased hamstring flexibility and decreased muscle recruitment in the spine and lower extremities which often interferes with normal movement strategy (44); (78).

The teacher increased or decreased the degree of assistance depending on the weight of the legs by altering spring tension. Lighter springs provided for an increased challenge to core stability. Heavier springs provided more support to the weight of the legs. If the participants did not tolerate the long lever with knees extended, the loops were placed behind the knees and knees remained flexed.

Supine Arm Arcs challenges core stability and shoulder disassociation (Figure 3.4).

Figure 3.4 – Supine Arm Arcs on Allegro Reformer



Similar to the Hamstring Arcs exercise this exercise incorporated the principle of breathing, inhaling while flexing the shoulders and exhaling while extending the shoulders to facilitate core control. Additionally, moving the arms through different arcs in space challenged coordination and awareness of the upper extremities in relationship to the trunk. The expected benefits included increased efficiency of movement by decreasing unnecessary muscle recruitment in the spine and shoulder girdle which could interfere with normal movement strategies. The springs were adjusted as needed to make the exercise manageable and increase the likelihood of a successful movement experience.

The Bridging exercise involves articulating the spine up and down from the Reformer carriage, emphasizing segmental spine movement (Figure 3.5).

Figure 3.5 – Supine Bridging on Allegro Reformer

The primary objective was to introduce sagittal movement of the spine with non-destructive forces. The expected benefits were a decrease in unwanted muscle guarding and an increase in spinal flexion ROM without pain.

The subject's ROM in flexion was modified to avoid end of range flexion that might caused discomfort. Various images and verbal cues were used to facilitate a positive outcome.

Quadruped

The quadruped position on the Reformer decreases the subjects' base of support and tactile feedback, raises the subjects' center of gravity and increases weight bearing through upper and lower extremities.

The Quadruped Exercise facing the head of the Reformer maintains the upper body and torso still in space while flexing the hips and moving the carriage toward the hands (Figure 3.6).

Figure 3.6 – Quadruped Facing Head on the Reformer

The primary objective was to challenge hip disassociation and trunk stability in a more challenging position. The exercise focused on accurate alignment of the trunk and the extremities while incorporating the principle of axial elongation.

The expected benefits of the quadruped exercise was to increase lower abdominal strength (balance the relationship between dominant hip flexors and weak abdominals), improve shoulder girdle organization and increase the awareness of neutral spine.

The spring tension was decreased to make the exercise easier. Props and padding were used to reduce stress on the knees and wrists.

The Quadruped Exercise facing the foot of the Reformer is similar to the above exercise in its initial organization, however, the challenge when facing the foot of the Reformer occurs when moving the carriage away from the hands through hip and knee extension and through the addition of shoulder flexion (Figure 3.7).

Figure 3.7 – Quadruped Facing Foot on Allegro Reformer

The challenge of core control further increased when the arms and legs moved away from the trunk center or when the spring tension (assistance) was decreased and the forces of gravity challenged the anterior trunk musculature and core stability. The exercise focused on accurate alignment of the trunk and the extremities and incorporated the principle of axial elongation to facilitate efficiency.

The expected benefits included increased abdominal strength, shoulder girdle organization and increased awareness of neutral spine.

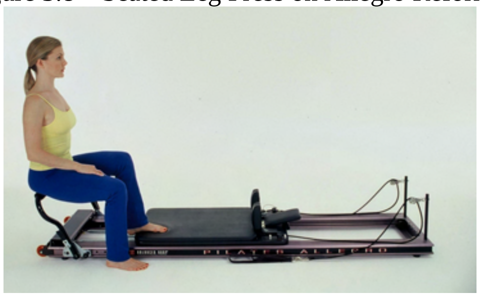
The spring tension was increased to decrease the challenge of the trunk musculature. Props and padding were used to reduce stress on the knees and wrists.

<u>Seated</u>

The seated position on the Reformer is the first functional Pilates position and continues to decrease the subjects' base of support and elevate their center of gravity.

The Seated Leg Press exercise is performed sitting on the footbar with one or both feet at the edge of the carriage. Balance is challenged by extending one or both of the knees (Figure 3.8)

Figure 3.8 – Seated Leg Press on Allegro Reformer



The primary objective was to facilitate correct sitting posture while maintaining balance and efficient trunk organization, and to decrease the recruitment of unwanted global stabilizers and mobilizers in the seated position.

The expected benefits were to increase tolerance, improve alignment and improve core control in a seated position. Participants were encouraged to hold onto the footbar of the Reformer and lighten the springs if they had difficulty maintaining their balance.

The Seated Arm Series on the box challenges the seated posture while moving the arms through space against spring resistance (Figure 3.9).

Figure 3.9 – Seated Arm Series on Allegro Reformer

The patterns of movement are similar to the Supine Arm Arc exercise; however the challenge to the trunk is increased due to a decreased base of support and an increased center of gravity. Greater emphasis was placed on thoracic and lumbar spine alignment and stability than arm strength. The expected benefits included improved balance and increased efficiency and awareness in seated postures. Spring tension was adjusted per participant to ensure appropriate challenge to the trunk and arms without discomfort.

The Seated Abdominal Series on the Box exercise is first performed by gently rolling the pelvis posteriorly and anteriorly, exploring segmental control of the spine against gravity (Figure 3.10).

Figure 3.10 – Seated Abdominal Series on the Reformer

The exercise was progressed by increasing ROM and introducing movement of the spine in the sagittal, coronal and horizontal planes with non-destructive forces. The primary objective was to increase awareness and strength of the trunk in the functional position of sitting. Emphasis was placed on the principle of axial elongation while articulating the spine against gravity.

The expected benefits were to develop a more efficient seated posture with the ability to incorporate subtle movement strategies without harmful forces. The participants were encouraged to stay in a pain free zone by minimizing the ROM.

Kneeling

Kneeling on the Reformer is the next progression of posture and further decreases the base of support and increases the challenge to trunk stability with external forces through the arms.

The Kneeling Arm Series on the Reformer is similar to the Seated Arm Series but due to a decrease in the base of support and the increased center of gravity there is an increased challenge to balance (Figure 3.11).

Figure 3.11 – Kneeling Arm Series on Allegro Reformer

The moving carriage increases the challenge to proprioception and provides an unstable surface under the knees while the arms move the body and carriage through space. The decreased stability of the carriage increases the need to recruit deep stabilizers and at the same time recruiting the global stabilizers and mobilizers. This requires an increased coordination between the muscle groups to execute the movement successfully. If there is an over recruitment or under recruitment of any of the muscle groups the participant will loose their balance. The successful execution of the above exercise may have a positive effect on the participants' perception of their ability to perform a challenging exercise.

Participants who were unable to perform the exercise in high kneeling were encouraged to perform the exercise seated on the box. The seated position is much easier than the kneeling but continues to provide a challenge to the core stabilization muscles.

Standing with One Foot on Reformer

Standing with one foot on the Reformer is a transitional position between kneeling and standing. This position provides more stability by having one foot on the ground while the other is on the Reformer carriage.

The Scooter exercise with hands on the footbar is performed with one foot on the floor and the other against the shoulder rest. The objective is to maintain the pelvis neutral while extending the hip and knee, pressing the carriage away from the footbar (Figure 3.12).

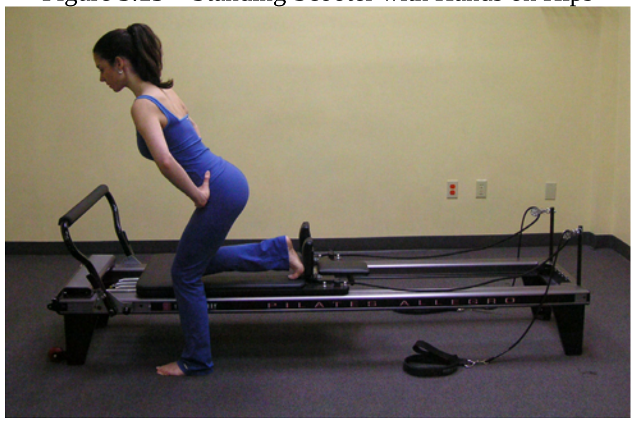
Figure 3.12 – Standing Scooter with Hands on the Footbar

Stability and proprioception of the trunk were challenged due to the lack of tactile feedback and visual reference. The participants were encouraged to maintain the pelvis in neutral while repeatedly extending the gesture leg (the foot on the carriage). The standing leg was challenged to maintain balance and proper alignment.

The expected benefits were to increase an awareness of trunk stabilization in a more functional orientation to gravity and to introduce reciprocal organization without harmful forces to the lumbar spine. The above exercise is a progression from the Quadruped exercises and if the participants were unable to perform this exercise they were encouraged to perform one of the more stable quadruped exercises.

Scooter with Hands on Hips is a continuation of the above exercise and increases the challenge to proprioception and balance (Figure 3.13).

Figure 3.13 – Standing Scooter with Hands on Hips



The balance challenge is greatly increased by removing hands from the bar. The expected benefits include those of the above exercise as well as the increased perception of their ability to successfully perform more advanced exercises. Without the hands on the footbar, the exercise becomes more functional and increases the challenge to the strength of the lower extremities and trunk muscles.

<u>Standing</u>

Standing on the Reformer is another functional posture in the Pilates repertoire of exercises. One foot is placed on the stable surface of the Reformer and the other foot is on the moving part (carriage).

The Standing Series incorporates standing hip abduction and adduction with the legs extended and with the knees bent (Figure 3.14).

Figure 3.14 – Standing Series on Allegro Reformer

The objectives of the above exercise were to improve alignment and to improve the neuromuscular connection between the torso and the lower extremities. Participants were encouraged to integrate the following principles; breathing, core control, axial elongation, efficient organization of the shoulder, head and upper torso, alignment and movement integration.

The expected benefits were to improve postural awareness in standing and challenge proprioception on a moving surface. Successful execution of the Standing Series on a moving surface may decrease the difficulty of walking and squatting on a stable surface. The spring resistance was raised to increase the sense of safety or was decreased to add challenge to inner thigh strength and to balance.

Design of Pilates Intervention Program

The Pilates intervention consisted of a six-week program with two Pilates Allegro Reformer sessions per week. All exercises were performed on the Pilates Allegro Reformer. Each session lasted approximately 50 minutes. The first two weeks consisted of exercises that emphasized disassociation of the hips from the spine and stabilization of the pelvis. The focus was on decreasing potentially harmful forces to the lumbar spine and re-educating functional posture of supine, sitting, kneeling and standing. The third and fourth weeks consisted of exercises that emphasized spine articulation with non-destructive forces. This was done by adding spring assistance and organizing the subject's orientation with gravity to minimize harmful forces and provide movement through out the spine without going to end range. The final two weeks consisted of exercises that emphasized functional movement in both a foreign and familiar environment. All of the exercises were modified to meet the specific needs of the subjects. The focus of the class was to provide a positive movement experience without pain. Each class focused or challenged the six principles at an attainable level. In addition, each class addressed five to eight different positions on the Pilates Allegro Reformer further reinforcing functional posture positions applicable to their activities of daily living.

Instructions Given to the Pilates Class Instructor

The Pilates instructor was instructed to introduce herself to the class on the first day and conduct an orientation to the equipment, the class and the principles. The instructor provided the purpose of the class (a positive movement experience without pain) before each session. This verbal instruction before each class reinforced the mission of the class. If at anytime a subject felt increased discomfort, they were to inform the instructor immediately and the instructor would modify to exercise to help make it a positive movement experience without pain. The instructor was informed to not discuss the study further with any of the participants.

The instructor kept a daily log for of each of the subjects and included any complaints, absences or difficulties that might have occurred during class. Up to two make-up sessions were allowed at the end of the six weeks. If a subject was not compliant with the program and missed more then two classes, the principle investigator was notified immediately and the subject was removed from the study. At the end of the intervention the instructor facilitated the scheduling of the post-testing.

Passive (Therapeutic Massage) Intervention Group

A licensed massage therapist with more than 5 years experience provided an individual session of approximately 30 minutes, two sessions per week, over a six-week period (61); (123). The therapist was professionally trained and allowed to utilize the following techniques as part of the passive intervention: superficial fluid techniques (e.g. effleurage), neuromuscular techniques (e.g. pétrissage) and connective tissue techniques (e.g. deep tissue, friction massage).

The therapist was instructed to use massage therapy techniques to reduce LBP by relaxing the subject, increasing muscle pliability and decrease connective tissue restrictions. Therapist was instructed to make the session a positive experience by matching the appropriate massage technique to the needs of the subject. For example, if the subject's LBP was found to be related to increased stress, then massage techniques with the purpose of relaxation (e.g. effleurage, superficial techniques) were used, if the subject's LBP was caused by structural restrictions, then connective tissue techniques (e.g. deep friction massage, neuromuscular massage) were used. Each technique was performed with the desired outcome to improve the dependant variables identified in this study using the ICF model (activity limitations, pain limitations, physical impairments and psychosocial).

The low back area was the primary focus of the massage intervention but the therapist was permitted to work from the gluteal folds to the base of the head in a prone position. Subjects were exposed and draped according to proper massage procedures and massage lotions or mediums were used as appropriate. A log book of techniques and daily outcomes were kept by the license massage therapist on each subject. The logbook included any complaints or relevant comments made by the subject.

Data Analysis

The study hypotheses were analyzed using a PC Statistical Analysis Software (SAS) version 9.1.3. An additional analysis was conducted only on subjects with CLBP, where CLBP was defined as a single episode greater than three months. Subjects with RLBP were excluded from this analysis because the massage and Pilates groups differed somewhat in the proportion of subjects with RLBP. RLBP involves multiple acute episodes of LBP which tend to resolve over time. An analysis was restricted to subjects with CLBP eliminated the possibility that differences in clinical improvement between the massage and Pilates might be due to differences in the proportion of subjects with RLBP.

Hypothesis 1: Subjects who receive Pilates will demonstrate a greater improvement in activity limitation than will subjects who receive massage.

A two-group (Pilates and massage), repeated measures (pre-post intervention) analysis of variance (ANOVA) was calculated to compare the two groups in terms of change in activity limitation (Oswestry and MBI Disability sub-scale).

Hypothesis 2: Subjects who receive Pilates will demonstrate a greater improvement in pain than will subjects who receive massage.

A two-group (Pilates and massage), repeated measures (pre-post intervention) ANOVA was calculated to compare the two groups in terms of change pain (SF-36 Pain sub-scale and MBI Pain sub-scale).

Hypothesis 3: Subjects who receive Pilates will demonstrate a greater improvement in physical factors than will subjects who receive massage.

A two-group (Pilates and massage), repeated measures (pre-post intervention) ANOVA was calculated to compare the two groups in terms of change in physical factors (abdominal strength, back extensor strength, trunk flexibility and motor control/side kick).

Hypothesis 4: Subjects who receive Pilates will demonstrate a greater improvement in psychosocial factors than will subjects who receive massage.

A two-group (Pilates and massage), repeated measures (pre-post intervention) ANOVA was calculated to compare the two groups in terms of change in psychosocial factors (FSE, GSE, Fear of Re-injury, SF-36 Vitality sub-scale)

Hypothesis 5: There will be a relationship between the change in activity limitation and pain and the change in physical factors.

Spearman correlation coefficients were calculated to examine the relationship between changes in activity limitation and pain (Oswestry, MBI

Disability sub-scale, SF-36 Pain sub-scale and MBI Pain sub-scale) and changes in physical factors (abdominal strength, back extensor strength, trunk flexibility and motor control/side kick).

Hypothesis 6: There will be a relationship between the change in activity limitation and pain and the change in psychosocial factors.

Spearman correlation coefficients were calculated to examine the relationship between changes in activity limitation and pain (Oswestry, MBI Disability sub-scale, SF-36 Pain sub-scale and MBI Pain sub-scale) and changes in psychosocial factors (FSE, GSE, Fear of Re-injury, SF-36 Vitality sub-scale).

Chapter 4 – Results

While strong trends were found in the data, only two of the measures achieved statistical significance ($p \leq 0.05$). This study was underpowered with an effect size of .42 calculated between the massage and Pilates groups. Given a p-value of 0.05, the power to detect a difference in the change scores was 0.23. This resulted in a 77% chance of producing a Type II error. In order to achieve a power of 0.8 there would need to be approximately 150 subjects enrolled in the study.

Thirty-one subjects signed consent forms to participate in the study and were evaluated at the clinic. Twenty-one subjects participated in the post-test measurements. Of the ten subjects who did not complete the study, five subjects dropped from the study due to personal reasons, two were asked to discontinue participating secondary to non-disclosure of information in the screening process that would have excluded them from the study and three were lost to follow-up due to their refusal or inability to contact them.

Data was collected from September, 2003 through March, 2004. Data was analyzed using PC SAS version 9.1.3. The dependent variables were activity limitation measures, pain measures, physical measures and psycho-social measures. These variables represent the major constructs included in the modified ICF model. The dependent variables were evaluated for the active (Pilates) and passive (massage) intervention groups prior to and following treatment protocols.

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Demographics

Demographic information regarding subject characteristics is shown in Table 4.1. The proportion of men and women in the two groups was approximately equal, with 52% (11) male and 48% (10) female. Ages ranged from 25 to 62 with a average age of 43. Subjects' mean height was 5'7"and mean weight was 163 lbs.

Table 4.1 - Subject Characteristics

Variable	Frequency/Range	Percentage/Average
Sex:		
Male	11	52%
Female	10	48%
Age:	25 to 62	43
Marital Status:		
Single	11	52%
Married	7	33%
Divorced	3	14%
Height:	5'2" to 6'4"	5'7"
Weight:	122 lbs to 230 lbs	163 lbs

Medical and Work History

Medical and work related history is shown in Table 4.2. Ninety-five percent of the subjects (20) reported being non-smokers. Ninety percent of subjects (19) reported taking some form of pain medication for their LBP with the majority (14) taking NSAIDS.

All of the subjects were referred for either RLBP or CLBP. Sixteen subjects were classified with CLBP. Of the 16 CLBP subjects, nine were assigned to massage and seven were assigned to Pilates. RLBP was differentiated from CLBP based on symptom duration and the number of reoccurrences. The number of back pain episodes ranged from 1 to >12. Of the five RLBP subjects, three were assigned to Pilates and two were assigned to massage.

Subjects reported the degree of physical labor associated with their work or ADLs. The majority of subjects (20) were employed in positions that required only light to moderate activity. Work productivity was assessed by asking the subject how many days of work had to be taken off last year. If the subject was not employed, they were asked to record the number of days that they could not perform their regular ADL's. An average of two days in the past year had to be taken off per subject with a total of 41 days taken off for the 21 subjects in the study.

Table 4.2 - Medical and Work History

Variable	**Frequency/Range**			**Percentage/Average**		
	Pilates	Massage	Total	Pilates	Massage	Total
Smoking:						
Smoker	0	1	1			5%
Non-smoker	10	10	20	0%	10%	95%
Medications:						
Narcotics	2	2	4	20%	18%	14%
NSAID	8	6	14	80%	55%	67%
COX II Inhibitor	3	0	3	30%	0%	14%
Acetaminophen	1	2	3	10%	18%	14%
Salicylates	0	2	2	0%	18%	10%
Total			19			90%
Number of Back Pain Episodes:						
CLBP	8	8	16	80	73%	76%
RLBP	2	3	5	20	27%	24%
Total			1 to >12			2
Amount of Physical Labor:						
Light	5	8	13	50	73%	62%
Moderate	4	3	7	40	27%	33%
Heavy	1	0	1	10	0%	5%
Days Off Work due to Back Pain: 41 Days Total Taken Off	5	5	0 to 10	50	45%	2

Baseline Comparisons

T-tests were calculated to compare baseline demographic characteristics and outcome scores of the massage and Pilates groups. There were no statistically significant differences between the groups however, there was a substantial difference between the groups in duration of current LBP episode (Table 4.3).

Table 4.3 - Baseline Demographic Variables

Variable	Group	N	Mean	Std. Dev	T-Value	P-Value
Age (years)	Massage	11	44.00	13.46	0.29	0.78
	Pilates	10	42.40	11.98		
Episode (number)	Massage	11	4.63	4.82	-0.31	0.76
	Pilates	10	5.30	4.95		
Duration of Current LBP Episodes (months)	Massage	11	58.00	103.74	1.23	0.24
	Pilates	10	18.10	26.97		

Baseline measures were divided into three categories for analysis of equality between groups. These categories included activity limitation/pain variables, physical variables and psychosocial variables (Tables 4.4-4.6).

In the activity limitation and pain measures the Oswestry, MBI Disability and MBI Pain measures were all found to be lower at baseline for the Pilates group but not statistically different (Table 4.4). The lower the score in the above measures represents a relatively healthier group at baseline.

Table 4.4 - Baseline Activity Limitation/Pain Variables

Variable	Group	N	Mean	Std. Dev	T-Value	P-Value
Oswestry	Massage	11	18.55	5.91	0.82	0.42
	Pilates	10	16.70	4.16		
MBI Disability	Massage	11	30.17	14.61	1.47	0.16
	Pilates	10	21.31	12.75		
MBI Pain	Massage	11	39.28	15.59	0.78	0.45
	Pilates	10	33.48	18.57		
SF-36 Pain	Massage	11	6.35	2.48	-1.02	0.32
	Pilates	10	7.30	1.69		

There was no statistical difference at base line between the two groups, however the Pilates group had a higher baseline score in back extension strength 78.5 seconds compared to the massage group 45.88 seconds; and trunk flexion strength for the Pilates group was 96.2 seconds where the massage group was 61.88 seconds (Table 4.5).

Table 4.5 - Baseline Physical Variables

Variable	Group	N	Mean	Std. Dev	T-Value	P-Value
Abdominal Strength	Massage	11	51.38	21.80	0.26	0.80
	Pilates	10	50.90	24.20		
Back Extension Strength	Massage	11	45.88	28.70	-0.82	0.42
	Pilates	10	78.50	50.70		
Trunk Flexion Strength	Massage	11	61.88	44.60	-1.25	0.23
	Pilates	10	96.20	81.30		
Motor Control	Massage	11	40.19	10.90	0.12	0.91
	Pilates	10	43.20	22.30		
Thoracic Flexion ROM	Massage	11	2.81	2.10	0.45	0.66
	Pilates	10	2.72	1.40		

In the psychosocial measures there was no differences statistically at baseline. The FSE baseline measurement between groups was close to statistical significance (p = 0.14) with the Pilates group having a higher mean score (.82) than the massage group (.66), where the higher the score represents a relatively healthier perception of ability (Table 4.6).

Table 4.6 - Baseline Psychosocial Variables

Variable	Group	N	Mean	Std. Dev	T-Value	P-Value
General Self-Efficacy	Massage Pilates	11 10	34.64 32.30	1.96 4.22	1.65	0.11
Functional Self-Efficacy	Massage Pilates	11 10	0.66 0.82	0.25 0.13	-1.55	0.14
Expected Re-injury	Massage Pilates	11 10	0.43 0.41	0.24 0.17	0.56	0.58
SF-36 Vitality Sub-Scale	Massage Pilates	11 10	14.13 13.40	3.10 3.10	0.24	0.81

Ten subjects dropped from the study, four from the Pilates group and six from the massage group, prior to completion of the post-testing. Baseline measurements for subjects who dropped from the study were compared to baseline measurements for subjects who completed the study in order to determine if there were any significant differences (Table 4.7). No significant differences were found between subjects who dropped out and subjects who completed the study. However, the group who withdrew from the study tended to have greater baseline strength, greater fear of re-injury and lower vitality than the group who completed the study.

Table 4.7 – Baseline Comparison between Subjects Who Dropped From the Study and Those That Completed the Study

Variable	Group	N	Mean	Std. Dev	T-Value	P-Value
Oswestry	Dropped Completed	10 21	19.40 17.63	4.6 5.1	-0.67	0.51
MBI Disability	Dropped Completed	10 21	35.21 25.74	16.70 14.87	-1.60	0.12
SF-36 Pain (rectified)	Dropped Completed	10 21	6.49 6.83	2.43 1.67	0.46	0.65
MBI Pain	Dropped Completed	10 21	37.38 36.38	15.43 17.30	-0.22	0.83
Abdominal Strength	Dropped Completed	10 21	66.40 51.14	12.28 22.51	-1.98	0.06
Trunk Flexion Strength	Dropped Completed	10 21	99.90 79.04	65.73 68.06	-0.71	.48
Back Ext. Strength	Dropped Completed	10 21	53.10 62.19	53.00 44.48	0.58	0.57
Motor Control	Dropped Completed	10 21	39.90 41.70	14.92 17.76	0.30	0.77
Trunk Flexion ROM	Dropped Completed	10 21	2.32 2.77	1.55 1.69	0.67	0.51
General Self-Efficacy	Dropped Completed	10 21	32.30 33.34	4.19 3.56	0.62	0.54
Functional Self-Efficacy	Dropped Completed	10 21	0.69 0.74	0.14 0.20	0.89	0.38
Fear of Re-Injury	Dropped Completed	10 21	0.55 0.42	0.14 0.20	-1.92	0.07
Vitality	Dropped Completed	10 21	11.30 13.77	4.47 3.03	1.71	0.10

Specific Aim 1

<u>Hypothesis 1: Subjects who receive Pilates will demonstrate a greater improvement in activity limitation than will subjects who receive massage</u>.

A two-group, repeated measures ANOVA was calculated to compare the groups (Pilates and massage) in terms of change in Oswestry and MBI Disability sub-scale scores (Table 4.8). Both the Pilates and massage groups showed a decrease in disability measured by the Oswestry, with a greater decrease in the Pilates group. The MBI Disability sub-scale also demonstrated a decreased disability in the Pilates and massage groups, with a greater decrease in the Pilates group.

Table 4.8 – Data Analysis of Activity Limitation Variables

Factor	Pilates			Massage			p-value
	Pre mean/sd	Post mean/sd	% Change	Pre mean/sd	Post mean/sd	% Change	
Oswestry	16.7 4.2	13.9 5.7	16.8% decrease	18.5 5.9	17.9 7.2	3.2% decrease	0.3466
MBI-Disability	21.3 12.7	15.9 12.8	25.4% decrease	30.2 14.6	23.8 14.1	21.2% decrease	0.8417

Hypothesis 2: Subjects who receive Pilates will demonstrate a greater improvement in pain than will subjects who receive massage.

A two-group, repeated measures ANOVA was calculated to compare the groups (Pilates and massage) in terms of change in SF-36 Pain sub-scale and MBI Pain sub-scale scores (Table 4.9). The MBI Pain sub-scale showed a decrease in pain in both the Pilates and massage groups, with a greater pain decrease in the Pilates group. The SF-36 Pain sub-scale showed a decrease in pain for the Pilates group (9.6% increase) and a small increase in pain for the massage group (1.6% decrease). It is important to keep in mind that all SF-36 scores have been rectified so that higher scores signify improvement in the specific area.

Table 4.9 – Data Analysis of Pain Variables

Factor	Pilates			Massage			p-value
	Pre mean/ sd	Post mean/ sd	% Change	Pre mean/ sd	Post mean/ sd	% Change	
SF-36 Pain (rectified)	7.3 1.7	8 1.2	9.6% increase	6.3 2.5	6.2 2.5	1.6% decrease	0.2264
MBI- Pain	33.5 18.6	24.2 14.7	27.8% decrease	39.3 15.6	35 18	10.9% decrease	0.4743

<u>Hypothesis 3: Subjects who receive Pilates will demonstrate a greater improvement in physical factors than will subjects who receive massage.</u>

A two-group, repeated measures ANOVA was calculated to compare the groups (Pilates and massage) in terms of change in abdominal strength, back extensor strength, trunk flexibility and motor control (Table 4.10). Although the Pilates group improved more than the Massage group in all measures of strength and flexibility only the change in back extensor strength achieved statistical significance. Both the massage and Pilates groups improved in trunk flexion ROM, and abdominal strength. For all other physical measures, the Pilates group improved and the massage group stayed the same or declined.

Table 4.10 – Data Analysis of Physical Variables

Factor	Pilates			Massage			p-value
	Pre mean/sd	Post mean/sd	% Change	Pre mean/sd	Post mean/sd	% Change	
Abdominal Strength	50.9deg 24.2	42.3deg 26.4	16.9% increase	51.4deg 19.1	49.4deg 27.8	3.9% increase	0.712
Trunk Flexion Strength	96.2sec 81.3	113.1sec 73.0	17.6% increase	60.7sec 45.3	60.3sec 64.1	0.7% decrease	.3499
Back Extensor Strength	78.5sec 50.7	93.5sec 50.3	19.1% increase	62.5sec 38.6	44.1sec 34.1	29.4% decrease	0.0274
Motor Control	43.2deg 22.3	50.1deg 16.6	16.0% increase	44.1deg 13.8	41deg 20.4	7.0% decrease	0.3439
Trunk Flexion ROM	2.7cm 1.4	4.3cm 2.6	59.3% increase	3cm 1.9	3.7cm 2.5	23.3% increase	0.3244

* Statistically significant results are highlighted

Hypothesis 4: Subjects who receive Pilates will demonstrate a greater improvement in psychosocial factors than will subjects who receive massage.

A two-group, repeated measures ANOVA was calculated to compare the groups (Pilates and massage) in terms of change in FSE, GSE, Fear of Re-injury and SF-36 Vitality sub-scale scores (Table 4.11). No significant difference was found in GSE, FSE or fear of re-injury. GSE demonstrated a mild positive increase in the Pilates group and a mild shift in the negative direction in the massage group. FSE experienced a small negative change by 1.2% in the Pilates group and a moderate positive change by 11.4% in the massage group. Fear of re-injury was an inverted scale where a decrease in score represents a positive change. Both Pilates and Massage groups improved, but more so for the Pilates group.

The SF-36 Vitality sub-scale was found to be statistically significant (p = 0.04). The Pilates group had an increased vitality while the massage group did not change.

Table 4.11 – Data Analysis of Psychosocial Variables

Factor	Pilates			Massage			p-value
	Pre mean/sd	Post mean/sd	% Change	Pre mean/sd	Post mean/sd	% Change	
General Self-Efficacy	32.3 4.2	33.4 3.2	3.4% increase	34.6 2	34.1 3.7	1.5% decrease	0.2732
Functional Self-Efficacy	0.82 0.13	0.81 0.15	1.2% decrease	0.7 0.22	0.78 0.13	11.4% increase	0.1543
Fear of Re-Injury	0.41 0.17	0.33 0.12	19.5% decrease	0.46 0.22	0.43 0.24	6.5% decrease	0.5825
SF-36 Vitality	13.4 3.1	15.7 2.1	17.2% increase	13.7 3.2	13.7 2.8	No Change	0.0415

* Statistically significant results are highlighted

Specific Aim 2

<u>Hypothesis 5: There will be a relationship between the change in activity limitation and pain and the change in physical factors.</u>

Spearman correlation coefficients were calculated to examine the relationship between changes in activity limitation and pain and changes in physical factors. No statistical significance was found. Trends were identified where r > 0.25 and are highlighted in Table 4.12. There were moderate to weak relationships between pain (MBI) and trunk flexion ROM (r = -0.25), pain (SF-36) and abdominal strength (r = 0.27), pain (SF-36) and motor control (r = -0.31) and between disability (MBI) and trunk flexion ROM (r = -0.36).

Table 4.12 – Relationship between Activity Limitation, Pain and Physical Factors

Factors	Change in Oswestry	Change in MBI Disability	Change in SF36 Pain	Change in MBI Pain
Change in Abdominal Strength	r = .0939 p = .6856	r = .0228 p =.9218	r =.2731 p =.2310	r = -.0013 p =.9955
Change in Back Extensor Strength	r = -.1168 p = .6140	r =.1482 p =.5213	r =.0974 p =.6746	r = -.1732 p =.4528
Change in Motor Control	r = -.0261 p .9107	r =.0403 p =.8624	r = -.3080 p =.1744	r =.0585 p =.8011
Change in Trunk Flexion ROM	r = -.2306 p = .3146	r = -.3580 p =.1110	r = -.2292 p =.3176	r = -.2505 p =.2734

* Trends, identified by r ≥ .2500, are highlighted

<u>Hypothesis 6: There will be a relationship between the change in activity limitation and pain and the change in psychosocial factors.</u>

Spearman correlation coefficients were calculated to examine the relationship between changes in activity limitation and pain and changes in psychosocial factors. Statistical significance was found in the relationship between the change in two SF-36 sub scales, Vitality and Pain (p = 0.03). Trends were identified where r ≥ .25 and are highlighted in Table 4.13. There were moderate to weak relationships between pain (MBI) and vitality (r = -0.29), disability (MBI) and vitality (r = -0.29), disability (Oswestry) and fear of re-injury (r = 0.30), pain (SF-36) and GSE (r = 0.30), pain (SF-36) and fear of re-injury (r = -0.32), disability (Oswestry) and FSE (r = -0.34), disability (MBI) and FSE (r = -0.36), pain (MBI) and FSE (r = -0.36), disability (MBI) and fear of re-injury (r = .40) and between pain (SF-36) and vitality (r = .47).

Table 4.13 – Relationship between Activity Limitation, Pain and Psychosocial Factors

Factors	Change in Oswestry	Change in MBI Disability	Change in SF36 Pain	Change in MBI Pain
Change in General Self -Efficacy	r = -.1811 p = .4320	r = .0848 p = .7147	r = .2987 p = .1884	r = .0059 p = .9798
Change in FSE	r = -.3429 p = .1281	r = -.3610 p = .1078	r = -.2134 p = .3530	r = -.3641 p = .1047
Change in Fear of Re-Injury	r = .2992 p = .1876	r = .3961 p = .0755	r = -.3191 p = .1586	r = .2419 p = .2908
Change in Vitality	r = -.2282 p = .3197	r = -.2875 p = .2063	r = .4727 p = .0304	r = -.2853 p = .2100

* Trends, identified by r ≥ .2500, are highlighted

Data Analysis for CLBP

An additional analysis was conducted on the CLBP population. RLBP was excluded to evaluate the possibility of it being a confounding factor due to the acute nature of RLBP injuries. There were nine subjects with CLBP in the Pilates group and seven subjects with CLBP in the massage group. Table 4.14 shows the mean scores and change between pre-test to post-test scores for subjects with CLBP in the study.

Table 4.14 – Mean Scores and Percentage Change for Subjects with CLBP

Factors	**Pilates (9)**			**Massage (7)**		
	Pre Means	Post Means	% Change	Pre Means	Post Means	% Change
Oswestry	16.57	13.57	18.1% decrease	18.88	18.33	2.9% decrease
MBI Disability	20.76	14.03	32.4% decrease	28.22	20.85	26.1% decrease
SF-36 Pain (rectified)	7.19	7.76	7.9% increase	6.4	6.27	2.0% decrease
MBI Pain	36.96	23.98	35.1% decrease	37.45	34.19	8.7% decrease
Abdominal Strength	49	41.57	15.2% increase	51.89	54.78	5.6% decrease
Trunk Flexion Strength	115.00	127.86	11.2% increase	66.44	67.00	0.8% increase
Back Ext. Strength	97.57	107.41	10.1% increase	56.88	43.44	23.6% decrease
Motor Control	47.42	53.71	13.3% increase	42	34.38	18.1% decrease
Trunk Flexion ROM	2.51	3.94	57.0% increase	3.05	3.72	22.0% increase
General Self-Efficacy	31.86	32.86	3.1% increase	34.56	34.11	1.3% decrease
Functional Self-Efficacy	0.83	0.81	2.4% decrease	0.72	0.79	9.7% increase
Fear of Re-Injury	0.39	0.33	15.4% decrease	0.44	0.41	6.8% decrease
SF-36 Vitality	12.57	15.71	25.0% increase	13.44	13.88	3.3% increase

* Inverted measures are highlighted

Changes in the mean scores were then compared between all subjects and CLBP subjects to observe the effect that the RLBP population had on the study (Table 4.15). Notable changes in the effect of an intervention were found in the Pilates group for MBI Pain and SF-36 Vitality and in the massage group for abdominal strength and motor control.

Table 4.15 – Comparison of Change Scores between All Subjects and CLBP Subjects

Factors	Pilates		Massage	
	All Subjects	**CLBP**	**All Subjects**	**CLBP**
Oswestry	16.8% Decrease	18.1% decrease	3.2% decrease	2.9% decrease
MBI Disability	25.4% Decrease	32.4% decrease	21.2% decrease	26.1% decrease
SF-36 Pain (rectified)	9.6% Increase	7.9% increase	1.6% decrease	2.0% decrease
MBI Pain	27.8% Decrease	35.1% decrease	10.9% decrease	8.7% decrease
Abdominal Strength	16.9% Increase	15.2% increase	3.9% increase	5.6% decrease
Trunk Flexion Strength	17.6% Increase	11.2% increase	0.7% decrease	0.8% increase
Back Ext. Strength	19.1% Increase	10.1% increase	29.4% decrease	23.6% decrease
Motor Control	16.0% Increase	13.3% increase	7.0% decrease	18.1% decrease
Trunk Flexion ROM	59.3% Increase	57.0% increase	23.3% increase	22.0% increase
General Self-Efficacy	3.4% Increase	3.1% increase	1.5% decrease	1.3% decrease
Functional Self-Efficacy	1.2% Decrease	2.4% decrease	11.4% increase	9.7% increase
Fear of Re-Injury	19.5% Decrease	15.4% decrease	6.5% decrease	6.8% decrease
SF-36 Vitality	17.2% Increase	25.0% increase	no change	3.3% increase

* Notable differences are highlighted

Chapter 5 - Discussion

The only statistically significant findings for this study were in back extension strength and vitality where the Pilates group demonstrated an improvement significantly greater than the massage group. Although most of the findings of this study did not achieve statistical significance, subjects who received Pilates improved more than the subjects who received massage on all of the physical, psychosocial, pain and activity limitation measures except FSE. Therapeutic massage had a positive effect on the Oswestry, MBI Disability and Pain, abdominal strength, trunk flexion and fear of re-injury but to a lesser extent compared to the Pilates group. The massage group showed a greater improvement in FSE than the Pilates group.

Subjects

The distribution of the demographic data was similar between groups. Male and female subjects were equally represented. The subject's average height of 5'7'' fell within the national average (153). The subjects' average weight of 163 lbs fell below the national average, which is 164 lbs for women and 191 lbs for men in 2002 (147).   Demographically the two groups were similar except for duration of symptoms.

At baseline, the average duration of symptoms appeared to differ between the Pilates and Massage groups (Table 4.3). There was one subject in the massage group that was an outlier and reported LBP duration greater than 360 months. The data analysis was repeated after removing the outlier data and no significant change in baseline comparison or the trends of the results were found other than duration.

The majority of the baseline measures of activity, pain, physical and psychosocial factors appeared to be similar between groups. Two of the physical measures, trunk flexion strength and back extension strength, were much better in the Pilates group at baseline than the massage group. All of the activity limitation and psychosocial measures were lower at baseline for the Pilates group except for SF-36 Vitality. A few of the baseline measures experienced a ceiling or floor effect, where the baseline differences might allow one group to improve and the other not. The ceiling and floor effects were apparent in the FSE, Oswestry and MBI Disability with a greater effect in the Pilates group.

While no significant difference was found, the average baseline scores in many of the categories suggested that subjects in the Pilates group experienced less severe LBP at baseline compared to subjects in the massage group. In addition, both groups appeared to represent a healthier than normal CLBP and RLBP population than might be experienced in a typical clinic setting. The high health status of the subjects might explain some of the studies limitations, specifically in measures that had a ceiling or floor effect. The scales and indices that were used in this study were not sensitive to change in a healthy population which might account for the small changes observed. Because a between groups, repeated measures ANOVA was used, where the comparison measure was performed on the differences between pre-test and post-test measures and not overall scores, the study's outcomes should theoretically not be affected by baseline differences.

An unexpected outcome was the negative change in the FSE scores for the Pilates group and the improvement in the massage group. The baseline measures were quite different between the groups, where the Pilates group was approximately 11% higher than the massage group. The massage group experienced a total improvement of 11.4% but still did not reach the average score of the Pilates group at baseline. The most likely explanation for the above finding is that the Pilates group had no room to improve on the FSE scale but the massage group did.

The self-efficacy scores seemed to suffer a ceiling effect with the lowest GSE score at 83% of the maximum score and the lowest FSE score at 79% of the maximum score. Because the literature showed a correlation between low self-efficacy and LBP it was believed that these scores would be lower at baseline (120).

In the recruitment process two groups of subjects were identified and admitted into the study, CLBP and RLBP. There is little literature that has compared the two groups, but there were differences noted in change in outcomes between the groups. Of the 16 subjects with CLBP who completed the study, nine were assigned to the massage group and seven to the Pilates group, creating a relatively equal distribution. CLBP subjects were analyzed separately from RLBP subjects to determine if there were any specific differences in how the different populations responded to the interventions (Table 4.15). Only marginal differences were noted. The table below shows the direction of change in response to treatment when RLBP subjects were removed form the data (Table 5.1).

Table 5.1 - Response to treatment between CLBP and all subjects

Category	Pilates	Massage	Measures
1	Increased	Increased	MBI Disability, SF-36 Vitality
2	Increased	Decreased	Oswestry, MBI Pain
3	Decreased	Increased	Back Ext. Strength,
4	Decreased	Decreased	Motor Control, Trunk Flexion ROM, Abd Strength, GSE, FSE, Fear of Re-Injury, SF-36 Pain

Both groups experienced an increased response in the MBI Disability and SF 36 Vitality scales when RLBP subjects were removed from the analysis. A decreased response to treatment was marginal in all physical measures and psychosocial scales. The Pilates group demonstrated a marginal increased response on the Oswestry and MBI Pain scales and the massage group experienced a marginal decreased response when RLBP subjects were removed from the analysis. Lastly, the massage group experienced an increased response in back extension strength when compared to the mixed subjects (RLBP and CLBP), however the change was still negative compared to the pre measure.

The decreased response after the RLBP subjects were removed from the analysis might be due to the tendency of the RLBP subjects being healthier upon entering the study and the increased likelihood of spontaneous improvement, similar to outcome of ALBP (2). The actual impact of the interventions on CLBP might be more accurate by avoiding mixing the RLBP population.

Thirty-one subjects signed consent forms, 21 of which completed the study. It was hypothesized that the ten subjects who dropped from the study might have different baseline psychosocial scores compared to those subjects that decided to participate. The data for the ten subjects who dropped from the study revealed no significant difference between the baseline scores in the subjects who dropped from the study compared to those that finished post-testing (Table 4.7). A greater number of subjects might have dropped from the Pilates group because they perceived that Pilates was too difficult because of their activity limitations. Additional demographic information that might help define sample populations in future studies include medical diagnosis, previous interventions, co-morbidities, educational levels and social support status.

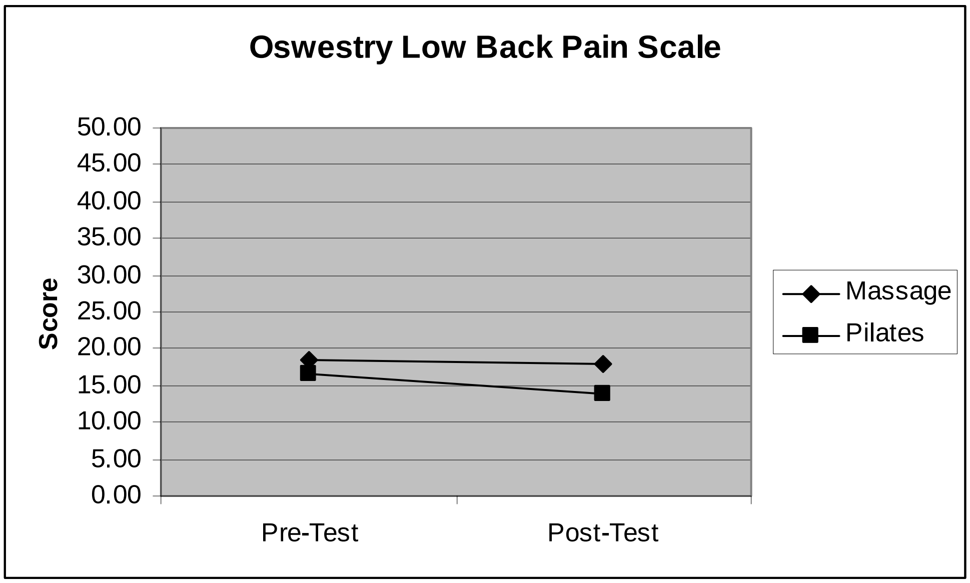
Hypothesis 1: Subjects who receive Pilates will demonstrate a greater improvement in activity limitation than will subjects who receive massage.

The Oswestry and MBI Disability subscale improved for both groups, however the improvement found in the Pilates group was greater than the improvement in the massage group. This improvement was not found to be significant and failed to support the hypothesis.

The Oswestry LBP Scale

Disability scores improved in the Pilates group by 16.8% and improved in the massage group by 3.2% (Figure 5.1). Although no statistical significance was achieved between the groups, the Pilates group demonstrated a change that was 4.7 times greater than the massage group. The lack of statistical significance in both groups may have been due to a floor effect, where the subjects entered the study with a low disability score therefore leaving little room for change. The lack of significance may have also been due to the lack of power in the study. When the RLBP subjects were removed from the analysis, the Pilates group increased to 18.1% improvement and the massage group worsened to 2.9% improvement.

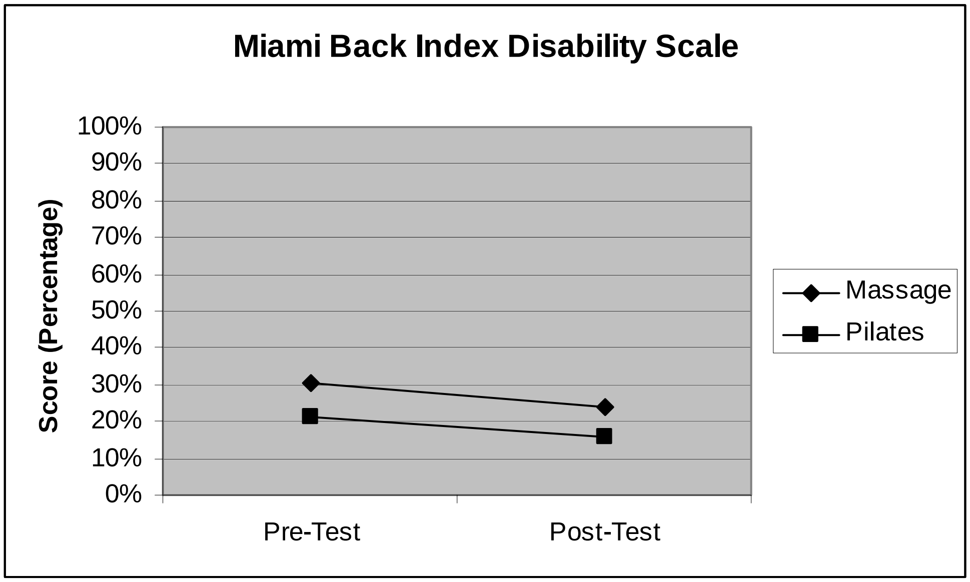
Figure 5.1 – Pre-Test/Post-Test Oswestry LBP Graph Comparing Groups



The Miami Back Disability Scale

Both intervention groups demonstrated an improvement in the MBI Disability sub-scale (Figure 5.2). Both groups had similar findings; the massage group improved 21.2%, while the Pilates group had a 25.4% improvement. The baseline measure for the Pilates group was 9% higher than the massage group. Both groups might have experienced a floor effect due to the baseline measures being so good. When the CLBP was analyzed independently, both groups demonstrated a greater improvement with a 32.4% improvement in the Pilates group and a 26.1% improvement in the massage group.

Figure 5.2 – Pre-Test/Post-Test MBI Disability Graph Comparing Groups



The results showed that both groups perceived their ability to perform ADLs to be high at baseline. The massage and Pilates groups showed improvements in both tests. The Pilates group had a greater improvement in perceived ability compared to the massage group in the Oswestry, but a slightly lesser improvement compared to massage for the MBI Disability sub-scale. The MBI Disability sub-scale examines perception of ability irrelevant of pain levels, while the Oswestry ties the two factors together in its questions. The Pilates group demonstrated a larger decrease in pain than the Massage group; see Table 4.9, which might explain why Pilates had greater impact on Oswestry scores than MBI disability. It could also be due to the fact that the Pilates group hit the bottom of the MBI scale and had no room to improve. The Massage group's positive effect on activity limitation measures is supported by Hernandez-Reif et al. (2001), that found massage therapy effective in reducing pain and stress and improving performance (94). Van den Dolder and Roberts (2003) showed that massage improved reported function (194).

The literature disagrees as to whether the pain perception measures (Oswestry, SF-36 Pain, MBI Pain) or disability measures (MBI Disability, FSE) are better predictors of function (9); (13); (120). The findings above suggest that pain perception is a better predictor; however, baseline disability measures (MBI Disability and FSE) were high to begin with in both groups and left little room for change. Disability measures might have a stronger predictive strength with a more severely disabled group.

The study was unable to support the literature claiming that active intervention has a greater effect on improving disability measures than passive interventions for the CLBP population (192); (189); (188); (72); (34). Further work is required to explore the impact of Pilates on activity limitation in patients with low back pain.

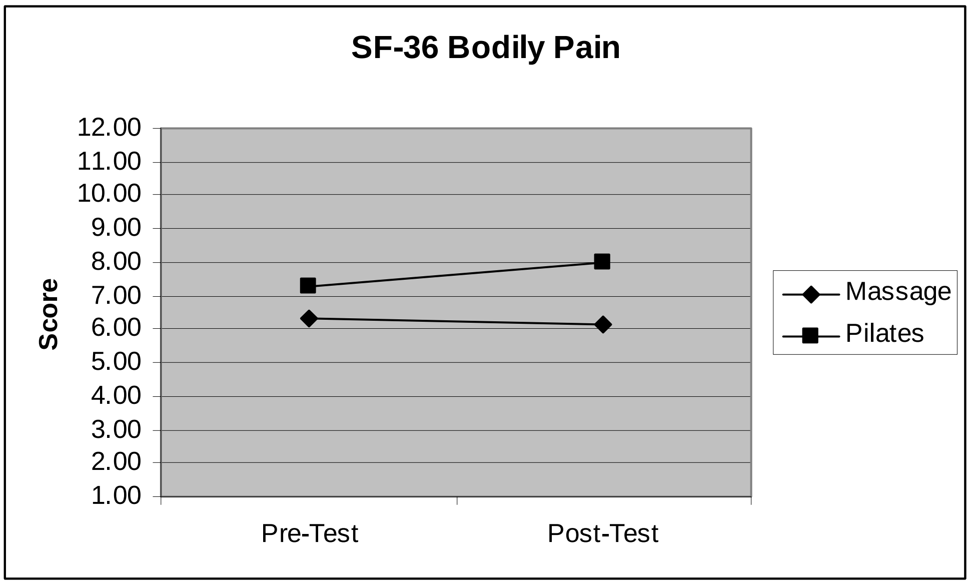
Hypothesis 2: Subjects who receive Pilates will demonstrate a greater improvement in pain than will subjects who receive massage.

The second hypothesis used the SF-36 BP sub-scale and the MBI Pain sub-scale to assess activity limitations as they relate to pain. No significant differences were found between the passive and active interventions, failing to support the hypothesis.

SF-36 Bodily Pain Sub-Scale

The SF-36 BP sub-scale measured the perception of pain's interference with ADL's. The massage group showed a 1.6% increase in pain while the Pilates group showed a 9.6% decrease in pain (SF-36 scores are rectified, so higher scores indicate decreased pain) (Figure 5.3).

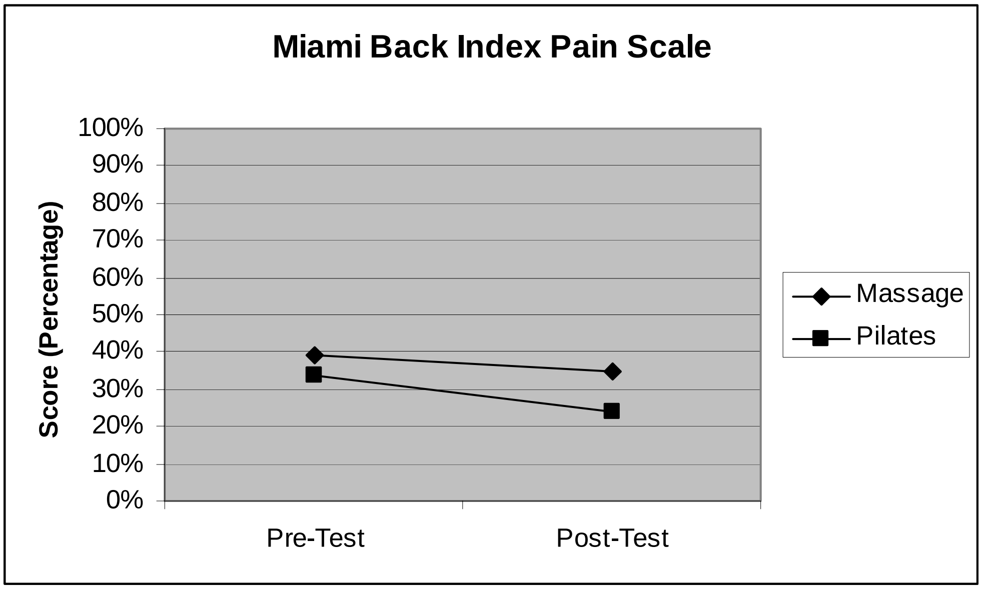
Figure 5.3 – Pre-Test/Post-Test SF-36 BP Graph Comparing Groups



Miami Back Index Pain Sub-scale

Both the massage and Pilates groups showed improvement in the MBI Pain sub-scale. However, the Pilates group demonstrated a greater decrease in pain (27.8%) than the massage group (10.9%) (Figure 5.4).

Figure 5.4 – Pre-Test/Post-Test MBI Pain Graph Comparing Groups



No statistical significance was found for either measure, but both groups did manifest positive changes. The MBI Pain scale is similar to the MBI Disability scale and appeared to have a similar floor effect. Despite the apparent floor effect, the Pilates group demonstrated over twice the amount of change than the massage group. In a sub-analysis of just the CLBP subjects, the change in the MBI Pain improved for the Pilates group (35.1%), while the massage group was still experiencing a positive change, the average change decreased to (8.7%) (Table 4.15).

The Pilates group's improvement in activity and pain limitation measures may be due to the active intervention providing a positive movement experience without pain (85). This type of movement experience might beneficially influence their confidence in functional activities that were previously associated with pain (177); (48); (216); (201).

The findings for the massage group response on the MBI Pain scale showed a decrease in pain, supporting evidence found in the literature stating that massage relieves pain (221); (194); (94), though it has been shown to be temporary and best when accompanied by exercise (75); (162).

In opposition, the massage group's response on the SF-36 Pain sub-scale demonstrated a slight increase in pain following the six week intervention, where the Pilates group showed a decrease in pain in support of literature that showed active intervention having greater impact on pain measures than passive intervention for CLBP (171); (186); (48); (201); (216).

Hypothesis 3: Subjects who receive Pilates will demonstrate a greater improvement in physical factors than will subjects who receive massage.

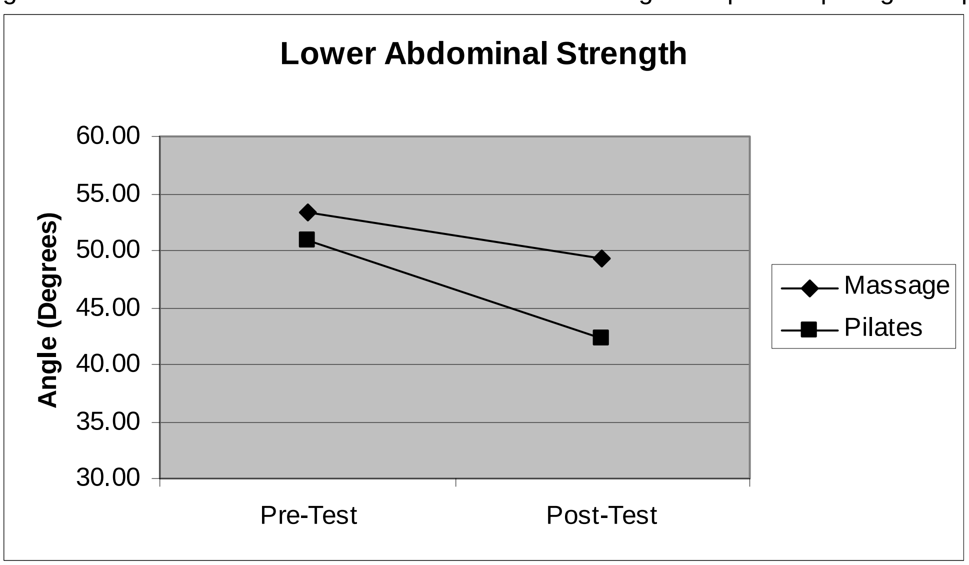
Standardized physical measures were conducted to assess changes in physical factors related to CLBP and RLBP. The hypothesis was supported significantly for the Back Extension Strength measure only. The other three measures showed no significant difference between groups.

Lower Abdominal Strength

Research showed that lower abdominal strength, coordination and alignment were associated with a healthy back and had a negative correlation with LBP (102); (101). In this study, abdominal strength was measured in degrees and represented the ability to control the lumbar spine on the table while the subject lowered straight legs; the lower the angle of the legs the greater a subjects abdominal strength. Both groups demonstrated improvement, however, the change in the Pilates group was over twice the change in the massage group (Figure 5.5). The larger increase in the Pilates group (16.9%) was expected due to the emphasis on core control and abdominal strength (44); (111); (149); (168). The change in the massage group (3.9%) was not anticipated and might be due to the pain relief provided from the massage (41); (42); (75). By decreasing pain, muscle inhibition is decreased and muscle recruitment might have been partially restored. The change in both groups might also be due to the acute behavior of RLBP which results in decreased pain in two to four weeks generally (2).

In the sub-analysis of CLBP, the massage group actually decreased (5.6%) in strength over the six week intervention. If the pain reduction expected in RLBP had been an influencing factor, a spontaneous improvement would have been observed, regardless of the intervention.

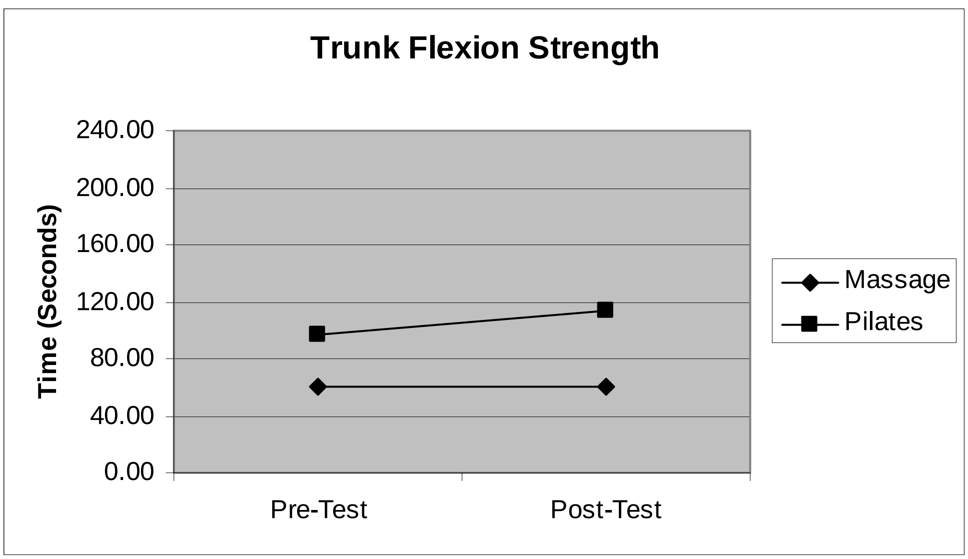
Figure 5.5 – Pre-Test/Post-Test Lower Abdominal Strength Graph Comparing Groups



Trunk Flexion Strength

Trunk flexion strength assessed upper abdominal muscle strength and endurance. Subjects were asked to rise up until their shoulders were off of the table and maintain that position for as long as possible (up to 240 seconds). The measure was in seconds and a higher score demonstrated greater endurance. The Pilates group (17.6% increase) continued to demonstrate a greater change than the massage group (0.7% increase) (Figure 5.6). Pilates exercises have a strong emphasis on abdominal control and trunk stabilization, therefore, an improvement in trunk flexion strength was expected (44); (101); (102); (149); (172).

Figure 5.6 - Pre-Test/Post-Test Trunk Flexion Strength Graph Comparing Groups

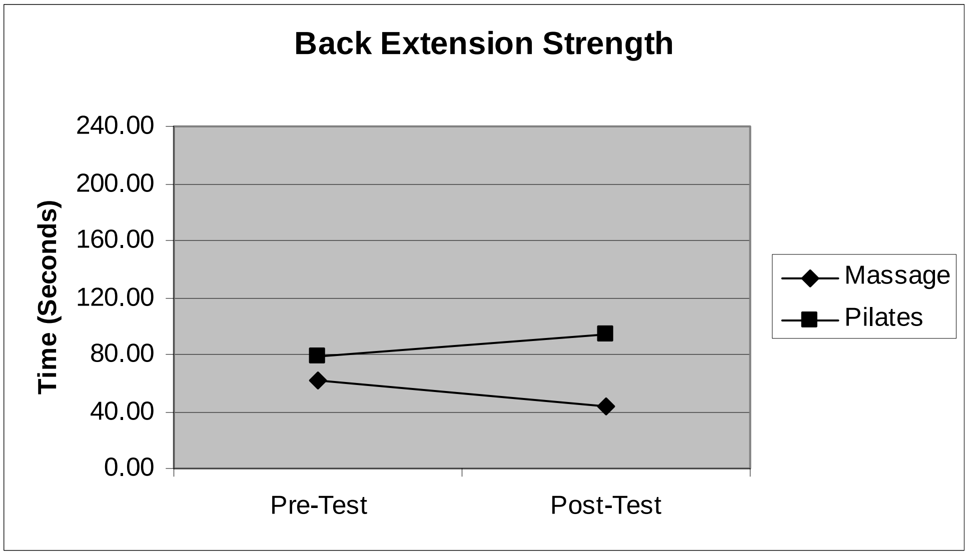


Back Extension Strength

Back extension strength measured strength and endurance of the back extensor muscles. Subjects were asked to lie over a barrel in a prone position and lift their head, neck and shoulders until their back was parallel to the floor. Subjects were asked to maintain this position for as long as possible and total time was recorded in seconds (up to 240 seconds). A greater time represented greater strength and endurance of the back extensor muscles. The Pilates intervention showed a significant improvement when compared to the massage group (p = 0.03). The Pilates group showed a 19.1% increase in back extension strength, while the massage group showed a 29.4% decrease in strength (Figure 5.7). Evidence supporting increased back extension strength through massage by Pope M.H. et al. (1994) was not supported by the findings (159). The findings did however support literature that showed massage being ineffective in muscle endurance, (98); (183). A possible reason for the decrease in the back strength in the massage group might be due to persistent pain, which would correlate with the results of the SF-36 BP scale, where the massage group experienced a negative trend in reported pain overall might have impeded their back extension strength.

The improvement in the Pilates group may be associated with changes in alignment, pain, organization of pelvic stability and muscular strength as a result of therapeutic exercise without pain (113); (114); (115); (44); (21); (206).

Figure 5.7 - Pre-Test/Post-Test Back Extension Strength Graph



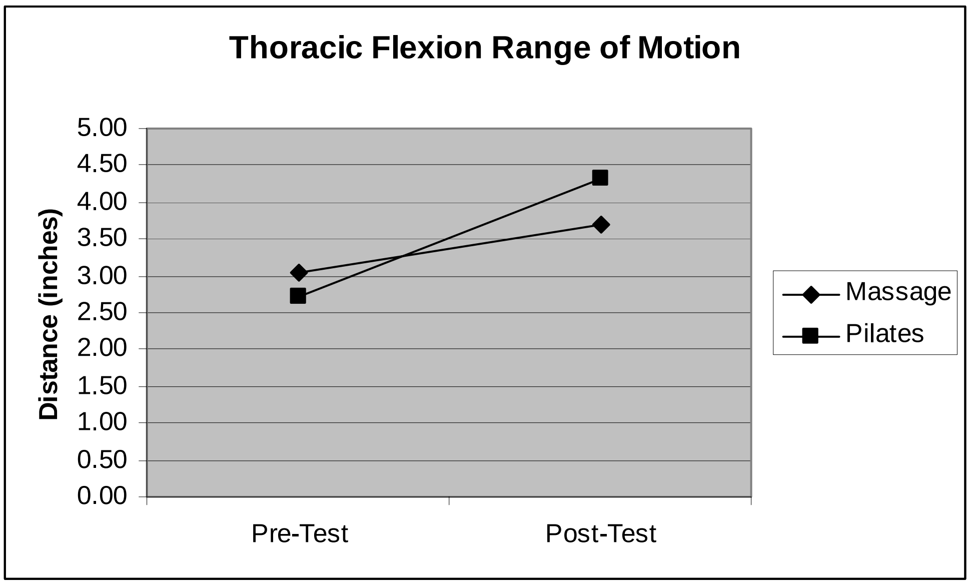
Trunk Flexion Range of Motion

Trunk flexion ROM measured the difference from a standing posture to a forward bent posture. A greater difference signified increased ROM over the six-week intervention period. The Pilates and the massage groups both showed improvement, but the Pilates group changed by 59.3% while the massage group only changed by 23.3%, less than half of the Pilates group (Figure 5.8).

Massage can provide an analgesic effect, decrease muscle guarding, relax the large extensor muscles and result in an increase in trunk flexion (53) (221); (194); (98); (94). The slight increase in ROM after massage, according to the literature seems to have only a temporary effect (49). The post measures were taken after the last session for both groups. No later measurements were taken and the author is unable to make a statement regarding the longevity of the effect.

In the Pilates group the increase in ROM might also be related to a change of motor strategy. The Pilates group was exposed to many movement sequences that explored more efficient motor learning strategies pertaining to functional movement. The Pilates principles pertaining to efficiency of movement and core control relate to a more efficient stabilization of the spine that permits increased movement of the spine through space. The decreased pain and increased ROM that were observed might support the theory that a distribution of movement and forces can minimize destructive or painful forces to the spine (43); (149); (126); (184).

Figure 5.8 - Pre-Test/Post-Test Thoracic Flexion ROM Graph



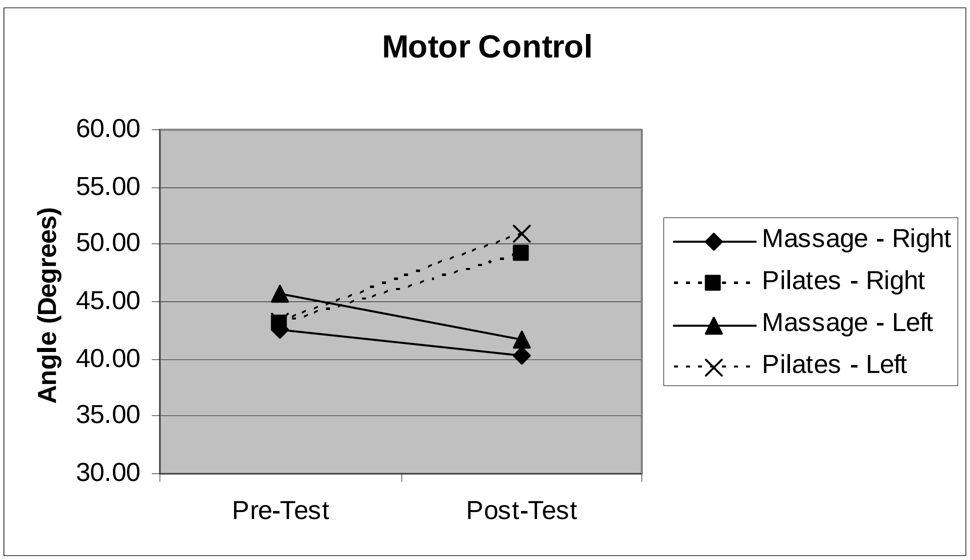
Motor Control & Coordination

Sidekick coordination is a new measure used to assess coordination and stability. There are currently no reliability or validity studies that have been performed on this measure and caution should be taken when extrapolating its findings. The test for all intensive purposes is intended to be a dynamic measure of the coordination between trunk stability and hip mobility.

The Pilates group demonstrated an improvement of 16.0% for both legs and the massage group demonstrated a loss of 7% (Figure 5.9). Because of the combination between stability and mobility required to perform this test and the change noted, the sidekick test might prove to be a better predictor of physical change as a result of a graded active intervention than some of the other physical measures currently used (126); (149); (184). Future research should be conducted comparing the Sidekick Measure in subjects with LBP to subjects without LBP and compare these results with other standard physical measures.

A Spearman correlation was performed between physical measures. The change in sidekick demonstrated a moderate correlation with the change in abdominal strength and change in hamstring length.

Figure 5.9 - Pre-Test/Post-Test Motor Control Graph



The decrease in the sidekick test after six weeks of massage could be due to the absence of neuromuscular re-education. Even if the pain decreases, it has been shown that neuromuscular inhibition of the deep stabilizers continues, leaving patients subject to future insults (97); (95); (96).

The Pilates class provided assisted movement with the lower extremities while the subjects were encouraged to maintain a neutral pelvis (see figure 3.2). In this way, the motor control necessary to balance between stability and mobility was learned in a less challenging, assisted environment (77); (78); (44); (126); (149); (184). Subjects in the Pilates group demonstrated an improvement in the sidekick test even though no exercise was introduced in the Pilates class that mimicked the position of the sidekick test. Motor learning that occurs in the Pilates may address faulty compensatory patterns that create sub-optimal strategies and potentially preserve segmental stability (143).

Theoretically, poor organization of the trunk and extremities may account for additional insults to the spine that frequently occur while LBP patients perform their regular ADLs. According to recent research, subjects who suffer from RLBP, even though their LBP had decreased and they felt like they could return to normal ADLs (77); (78), remain ill prepared to handle these activities due to weakened deep local stabilizers (111); (112). The inhibition of the deep stabilizers post-injury has been confirmed using ultrasound and MRI imaging (97); (96). Muscular inhibition was shown to facilitate an over-recruitment of global stabilizers, such as the gluteus maximus, hip flexors and quadratus lumborum. This over-recruitment could potentially decrease accessibility to functional ROM, increasing harmful forces to the spine (95); (96); (97).

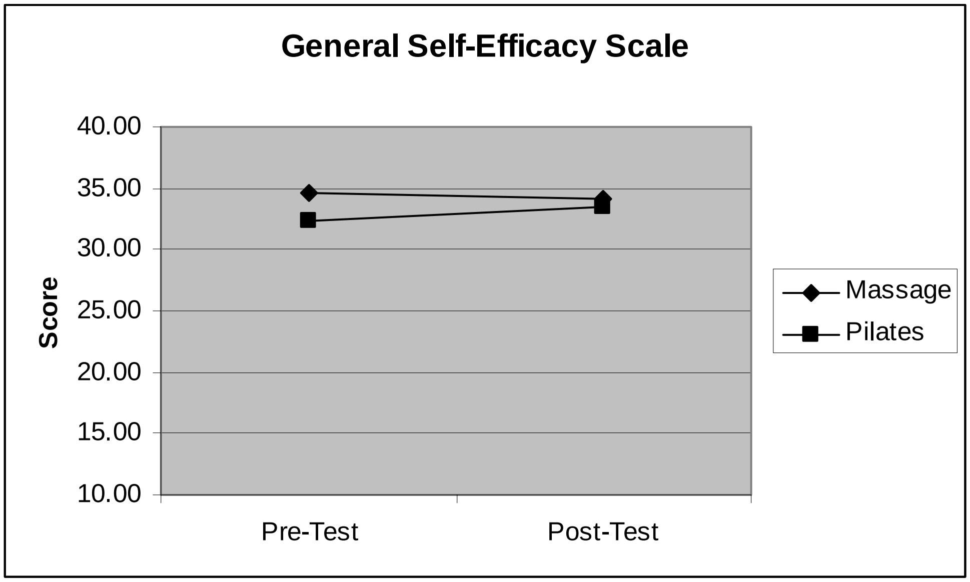
Hypothesis 4: Subjects who receive Pilates will demonstrate a greater improvement in psychosocial factors than will subjects who receive massage.

The results of the psychosocial indices for the Pilates and massage interventions were mixed. The SF-36 sub-scale “Vitality” was the only psychosocial measure that achieved statistical significance and supported the hypothesis. The other three measures included were GSE, FSE and fear of re-injury which were not found to be significantly different between groups.

The General Self-Efficacy Scale

The GSE scale does not relate directly to LBP but addresses coping strategies and beliefs of ability to cope with difficult demands in life, including physical pain limitations. The Pilates group demonstrated an improvement of 3.4% while the massage group demonstrated a small decline of 1.5% (Figure 5.10). Similar to the disability measures, the subjects in both groups demonstrated a high baseline measure which limited the amount of possible improvement. It is also possible that this measure is not relevant for CLBP. In the future, a more impaired subject population may provide a better determination if the GSE is an appropriate and useful measure for CLBP.

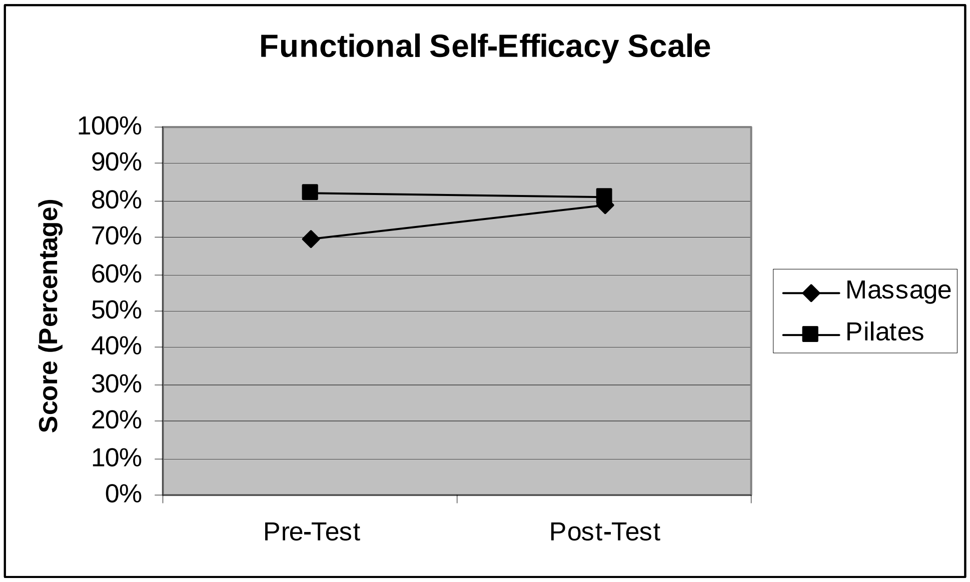
Figure 5.10 – Pre-Test/Post-Test General Self-Efficacy Graph



<u>The Functional Self-Efficacy Scale</u>

The FSE measure was the only test where the Pilates group did not show an improvement; the Pilates group declined by 1.2% and the massage group improved by 11.4% (Figure 5.11). Both groups started with a relatively high FSE score but there was also a substantial difference at baseline between the two groups. The Pilates group started at a mean score of 82% while the massage group started at a mean score of 70%. Even with the 11.4% improvement, the massage group did not exceed the Pilates group average baseline score.

Figure 5.11 – Pre-Test/Post-Test Functional Self-Efficacy Graph



Cowen et al., in a study awaiting publication on Pilates and CLBP, found a mean baseline measurement in FSE that was lower than 30%. The mean FSE score after a private Pilates intervention with a physical therapist had risen to 70% (46). The baseline FSE scores in the current study were higher than the final FSE scores in the Cowen et al. Pilates study. This discrepancy in FSE scores may be related to a volunteer bias. Subjects who actively seek out or volunteer for research studies may have higher FSE scores than patients sent to a therapist for treatment. This possible bias requires further investigation and a modification to the inclusion criteria to capture LBP patients that score lower on the FSE scale. The above findings failed to support the literature showing active intervention of successful exercises without pain would have a positive change on FSE scores (120); (204); (216); (8).

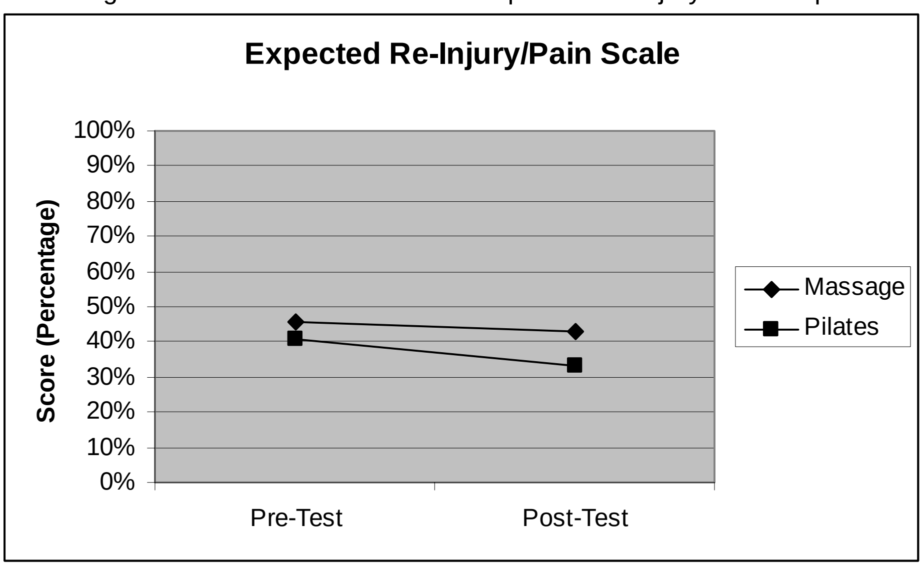
The results did show a positive trend for the massage intervention on the FSE scale. There is evidence that supports massage as having impact on perception and emotional states (94); (80); (81); (185). The massage group also experienced a ceiling effect and warrants further studies to truly evaluate the impact of massage with a more severely disabled population.

<u>Expected Re-injury/Pain Scale</u>

The Fear of Re-Injury scale measured subjects' expectation of re-injury and is related to the FSE. In this study both groups scored just under 50% at baseline. The Pilates group had a 19.5% improvement in fear of re-injury while the massage group had a 6.5% improvement (Figure 5.12). In future studies either the fear of re-injury or Fear Avoidance Back Questionnaire should be used to examine subjects level of anxiety regarding their injury (201); (216).

Even though the study was underpowered, the trend indicated that both interventions had an impact on fear of re-injury measures, and supported literature showing that treatment, that influences pain levels might influence a positive change in fear expectation scales (186); (201); (216); (129); (119).

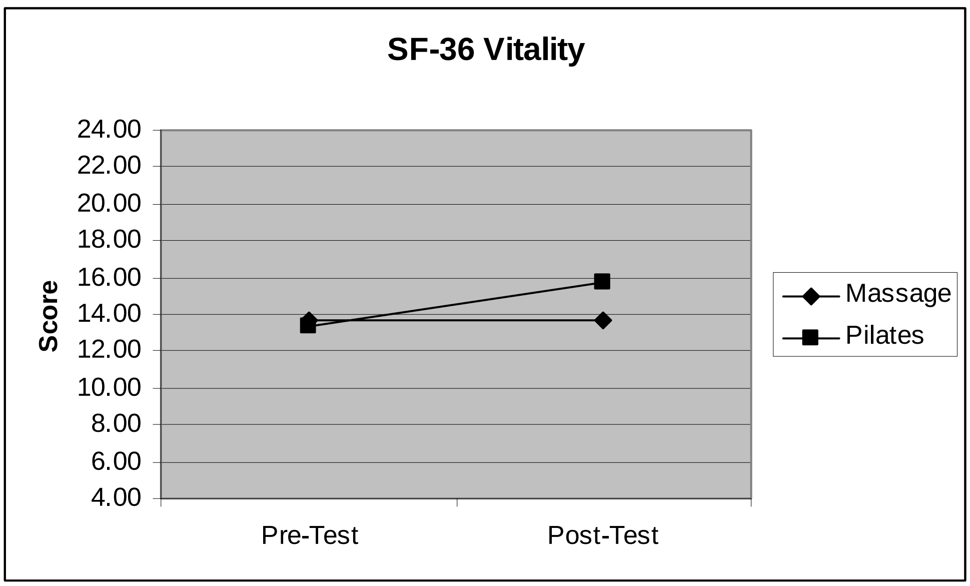
Figure 5.12 – Pre-Test/Post-Test Expected Re-injury/Pain Graph



<u>The SF-36 Vitality</u>

The SF-36 Vitality sub-scale is a two question index that looks at the subject's energy level and compares it to their fatigue. The Pilates group had a significant change in vitality compared to the massage group (p =0.04).
The Pilates group had a 17.2% increase in vitality while the massage group score did not change (Figure 5.13). Vitality was found to correlate with several of the activity limitation measures, in particular the MBI Pain sub-scale supporting the hypothesis that psychosocial measures would correlate with activity and pain limitations.

Figure 5.13 – Pre-Test/Post-Test SF-36 Vitality Graph



A common clinical result of Pilates is a client reporting "I feel so much energy", "I feel happier" or "I feel less fatigue in my daily activities". Because Pilates exercise is partially based in breathing and movement of energy, it would make sense that increased perception of energy might result from Pilates. No cueing was used or discussion conducted with the subjects pertaining to an expected increase in energy. From a physiological framework energy can be increased by increasing oxygen uptake, improving posture and improving efficiency of movement. Vitality deserves further investigation as it relates to predictors of functional outcome and quality of life measures.

Evidence of massage improving mood and emotional state was not supported by the above findings (94); (80); (81); (185). It did support similar findings in a study by Drews et al. (1990) when massage was performed on elite athletes no change in mood profile was found post intervention (61).

Hypothesis 5: There will be a relationship between the change in activity limitation and pain and the change in physical factors.

The results showed a modest correlation between the change in physical measures and the change in activity limitation measures (Table 4.12). There were four results that manifested a modest correlation ($r \geq .25$); the change in trunk flexion ROM compared to the change in both the MBI disability and pain sub-scales, the change in the sidekick (motor control) measure compared to the change in the SF-36 BP sub-scale and the change in abdominal strength with the change in SF-36 BP sub-scale.

The SF-36 BP sub-scale was related to the change in motor control measured and the difference in abdominal strength measured. It was also shown that, within the physical measures, the highest correlation with the change in motor sidekick measures were the change in abdominal strength measured. Though the relationship is modest, it supports the literature that indicated that the stability of the trunk is crucial to the reduction of pain in individuals that suffer from segmental instability (65); (102); (135); (138); (150); (156); (181) and that stabilization exercises can influence the locus of control in patients with LBP (172); (151); (89).

When the CLBP was analyzed by itself, three other categories showed a modest correlation; the change in abdominal strength correlated with the change in Oswestry; the change in back extension strength correlated with the change in MBI Pain sub-scale and the change in trunk flexion ROM correlated with the change in the Oswestry. With the CLBP group, it appeared that ROM changes had a moderate relationship with changes in three of the activity and pain limitation measures; Oswestry, MBI Disability and MBI Pain. There is no literature that supports a distribution of movement, or a lack there of being related to a distribution of harmful forces (51) however, it may be hypothesized that increased mobility of the spine correlates with an increased distribution of movement and forces within the spine. Because forces are decreased segmentally, successful movement of the spine without pain may lead to an increased perception of ability to perform daily tasks and activities (133). In addition, increases in physical performance can account for decreases in disability (85). For example, increased trunk flexion provides a person with the ability to bend over and pick up an object.

Hypothesis 6: There will be a relationship between the change in activity limitation and pain and the change in psychosocial factors.

There was a moderate relationship found between the change in activity limitation and pain measures and the change in psychosocial measures (Table 4.13). Changes in FSE, fear of re-injury and vitality scales all showed correlations with changes in the Oswestry, MBI Disability, SF-36 Pain and MBI Pain scales. One of the stronger correlations was between the change in FSE and the change in MBI Pain and Disability sub-scales. This supports Lackner et al.'s finding where FSE scores were considered better predictors of outcome (increased activity) than pain (13); (120). The true relationship between the FSE and MBI Disability may be underestimated due to the ceiling effect of the FSE and the floor effect of the MBI Disability sub-scale.

The relationship between the change in psychosocial factors and the change in activity limitations and pain may have great implications in the clinic. Physical constructs tend to be the primary focus in conventional physical therapy even though psychosocial factors are strongly supported in the literature as influencers of LBP (120); (15); (69); (115); (161); (2). In this study, psychosocial factors were found to be stronger predictors of activity limitations and disability than physical measures supporting the literature that emphasizes the impact that FSE and fear avoidance can have in the susceptibility and development of CLBP (85); (48); (186); (216); (201). A larger sample size is warranted in future studies to better determine the significance of the relationship between the interventions and their effects on the psychosocial and activity limitation factors.

Even though the Pilates group did not demonstrate a positive effect on the FSE as anticipated, the results of the study supports the literature in that a correlation does exist between psychological factors and activity limitations (201); (216); (120); (13).

Conclusions

Due to a small sample size and the impact of floor and ceiling effects on a number of outcome measures, it is impossible to draw firm conclusions from this study. The findings suggest that both massage and Pilates produced improvement in many outcomes, however, with the exception of FSE, subjects, who received Pilates improved more post intervention than subjects who received massage.

Massage was able to positively influence MBI Pain and Disability and the Oswestry but to a lesser degree compared to Pilates (41); (42); (75); (126). While passive interventions have been shown to reduce pain (41); (42); (75); (107); (123), this study showed little change in pain levels for subjects in the massage group.

Pilates showed a greater change in all physical measures as hypothesized. Back extension strength was the only physical measure showing a statistically significant difference between groups. Massage did demonstrate a positive change in abdominal strength and trunk flexion which may have been due to pain reduction and relaxation of the back extensor muscles (6); (54); (76); (122).

The findings for the psychological variables were mixed with the massage group improving more than the Pilates group on the FSE and the Pilates group improving more than the massage group on re-injury and vitality (89); (151); (171). Little change was observed in GSE. The SF-36 Vitality sub-scale was the only psychosocial measure that differed significantly between the Pilates to massage groups. Vitality warrants further investigation since it is related to functional outcomes and with other physical and psychological measures.

A modest correlation was found between changes in psychosocial factors and changes in activity limitations. A weaker correlation was found between changes in physical factors and changes in activity limitations. This suggests that psychosocial factors may contribute more to the rehabilitation process than physical factors in CLBP and RLBP. The findings for the sub-analysis using CLBP subjects did not differ significantly from the findings for the whole group.

The findings suggested that both the group Pilates classes and massage, may be effective treatments for CLBP and RLBP. Further research with a larger sample size and a long-term follow-up are required to determine the full and lasting impact that Pilates and massage have on subjects with CLBP and RLBP.

Study Limitations

Sample Size

This clinical trial was underpowered and therefore unable to obtain statistical relevance. After doing a power analysis, the power to detect a difference was 0.23, such that the study would need more than double the sample size to achieve a level of significance at $p \leq .05$. The likelihood of a type II error was increased, indicating an increased likelihood that the true effect was missed.

Recruitment and Retention

Thirty-one subjects signed consent forms to participate in this study. Twenty-one subjects participated in post-testing. Of the ten subjects who did not complete the study, five subjects dropped from the study due to personal reasons, two were asked to discontinue participating secondary to non-disclosure of information in the screening process which would have excluded them from the study and three were lost to follow-up due to their refusal or inability to contact them. There were over 30 additional potential subjects who expressed interest in participating in the study but did not meet the inclusion/exclusion criteria. This study relied on referrals from physicians and other medical practitioners in the community. Recruitment appeared to be more difficult in a voluntary setting than an internal referral source like a hospital or university. An internal recruitment may have resulted in a subject population whose self-efficacy scores were low enough to evaluate a change following their interventions.

Subjects with CLBP and RLBP were accepted for this study. These two groups appear to have slightly different characteristics, where RLBP tendencies appeared to be more parallel with ALBP than CLBP, and respond differently to therapy in some measures. Future studies should exam these groups separately.

Timing of Sessions

Timing of the sessions is another possible confounding factor. Subjects assigned to the Pilates group attended a 50 minute class on the same days and at same time for the six week intervention. Subjects assigned to the massage group received 30 minute interventions and the times of therapeutic massage varied based on availability of the massage therapist. All massages were completed within the six week schedule. The intervention design was organized as per professional recommendations of effective duration of treatment. Due to the expense of one-on-one intervention compared to group it would also be cost prohibitive to have a massage greater than 30 minutes.

Intervention Advancement

The graded advancement of the active intervention might be another confounding factor in the study. Built into the Pilates intervention was a three tiered progression every two weeks. There was no progression built into the massage intervention. The subject's expectancy of advancement alone might influence the outcome measures.

Group vs. One-on-One Interventions

The group Pilates intervention created a limitation in the therapists ability to meet the unique needs of each subject. A previous study that assessed one-on-one Pilates sessions showed greater change in FSE and other psychosocial measures than the group Pilates in this study (46). Future research should compare group to one-on-one Pilates interventions. An ideal intervention might consist of a progression from the one-on-one Pilates rehabilitation to group sessions. This could potentially minimize patient costs (134); (72); (200); (141).

Ceiling and Floor Effects

In this study, the baseline FSE scores for both the Pilates and massage groups were in the upper 70% therefore leaving little room for change. This could possibly be due to the recruitment process. Volunteers with LBP interested in getting free massage or free Pilates might have higher FSE scores. Even with the lack of change in FSE, a positive trend was still found in the active group in the majority of the psychosocial measures. The socialization that took place in the Pilates group may account for the improvement the active intervention had on the psychosocial measures when compared to the massage group, which did not have any group socialization. To better evaluate changes in psychosocial variables, future studies should:

1. Recruit subjects with lower scores in the psychosocial scales, making it part of the inclusion criteria. This might be done by working with medical centers that specialize in chronic pain or a government agency like the

Veteran Administration (VA), where a large percentage of the patients suffer from both physical and psychological impairments.

2. Recruit subjects from large agencies or hospitals that treat patients with CLBP, eliminating the mixture of CLBP with RLBP. This would aid in decreasing some of the biases associated with the recruitment procedures found in this study and possible confounding data from the RLBP population.
3. Involve a socialization component to the control group to avoid further bias.

Socialization

Socialization in the Pilates group but not in the massage group was another bias that was inherent in the design. Subjects that were assigned to the massage group did not participate in group activity and were not exposed to the effects of socializing before and after the intervention.

Self-Report

Functional and psychosocial measures were obtained via a self-report questionnaire. Self-report measures are influenced by the subject's perception and psychological state at the time of reporting. By nature, self-report questionnaires are more subjective and can present recall bias. The real limitation lies in the rater error in that subjects were not instructed and supervised sufficiently. Future studies might want to improve subject instruction and review after each administration to ensure successful completion of the questionnaire.

Generalizability

The subjects of this study entered at a much healthier level than most CLBP patients would enter into a clinical setting further limiting the ability to generalize the findings to the clinic. The results of this study can only be generalized to individuals with functional levels of LBP because of the high self efficacy and low disability scores. Future studies will need to recruit patients that better represent CLBP that typically presents at the clinic.

Clinical Implications

Both Pilates and massage showed benefits in the treatment of CLBP and RLBP. Pilates, which focused on successful movement experiences without pain, was found to be significantly better than massage in improving vitality and back extension strength. Pilates also improved all of the activity limitations and pain measures, all of the physical measures and all of the psychosocial constructs except FSE. Massage improved both the physical and psychosocial constructs. Massage showed a greater improvement in FSE, and a lesser improvement in Oswestry, MBI Disability, SF-36 Pain, MBI Pain, trunk flexion ROM, GSE, and fear of re-injury. No change was found in the massage group for vitality and a negative change was found for back extensor strength, trunk flexion ROM and motor control.

Group classes are an affordable way to influence change with the CLBP and RLBP population when compared to some of the alternative treatments for this population (72); (200); (141). A group class costs as little as $15 to $20 dollars per session. For the same amount of money that an individual might spend on one massage, one injection or a drug prescription, they could participate in three to four active exercise classes per week. The latest research supports an integrated program that combines aspects of socialization, behavioral modification and graded exercises with an increased emphasis on successful acquisition of movement (85); (134); (108); (171); (85); (19). One precaution is that the Pilates class discussed in this study is a modified Pilates class taught by a physical therapist certified in Pilates. Most Pilates instructors are not medical professionals and lack the knowledge to safely care for patients with LBP. In addition, classes were conducted on the Allegro Reformer and not on the mat. Traditional Pilates mat exercises tend to be more challenging and, in many cases, inappropriate for LBP populations. It is the responsibility of the health care provider to ensure that the Pilates intervention is provided by an appropriately trained individual.

Private Pilates sessions may have a greater effect in facilitating change in outcome measures for CLBP and RLBP than group Pilates classes (46). A graded activity program can be created by starting patients with a basic one-on-one training program and progressing them to more complex group sessions (44); (77); (78); (126). The group classes might serve better to achieve the third, autonomous stage of graded activity, which is often neglected in rehabilitation (149); (65). The group class provides an affordable way to facilitate long-term neuromuscular re-education and retention of the performance of correct motor task.

A more effective Pilates intervention might consist of a progression from the one-on-one Pilates rehabilitation to group sessions. This would theoretically minimize patient costs and continue to provide patients with a successful, pain-free movement experience and possibly help avoid recurrence of LBP.

Socialization can also affect change in CLBP and RLBP outcome. Many of the subjects discussed the outcomes and benefits of exercise possibly affecting perceived outcome of wellness. Socialization was not incorporated in the massage intervention.

Successful intervention with massage appears to be centered on the correct selection of the soft tissue technique that matches the mechanism of pain and activity limitation. It would be worthwhile to develop a predictive procedure for each technique, where someone's LBP is related to soft tissue pain and has lasted for less than three months might have a positive outcome by implementing a connective tissue massage followed by neuromuscular education to reinforce the soft tissue changes. Massage might be more appropriate as an intervention for RLBP than CLBP, where RLBP acts more like ALBP and is defined by brief episodes of LBP that spontaneously resolve (40); (41); (42).

Health care workers need to consider psychosocial factors when working with CLBP and RLBP. This study demonstrated that psychosocial factors influenced activity limitation outcome measures following treatment. It is important that health care workers consider incorporating behavioral conditioning as part of their treatment (85); (114); (134). Self-efficacy and fear avoidance are two influencing variables of general health and are particularly applicable to chronic pain populations (120); (201); (216). The ICF health model allows the health care practitioner to evaluate a patient based on physical, psychosocial and activity limitation factors and prescribe based on a patient's individualized needs.

Psychosocial and disability measures in physical therapy can play a much larger role in the assessment, diagnosis and prognosis of patients. An increased focus on the psychosocial and activity factors in patient's health can greatly improve functional outcomes. Using the psychosocial and activity limitation scales provides a better overall measure of well-being for patients prior to discharge. A patient's perception of confidence in returning to work or daily activities might be a better determinate of their readiness to actually do so than measures of strength, ROM, or pain (186); (48); (216); (201).

Pilates rehabilitation has been used as a treatment for conditions that include neurological, rheumatologic, geriatric, pediatric, orthopedic, women's health and sports medicine impairments. The design of this study, using the foundation of the ICF Health model and measurement of psychosocial, physical and activity limitations factors, can serve as an instrument in the design and implementation of future investigations.

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Appendix I

Informed Consent

INFORMED CONSENT

Randomized Clinical Trial comparing Active Versus Passive Approaches to the Treatment of Post Acute Low Back Pain

You are being asked to participate in this study because you suffer from persistent low back pain. If you have any questions about this document, or find words or concepts that are not clear to you, please let the investigators know and they will answer your questions.

PURPOSE

There are many methods used to treat persistent low back pain including various types of exercise and massage. One type of exercise program used to treat persistent low back pain is the Pilates approach. This type of exercise program involves a combination of flexibility, strength and balance exercises on a unique type of exercise equipment called the Allegro Reformer. The purpose of this study is to compare the benefits of a Pilates exercise to massage in 100 patients for a time period up to one year, in the treatment of persistent low back pain.

PROCEDURE

Your participation in this research project will last approximately one year. During your initial visit you will be asked to complete a number of questionnaires and perform a series of activities to measure your strength and flexibility. After you complete all testing you will be randomly assigned (like by the flip of a coin) to receive either Pilates exercises or massage for six weeks. At the end of six weeks you will be asked to complete the questionnaires and perform the strength and flexibility tests a second time. At three months, six months and twelve months after you complete the program you will be contacted and asked to complete the questionnaires again.

The questionnaires you will be asked to complete contain questions concerning your health beliefs, your experience with low back pain and your ability to perform various daily activities. The questionnaires will require approximately 20-30 minutes to complete.

The strength and flexibility tests will require that you perform a number of activities. You will need to wear loose comfortable clothing to perform these tests. You will be asked to perform the following 7 activities while lying on a padded table.

While lying on your back, you will be asked to curl your upper body to lift your trunk off the table, and hold that position as long as possible for up to 240 seconds. This test will be timed. While lying on your back, you will also be asked to lift your leg as high as possible while keeping your knee straight; bring one knee to your chest while letting the other leg drop to the table; bend your knee as far as possible; slide your leg as far out to the side as possible; and while sitting with your knees out stretched you will be asked to move your ankle up and down as far as possible. Someone will measure how

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APPROVAL DATE: 12/28/04
EXP. DATE: 12/16/05
INITIALS: BS

far you move using a clear plastic device that is aligned with your trunk limbs to measure the degrees of movement.

While lying on your stomach with support under your hips, you will be asked to place your hands behind your head, lift your trunk so that it is parallel to the floor, and hold that position as long as possible for up to 240 seconds. While lying on your stomach, you will also be asked to bend your knees and let your legs roll in and out as far as possible. While lying on your stomach, you will be asked to lift your leg at the hip as far as possible while keeping your knee straight. Your movements will be measured with the clear plastic device.

While lying on your side, you will be asked to bring one leg forward horizontal to the ground while maintaining the back and pelvis still. Using a plastic measuring device you will be measured on how high you can lift your leg towards your chest without moving your pelvis or back.

While in standing, you will be asked to bend at the waist backward, forward and to the side as far as possible. While in sitting you will be asked to twist your trunk as far as possible in both directions. The range of your movements will be recorded using a tape measure and/or the clear plastic device that measures angles.

If you are assigned to the Pilates exercise group you will come to class two times per week for six weeks in a row. You should come dressed in comfortable exercise clothing. During the classes you will be asked to perform a series of Pilates exercises on the Pilates Allegro Reformer. This piece of exercise equipment lies on the ground and consists of a carriage that is attached by springs to a metal frame. The carriage slides smoothly to facilitate stretching, strengthening and coordination. The springs are used to assist movement that normally is difficult against gravity. The exercises in this class will consist of lying on your back, kneeling on the carriage, seated on the frame, lunging and standing. Each exercise is specifically designed to help improve strength of the trunk and core, increase flexibility of limbs and spine and increase the coordination of movement. Pilate's movement is designed to be pain free. If you experience discomfort the activity will be modified or you will be allowed to stop. Classes will generally last 55-60 minutes.

If you are assigned to the massage group you will need to wear comfortable clothing that can be easily removed for massage. Massage and other soft tissue treatments have helped to relax muscles that are causing discomfort and increase the ability to move. During the massage your low back region may be exposed and will be massaged by a certified massage therapist for approximately 30 minutes two times per week for a six-week period. Massages will take place in a private room in a physical therapy office. Professional draping techniques will be practiced to maintain modesty. The massage therapist is likely to use lotion or massage oils to facilitate massage. If you have any adverse reaction to the lotion or oils, the massage medium will be changed or not used at all. Those who belong to the massage group will also have one organized discussion as a group towards the end of the massage sessions.

RISKS

It is possible that you might experience muscle or joint soreness while performing the flexibility and strength tests. It is also possible that you might experience an aggravation to your low back following Pilates exercise or massage treatment. These symptoms could also be delayed a day or two after performing these tests. Testing and or exercises will be stopped if symptoms worsen.

BENEFITS

No direct benefit can be promised to you for your participation in this study.

COSTS

You will not incur any costs as a result of participating in this study. There will be no charge for parking.

PAYMENT TO SUBJECTS

You will not be paid to participate in this study.

ALTERNATIVES

You have the alternative to not participate in this study.

COMPENSATION FOR INJURY

Although injury is unlikely, if one should occur, treatment will in most cases be available. If you have insurance, your insurance company may or may not pay for these costs. If you do not have insurance, or if your insurance company refuses to pay, you will be expected to pay. Funds to compensate for pain, expenses, lost wages and other damages caused by injury are not routinely available.

CONFIDENTIALITY

By signing this consent, you authorize the investigators and their staff to access your medical records and associated information as may be necessary for purposes of this study. Your records and results will not be identified as pertaining to you in any publication without your expressed permission. The investigator and his collaborators, staff will consider your records confidential to the extent permitted by law. The Food and Drug Administration (FDA) and Department of Health and Human Services (DHHS) may review these research records. Authorized University of Miami employees or other agents who will be bound by the same provisions of confidentiality may also review your records for audit purposes.

RIGHT TO WITHDRAW

Your participation in this study is voluntary. You are free to refuse to participate in the study or withdraw your consent at any time during the study. Your withdrawal or lack of participation will not prejudice further/additional medical treatment. The investigators and/or their assistants reserve the right to remove you from the study without your consent at such time that they feel it is in the best interest for you medically or for administrative reasons.

You may ask and will receive answers to any questions during the course of the study. If you have any questions about this study, please contact Brent Anderson PT OCS or Kathryn Roach, PhD PT. If you have questions about your rights as a research participant you may contact Maria Arnold, Director of the Human Subjects Research Office, at 305-243-3195.

________________________ _______________
Subject's Signature Date

________________________ _______________
Witness Signature Date

________________________ _______________
Person Obtaining Consent Date

________________________________ _______________
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Appendix II

Telephone Interview and Screening Form

Telephone Screening Form
Date:_________________

Hello_________________________, (name of participant) Screening Number_______

Thank you for your interest in our study "Randomized Clinical Trial Comparing Active Versus Passive Approaches to the Treatment of Post Acute LBP". The purpose of this study is to differentiate between various methods of intervention commonly used for management of LBP. If chosen, you will be assigned to one of two groups, massage or Pilates. There will be no costs to you other than standard transportation and parking expenses as they apply. The treatment will last for six weeks. A series of questionnaires will be administered before and after treatment as well as seven physical tests. All testing and interventions will be conducted in Coral Gables. Following the second questionnaire, we will continue to conduct phone interviews three more times over that year. Are you still interested in continuing with the screening process?

I would like to ask you a few questions regarding your eligibility for this study, is now a good time to ask you those questions?

1. **Are you available for up to two, hour sessions per week for a period of six weeks? Yes No**
2. **Do you read English well enough to answer a questionnaire or will you need a reader? Yes No**
3. **Inclusion Criteria:**
    a. **Do you have a recent history of LBP in which you have seen a medical professional? Yes No**
    b. **Have you completed your treatment for this episode of LBP? Yes No**
    c. **Satisfaction measure:**
        i. **If you were to spend the rest of your life with the amount back pain that you have now, how satisfied would you be on a scale of 1 – 10, with 1 being miserable and 10 being very happy?**
            1. **Delighted**
            2. **Pleased**
            3. **Mostly Satisfied**
            4. **Mixed (about equally satisfied and dissatisfied)**
            5. **Mostly Dissatisfied**
            6. **Unhappy**
            7. **Terrible**
    d. **Are you between 18-65 years old? Yes No**
4. **Exclusion Criteria:**
    a. **Have you had or experienced any of the following?**
        i. **Previous spine fusion Yes No**
        ii. **Significant weakness of the lower extremities Yes No**
        iii. **Sternotomies Yes No**
        iv. **Other compromising surgeries Yes No**
        v. **Systemic illness Yes No**
        vi. **Recent abdominal surgery Yes No**
        vii. **Cauda equina compression (bowel or bladder dysfunction) Yes No**
        viii. **Acute nerve root compression Yes No**
        ix. **Neurological/muscular degenerative disease (ALS, MS, MD, etc.) Yes No**
        x. **Concomitant health problems limiting exercises (heart, stroke, neuropathies, etc.) Yes No**

xi. **Narcotic addiction** **Yes**
No

xii. **Peripheral joint disease or dysfunction that would preclude you from Pilates exercises (carpal tunnel, PF pain, Plantar fascitis, etc.)** **Yes**
No

xiii. **Are you currently pregnant** **Yes**
No

xiv. **Do you have a pending civil or social law suit** **Yes**
No

xv. **Have you every participated in Pilates before?** **Yes** **No**

A. **You are eligible for this study; we start a new group once we get to 16 volunteers. We will call you as soon as we schedule the next series. We will ask you to come in and fill out some paper work and perform a few basic tests. At that time you will randomly assigned to one of the two interventions that will have a time assigned to them.**

B. **We regret that you are not eligible for this study. However, if you are still interested in either of the two interventions, they remain available to you as a client or patient even though you will not be included in this study.**

Appendix III

Demographic Information Form

Demographic Data

Subject ID #:_________

Age: _____ **Sex** (Please circle one): Male / Female

Marital Status (Please circle one): Married / Single / Divorced / Widowed

Height: ___'_____'' **Weight**: _______ lbs

Have you had a previous history of LBP (Please circle one): Yes / No

Number of previous LBP episodes: _______

Duration of current LBP episode: _____ years _____ months

Type of employment: ____________________
(Please include housework, caregiver, etc. if it is your primary activity)

Amount of physical labor job requires (Please circle one): Heavy / Moderate / Light

Time off work in last year for LBP: ________

Type of pain meds currently taken for LBP (please check all that apply):
Narcotics (Percocet, Oxycodone) □
NSAID (Ibuprophen) □
Acetaminophen (Tylenol) □
Salicylates (Aspirin) □
COX 2 Inhibitors (Vioxx, Celebrex) □
Other:_______________ □

Do you smoke? (Please circle one): Yes / No

Recreational activities:
1.____________________
2.____________________

Appendix IV

Physical Measures Form

Physical Measurements

Subject ID#________________ Date____________________

Test: Pre ______Post _______ (check one)

Test	Instructions	Measurement
Lower Abdominal Strength	angle at the hip between the straight legs and floor	Degrees
Trunk Flexion Strength	Subject in a sit-up position for as long as possible	sec
Back Extension Strength	Subject in a lumbar and thoracic extension	sec
Lumbar Extension ROM	S2-10cm above difference	cm
Thoracic Extension ROM	T12-T2 difference	cm
Lumbar Flexion ROM	PSIS line, 5 & 10 cm above	(5cm) cm (10cm) cm
Thoracic Flexion ROM	T12-T2	cm
Hamstring Flexibility	Straight leg raise, while stabilizing opposite	R Degrees L Degrees
Side Kick coordination Test	Flex hip in Sidelying, while maintaining pressure	R Degrees L Degrees

Appendix V

Symptoms Satisfaction Index

Symptoms Satisfaction Measure

If you were to spend the rest of your life with your back or leg symptoms just the way they have been in the last 24 hours, would you feel. ……… (Circle one answer)

1. Delighted
2. Pleased
3. Mostly Satisfied
4. Mixed (about equally satisfied and dissatisfied)
5. Mostly dissatisfied
6. Unhappy
7. Terrible

From Cherkin, D.C., Deyo, R.A., Street, J.H., and Barlow, W. Predicting Poor Outcomes for Back pain Seen in primary Care Using Patients' Own Criteria

Appendix VI

General Perceived Self-Efficacy Scale

The General Perceived Self-Efficacy Scale
English Version by Ralf Schwarzer & Matthias Jerusalem, 1993

Instructions: Please read each statement carefully and choose one of the below responses that best match your feelings towards each statement.

Response Format:
1= Not at all true 2= Hardly true 3= Moderately true 4= Exactly true

1. I can always manage to solve difficult problems if I try hard enough.	
2. If someone opposes me, I can find the means and ways to get what I want.	
3. It is easy for me to stick to my aims and accomplish my goals.	
4. I am confident that I could deal efficiently with unexpected events.	
5. Thanks to my resourcefulness, I know how to handle unforeseen situations.	
6. I can solve most problems if I invest the necessary effort.	
7. I can remain calm when facing difficulties because I can rely on my coping abilities.	
8. When I am confronted with a problem, I can usually find several solutions.	
9. If I am in trouble, I can usually think of a solution.	
10. I can usually handle whatever comes my way.	

Appendix VII

Functional Self-Efficacy Scale

Functional Self-Efficacy Scale

Instructions: Please read carefully each activity listed and circle the number that most appropriately matches your level of confidence in performing each activity. If the activity is not applicable to your daily activities please check the N/A box.

Confidence Scale

Essential activity required to perform your job	**Confidence scale** 10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	**Check if N/A**
1. Reaching forward while standing	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
2. Reaching forward while sitting	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
3. Reaching overhead	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
4. Crouching	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
5. Squatting repeatedly	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
6. Lifting from the floor to waist	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
7. Lifting from the waist to your eye	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
8. Carrying both hands (arms)	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	

9. Carrying with right hand	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
10. Carrying with left hand	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
11. Prolonged sitting	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
12. Prolonged standing	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
13. Climbing stairs	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
14. Walking	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	
15. Reaching above shoulders	10 20 30 40 50 60 70 80 90 100 not certain at all / moderately certain / very certain	

What is the maximum weight you could lift from the floor to your waist today? _________ Pounds

What is the maximum weight you could lift from your waist to your eyes today? ________ Pounds

How many minutes could you sit without standing today? _______ Minutes

How many minutes could you stand without lying down, sitting, or reclining today? _____________ Minutes

Using the scale above, how confident are you that you can perform the essential tasks that your job involves? ______________________________

Appendix VIII

Expected Re-Injury/Pain Scale

Expected Re-injury/Pain Scale

Instructions: Please read carefully each activity listed below and identify the most appropriate level that you think the activity would aggravate or re-injure your Low Back Symptoms. If the activity is not applicable to your daily activities please check the N/A box.

Essential activity required to perform your job	**Re-injury/Pain scale** 10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	**Check if N/A**
1. Reaching forward while standing	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
2. Reaching forward while sitting	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
3. Reaching overhead	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
4. Crouching	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
5. Squatting repeatedly	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
6. Lifting from the floor to waist	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
7. Lifting from the waist to your eye	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
8. Carrying both hands (arms)	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
9. Carrying with right hand	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
10. Carrying with left hand	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
11. Prolonged sitting	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	
12. Prolonged standing	10 20 30 40 50 60 70 80 90 100 very unlikely / moderately likely / very likely	

13. Climbing stairs	10 20 30 40 50 60 70 80 90 100 very unlikely — moderately likely — very likely	
14. Walking	10 20 30 40 50 60 70 80 90 100 very unlikely — moderately likely — very likely	
15. Reaching above shoulders	10 20 30 40 50 60 70 80 90 100 very unlikely — moderately likely — very likely	

Appendix IX

Short Form SF-36 Health Status Questionnaire

SF36-Health Status Questionnaire

Instructions: This survey asks for your views about your health. The information will help your health care provider track how you feel and how well you are able to do your usual activities.

Answer each question by circling the appropriate number. If you are unsure about how to answer a question, please give the best answer you can.

1. In general, would you say your health is:
   a. Excellent
   b. Very Good
   c. Good
   d. Fair
   e. Poor

2. Compared to 1 year ago, how would you rate your health in general now?
   a. Much better now
   b. Somewhat better now
   c. About the same
   d. Somewhat worse now
   e. Much worse now

The following items are about activities you might do during a typical day. Does your health limit you in these activities? If so, how much?

3. Does your health limit you in these activities/ vigorous activities such as running, lifting heavy objects, strenuous sports?
   a. Yes, limited a lot
   b. Yes, limited a little
   c. No, not limited at all

4. Does your health limit you in these activities? Moderate activities like moving a table, vacuuming, bowling, golf?
   a. Yes, limited a lot
   b. Yes, limited a little
   c. No, not limited at all

5. Does your health limit you in these activities? Lifting or carrying groceries?
   a. Yes, limited a lot
   b. Yes, limited a little
   c. No, not limited at all

6. Does your health limit you in these activities? Climbing several flights of stairs?
   a. Yes, limited a lot
   b. Yes, limited a little
   c. No, not limited at all

7. Does your health limit you in these activities? Climbing one flight of stairs?
   a. Yes, limited a lot
   b. Yes, limited a little
   c. No, not limited at all

8. Does your health limit you in these activities? Bending, kneeling or stooping?
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all

9. Does your health limit you in these activities? Walking more than one mile?
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all

10. Does your health limit you in these activities? Walking several blocks?
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all

11. Does your health limit you in these activities? Walking one block?
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all

12. Does your health limit you in these activities? Bathing or dressing yourself?
    a. Yes, limited a lot
    b. Yes, limited a little
    c. No, not limited at all

13. During the past 4 weeks, have you cut down the amount of time you spent on work or other activities as a result of your physical health?
    a. Yes
    b. No

14. During the past 4 weeks, have you accomplished less than you would like as a result of your physical health?
    a. Yes
    b. No

15. During the past 4 weeks, were you limited in the kind of work or other activities as a result of your physical health?
    a. Yes
    b. No

16. During the past 4 weeks, have you had difficulty performing work or other activities (e.g. it took extra effort) as a result of your physical health?
    a. Yes
    b. No

17. During the past 4 weeks, have you cut down the amount of time you spent on work or other activities as a result of an emotional problem such as depression or anxiety?
    a. Yes
    b. No

18. During the past 4 weeks, have you accomplished less than you would like as a result of an emotional problem such as depression or anxiety?
    a. Yes
    b. No

19. During the past 4 weeks, have you had difficulty doing work or other activities as carefully as usual as a result of an emotional problem such as depression or anxiety?
    a. Yes
    b. No

20. During the past 4 weeks, To what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups??
    a. Not at all
    b. Slightly
    c. Moderately
    d. Quite a bit
    e. Extremely

21. How much bodily pain have you had during the past 4 weeks?
    a. None
    b. Very mild
    c. Mild
    d. Moderate
    e. Severe
    f. Very severe

22. During the past 4 weeks how much did pain interfere with your normal work (including both outside the home and housework)?
    a. Not at all
    b. A little bit
    c. Moderately
    d. Quite a bit
    e. Extremely

These questions are about how you feel and about how things have been with you during the PAST 4 WEEKS. For each question please give one answer that comes closest to the way you have been feeling.

How much of the time during the past 4 weeks…

23. How much of the time during the past 4 weeks did you feel full of pep?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

24. How much of the time during the past 4 weeks have you been a very nervous person?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

25. How much of the time during the past 4 weeks have you felt calm and peaceful?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

26. How much of the time during the past 4 weeks did you have a lot of energy?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

27. How much of the time during the past 4 weeks have you felt downhearted and blue?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

28. How much of the time during the past 4 weeks did you feel worn out?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

29. How much of the time during the past 4 weeks have you been a happy person?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

30. How much of the time during the past 4 weeks did you feel tired?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

How TRUE or FALSE is each of the following statements for you?

31. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?
    a. All of the time
    b. Most of the time
    c. A good bit of the time
    d. Some of the time
    e. A little of the time
    f. None of the time

32. I seem to get sick a little easier than other people.
    a. Definitely true
    b. Mostly true
    c. Do not know
    d. Mostly false
    e. Definitely false

33. I am as healthy as anybody I know.
    a. Definitely true
    b. Mostly true
    c. Do not know
    d. Mostly false
    e. Definitely false

34. I expect my health to get worse.
    a. Definitely true
    b. Mostly true
    c. Do not know
    d. Mostly false
    e. Definitely false

35. My health is excellent.
    a. Definitely true
    b. Mostly true
    c. Do not know
    d. Mostly false
    e. Definitely false

Please answer YES or NO for each question.

36. In the past year, have you had 2 weeks or more during which you felt sad, blue or depressed; or when you lost all interest or pleasure in things you usually cared about or enjoyed?
    a. Yes
    b. No

37. Have you had 2 year or more in your life when you felt depressed or sad most days, even if you felt okay sometime?
    a. Yes
    b. No

38. Have you felt depressed or sad much of the time in the past year?
    a. Yes
    b. No

Appendix X

Oswestry LBP Index

Oswestry LBP Scale

Please rate the severity of your pain by circling a number below:

No pain 0 1 2 3 4 5 6 7 8 9 10 ***Unbearable pain***

Instructions: Please circle the **ONE NUMBER** in each section, which most closely describes your problem.

Section 1 – Pain Intensity
0. The pain comes and goes and is very mild.
1. The pain is mild and does not vary much.
2. The pain comes and goes and is moderate.
3. The pain is moderate and does not vary much.
4. The pain comes and goes and is severe.
5. The pain is severe and does not vary much.

Section 2 – Personal Care (Washing, Dressing, etc.)
0. I would not have to change my way of washing or dressing in order to avoid pain.
1. I do not normally change my way of washing or dressing even though it causes some pain.
2. Washing and dressing increase the pain but I manage not to change my way of doing it.
3. Washing and dressing increase the pain and I find it necessary to change my way of doing it.
4. Because of the pain I am unable to do some washing and dressing without help.
5. Because of the pain I am unable to do any washing and dressing without help.

.

Section 3 – Lifting
0. I can lift heavy weights without extra pain.
1. I can lift heavy weights but it gives extra pain.
2. Pain prevents me lifting heavy weights off the floor.
3. Pain prevents me lifting heavy weights off the floor, but I can often manage if they are conveniently positioned, e.g., on a table.
4. Pain prevents me lifting heavy weights but I can manage light to medium weights if they are conveniently positioned.
5. I can only lift very lightweights at most.

Section 4 – Walking
0. I have no pain on walking.
1. I have some pain on walking but it does not increase with distance.
2. I cannot walk more than 1 mile without increasing pain.
3. I cannot walk more than ½ mile without increasing pain.
4. I cannot walk more than ¼ mile without increasing pain.
5. I cannot walk at all without increasing pain.

Section 5 – Sitting
0. I can sit in any chair as long as I like.
1. I can sit only in my favorite chair as long as I like.
2. Pain prevents me from sitting more than 1 hour.
3. Pain prevents me from sitting more than ½ hour.
4. Pain prevents me from sitting more than 10 minutes.
5. I avoid sitting because it increases pain immediately.

Section 6 – Standing
0. I can stand as long as I want without pain.
1. I have some pain on standing but it does not increase with time
2. I cannot stand for longer than 1 hour without increasing pain..
3. I cannot stand for longer than ½ hour without increasing pain.
4. I cannot stand for longer than 10 minutes without increasing pain.
5. I avoid standing because it increases the pain immediately.

Section 7 – Sleeping
0. I get no pain in bed.
1. I get pain in bed but it does not prevent me from sleeping well.
2. Because of pain my normal nights sleep is reduced by less than one-quarter
3. Because of pain my normal nights sleep is reduced by less one-half
4. Because of pain my normal nights sleep is reduced by less than three-quarters
5. Pain prevents me from sleeping at all.

Section 8 – Social Life
0. My social life is normal and gives me no pain.
1. My social life is normal but it increases the degree of pain.
2. Pain has no significant effect on my social life apart from limiting my more energetic interests, e.g., dancing, etc
3. Pain has restricted my social life and I do not go out very often
4. Pain has restricted my social life to my home.
5. I have hardly any social life because of the pain.

Section 9 – Traveling
0. I get no pain when traveling.
1. I get some pain when traveling but none of my usual forms of travel make it any worse
2. I get extra pain while traveling but it does not compel me to seek alternate forms of travel.
3. I get extra pain while traveling which compels me to seek alternative forms of travel
4. Pain restricts me to short necessary journeys under ½ hour.
5. Pain restricts all forms of travel.

Section 10 – Changing Degree of Pain
0. My pain is rapidly getting better.
1. My pain fluctuates but is definitely getting better.
2. My pain seems to be getting better but improvement is slow.
3. My pain is neither getting better nor worse
4. My pain is gradually worsening.
5. My pain is rapidly worsening.

Appendix XI

Miami Back Index Disability Scale

Miami Back Index Disability Scale

The line next to each item represents how much difficulty you had doing that activity. The far left of the line represents "No difficulty" and the far right of the line represents "SO much difficulty you were unable to do the activity or required help". Place a mark on the line to indicate the amount of difficulty you had doing each activity during the past week. Mark the item NA if you did not do that activity during the past week.

A. During the past week, how much difficulty did you have:

				Score
1. Falling asleep?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
2. Sleeping on stomach?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
3. Sleeping on your side?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
4. Putting on hose or socks?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
5. Lifting heavy objects?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
6. Picking an object off the floor?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
7. Getting in and out of a car?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
8. Driving a car?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
9. Getting out of a bath tub?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
10. Getting up from the toilet?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
11. Getting out of bed?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
12. Getting up from a low chair?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
13. Walking for more than a block?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	
14. Climbing stairs?	No difficulty	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	So difficult required help	

Appendix XII

Miami Back Index Pain Scale

Miami Back Index Pain Scale

The line next to each item represents the amount of pain you have in each situation. The far left of the line represents "No pain" and the far right represents "Worst pain imaginable." Place a mark on the line to indicate how much pain you had during the past week in each of the following situations. Mark the NA if you did not experience this situation during the past week.

B. During the past week, how severe was your back and or leg pain:

				Score
1. At its worst?	No Pain	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	Worst pain imaginable	
2. When coughing, sneezing or bearing down?	No Pain	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	Worst pain imaginable	
3. When standing for a long time?	No Pain	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	Worst pain imaginable	
4. When sitting for a long time?	No Pain	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	Worst pain imaginable	
5. When walking for a block or more?	No Pain	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	Worst pain imaginable	
6. When bending over sink to brush teeth?	No Pain	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	Worst pain imaginable	
7. When pushing a heavy object like a vacuum or lawn mower?	No Pain	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	Worst pain imaginable	
8. When lying on your back?	No Pain	0 – 1 – 2 – 3 – 4 – 5 –6 – 7 – 8 – 9 – 10	Worst pain imaginable	

Appendix XIII

Pilates Allegro Class

Pilates Allegro Reformer Class for LBP

Name of Exercise	Position on Allegro Reformer	Primary Principle	Variations/Mod.
Footwork	Supine	Breathing, AE, Core Control	Various foot positions on bar
Hamstring Arcs	Supine	Disassociation	Straps above knees
Supine Arm Arcs	Supine	Core Control	Legs crossed, knees close to chest
Bridging	Supine	Spine Articulation	Wide base of support
Quadruped Facing Head	Quadruped	Core control	Altering spring tension
Quadruped Facing Foot	Quadruped	Trunk Stabilization / Disassociation	Altering spring tension
Seated Leg Press	Seated on footbar	Trunk Stabilization / Disassociation	Bilateral or unilateral, addition of arms with movement
Seated Arm Series	Seated on Box on reformer	Posture and Upper Extremity Strength	Triceps, biceps, rhomboids, latissimus dorsi
Seated Abdominal Series	Seated on Box on reformer	Core Control	Sagittal, rotation
Kneeling Arm Series	Kneeling on reformer	Posture and Upper Extremity Strength	Low kneeling or high kneeling
Standing with Hands on Footbar	Standing	Disassociation, Hip Flexor and Hamstring Flexibility	Knee extension only
Standing with Hands on Hips	Standing	Disassociation, Hip Flexor and Hamstring Flexibility	Knee extension only
Standing Series	Standing	Posture, Disassociation, Stabilization	Parallel, knees flexed