Predictors of functional improvement in people with chronic low back pain following a graded programme of movement control exercises

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Declaration

**Name of candidate:** Leyla Okyay

This Research Project entitled "**Predictors of functional improvement in people with chronic low back pain following a graded programme of movement control exercises**" is submitted in partial fulfilment for the requirements for the Unitec degree of Master of Osteopathy.

**Candidate’s declaration:**

I confirm that:

- This research project represents my own work.
- The contribution of supervisors and others to this work was consistent with the Unitec Regulations and Policies.
- Research for this work has been conducted in accordance with the Unitec research Ethics Committee Policy and Procedures, and has fulfilled any requirements set for this project by the Unitec Research Ethics Committee.

Research Ethics Committee Approval Number: 2009-923

Candidate Signature: Date:

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Introduction to the thesis

Low back pain (LBP) has been, and continues to be extensively researched, without being well understood. In recent years there has been a shift in the research on two key fronts. For one, the search for patho-anatomical origins of disease and dysfunction has given way to more neurological-psychological explanations for LBP with recognition of the complex multi-factorial determinants of pain. Secondly, with recognition of the heterogeneity that exists in the patient presentation and treatment response, there has been an increased effort in identifying subgroups of low back pain patients with distinct features that predict response to a particular treatment.

How do we decide which treatments have the potential to work in a personalized care paradigm, if we have only research that tells us that nothing works on everyone, and anecdotally that any treatment will work for someone? A basic understanding of pain and disability along with sound theories on potential mechanisms of the effect of particular treatments might pave the way. Promising treatments can then be researched within LBP populations to identify people who will benefit.

The aim of the study reported in this thesis was to investigate predictors of outcome for one potential treatment for people with chronic LBP. A clinical prediction rule was developed to identify a subgroup of people with chronic LBP who show improvement in function following a graded programme of movement control exercises. The preceding literature review examines the research relating to subgrouping, clinical prediction rules, and movement control exercises in the treatment of chronic LBP, and provides justifications for the choice of potential predictors included in the subsequent research study.
Overview

The following research project is divided into three sections:

1. The literature review, with emphasis on:
   - Classification Systems
   - Methods of subgrouping low back pain
   - Definition and use of clinical prediction rules in low back pain care
   - The treatment of chronic low back pain with exercise
   - Predictors of rehabilitation outcome in low back pain

2. A manuscript in the format specified for submission to the *Journal of Bodywork and Movement Therapies*.

3. Appendices that include ethics approval, participant information sheet, screening questions, consent form, questionnaires, medical history form and the guidelines for authors to the *Journal of Bodywork and Movement Therapies*. 
Section 1: Literature Review
Introduction

Over the last 20 years there has been a shift in the wider medical literature to personalize patient care, supported by the research discoveries within genomics and pharmacogenetics. Groups of people at risk for chronic diseases like cancer and heart disease can be identified and appropriate individualized preventative strategies and early treatment programmes can be initiated. Low back pain (LBP) is a chronic problem that could also benefit from personalized care that is supported by an evidence-based framework.

In the first instance, this review explores some of the problems in the research and care of LBP. The concepts of subgrouping and clinical prediction rules are discussed. This is followed by an overview of research supporting exercise as a treatment of choice for chronic LBP. Finally, potential predictors of outcome are discussed.

Chronic low back pain and disability

Low back pain poses a substantial problem to our society. In a 12-month period 22-67% of people will experience LBP, and up to 84% of the population will report LBP at some point in their lives (McBeth & Jones, 2007; Walker, 2000). While most patients show rapid improvement in pain and disability within the first month of experiencing LBP, full resolution is often not reached and over 70% of people experience at least one recurrent episode within a year (Pengel, Herbert, Maher & Refshauge, 2003). Almost a third of patients will still complain of symptoms 12 months later, and in about 7% of cases LBP becomes a persisting and highly disabling problem (Carey, Garrett & Jackman, 2000; Henschke et al., 2008; Pengel et al., 2003). In Australia, more than 10% of the population reports LBP with a high level of disability causing moderate to severe limitations in usual activities.
(Walker, Muller & Grant, 2004). Chronic LBP causes particularly large socioeconomic problems in the form of long-term disability, work absenteeism, income compensation, and healthcare costs. Based on a young adult population, the annual cost of LBP in New Zealand is estimated at almost $500 million (McBride, Begg, Herbison & Buckingham, 2004).

A specific pathology such as an infection, tumour, fracture or nerve root compression can be identified in less than 15% of LBP patients (Deyo & Phillips, 1996). These patients are labelled as experiencing ‘specific’ LBP, while the remaining 85% of patients are classified as having ‘non-specific’ LBP. This latter group is often further subdivided based on duration of symptoms. Acute LBP lasts up to 6 weeks, sub-acute pain is identified as lasting 6 weeks to 3 months, and chronic pain persists for greater than 3 months. Unfortunately the course of LBP is not so simple and many patients experience multiple flare-ups of acute pain interspersed with periods of remission (Pengel et al., 2003; von Korff & Saunders, 1996). In light of this, a further patient population group with ‘recurrent’ non-specific LBP has been suggested (Stanton, Latimer, Maher & Hancock, 2009). Most treatment trials study either acute or chronic (persistent) LBP populations, and it is often unclear if the authors have included and acknowledged people who experience recurrent episodes of pain. Because of the long-term nature of recurrent LBP it may perhaps be classed as an intermittent form of chronic LBP. A review that found exercise to be beneficial for subacute, chronic, and recurrent LBP, but not for acute LBP (Henchoz & Kai-Lik So, 2008), supports this association.

LBP is characterised by the sensation of pain between the lower ribs and buttock creases and is usually associated with some level of functional limitations (disability). Arguably, it is disability that causes the biggest problems in those experiencing LBP. Disability may range from limitations in leisure activities and
decreased productivity at work, to inability to perform basic activities of daily living, unemployment and adopting an ‘invalid’ status (Bogduk, 2006). Levels of disability are only to some extent linked to the amount of physical impairment. Waddell et al. (1993) have shown that 40% of disability can be explained by physical impairment, 23% can be explained by psychological distress, and 8% is explained by illness behaviour. It can be said that disability is a representation of the patient’s response to pain, motivated by the desire to avoid aggravation of pain (Bogduk, 2006).

**Current guidelines and the nature of research and clinical practice**

Many studies have been undertaken to investigate the benefits of various treatments on LBP, but few have been found to be effective (Bogduk, 2004; van Tulder, Koes & Malmivaara, 2006). Current guidelines for chronic LBP advise screening for signs of serious spinal pathology and nerve root compression that require referral to a specialist, and signs of psychosocial problems that may require more intensive, multidisciplinary care (Airaksinen et al., 2006; Koes, van Tulder, Ostelo, Kim Burton & Waddell, 2001). Beyond this, the guidelines give generic advice to reassure the patient, promote early return to work and usual activities, and recommend trialling a number of conservative treatments (cognitive behavioural therapy, education, and supervised exercise).

The greatest problem in recommending appropriate treatment for non-specific LBP is the lack of clear, positive evidence of effectiveness. A number of conservative treatments show short-term benefits in pain and disability for chronic LBP: COX2 inhibitors, back schools, progressive relaxation, exercise therapy, and multidisciplinary treatment (van Tulder et al., 2006). However, none of these treatments have been shown to provide long-term amelioration of pain and
disability. Furthermore, whilst some high-quality randomized controlled trials of these treatment modalities confirm a positive effect, the effect size is small and, when more than one treatment is compared, no difference between interventions has been found (Critchley, Ratcliffe, Noonan, Jones & Hurley, 2007; van Tulder et al., 2006).

Intervention trials usually recruit a heterogeneous sample of non-specific LBP patients and report the mean effect of the intervention. Thus it is, in effect, incorrectly treated as an homogenous problem. However, patients with non-specific LBP have many different presentations, and factors that contribute to their experience of pain and disability may vary. Because of this diversity, certain groups of patients may respond better than others to a particular treatment (Delitto, 2005). Trials with heterogeneous LBP populations may experience a dilution effect where a marked improvement in some patients is, in effect, cancelled out by lack of improvement in other patients, giving the overall impression of only mild effectiveness (Leboeuf-Yde & Manniche, 2001). It has been argued that interventions that do not take the heterogeneity of the LBP population into account, may fail to identify treatments that are effective for a subgroup of people with LBP (Brennan et al., 2006).

There is evidence that better outcomes are reported when a population of LBP patients is divided into subgroups and treatment is tailored to the subgroups compared to a one-hat-fits-all model (Fritz, Delitto & Erhard, 2003; Hall, McIntosh & Boyle, 2009). Fritz and co-workers (2003) compared the use of a classification system where patients were assigned to one of four treatments (manipulation/mobilization, directional exercises, traction, or stabilization exercises) to treatment based on clinical practice guidelines involving reassurance, advice to stay active, low-stress aerobic exercise, and general muscle
reconditioning exercises after the first 2 weeks. The classification group was evaluated at the beginning of every session and treated using one of the four treatment methods, as determined by the clinical prediction rules. After four weeks, greater percentage improvement in the Oswestry disability Questionnaire score (difference = 10.9, 95% CI: 1.9-19.9, \( P < .05 \)) was observed in the classification group compared to the guideline group. As can be seen by the large standard deviations, there was considerable variation in response in both groups, which could be a reflection of the sample size \((n=78)\). Although the authors state that they had sufficient participants to detect change, the total number of participants was perhaps rather low compared to other studies that assess the impact of a new treatment approach on outcome in a clinical setting. For example, Hall et al. (2009) compared the treatment results of 2223 patients with low back and leg pain who were either treated ‘as usual’ using numerous physical therapy modalities including exercise, reassurance, and advice to stay active, or classified into one of four subgroups that guided selection and personalization of the same treatment modalities. The odds of complete pain relief following treatment were two to ten times greater (depending on the subgroup) in the classified group than in the non-classified group. In addition, the odds of a minimal clinically important improvement in function were all greater in the classified groups, although these differences were not as large as for pain relief. Classified patients on average also had fewer treatments (9.9-16.5 days) than the comparison group (21.5 days). Studies such as these two provide strong motivation to find clinically useful systems that can guide clinicians in their treatment choices.

Most primary care clinicians believe that non-specific LBP is not a single condition (Kent & Keating, 2004). Over 70% also believe that it is possible to identify subgroups within LBP populations, and they treat patients differently based on signs and symptoms (Kent & Keating, 2004). However, clinicians tend to rely
heavily on physical assessments of impairment, many of which have poor or uncertain reliability (Essendrop, Maul, Läubli, Riihimäki & Schibye, 2003; May, Littlewood & Bishop, 2006; van Trijffel, Oostendorp, Lindeboom, Bossuyt & Lucas, 2008). Diagnosis is usually made on a patho-anatomical basis, with little and controversial evidence of validity (Kent & Keating, 2005). Allowing clinicians the freedom to choose the type of manual therapy technique they use in a particular patient has been shown to provide no additional benefit compared to applying a predetermined technique (Kent, Marks, Pearson & Keating, 2005). Kent et al. (2005) reviewed randomized controlled trials that compared lumbar spine manipulations/mobilizations to no intervention/placebo or other interventions. They determined that studies where practitioners had no choice of technique reported better outcomes for both pain (difference in effect size = 0.39±0.37, \( P=.02 \)) and activity limitation (difference in effect size = 0.62±0.47, \( P<.01 \)). It is evident that different strategies in both research and clinical practice are needed to address these problems and a potential solution is to undertake research into subgroup identification.

**Subgroups and classification systems**

The development of subgroups of LBP patients has been identified as an important research priority by researchers (Foster, Dziedzic, Van Der Windt, Fritz & Hay, 2009), clinicians (Henschke, Maher, Refshauge, Das & McAuley, 2007), and guideline working groups (Airaksinen et al., 2006). It is evident that clinicians already use informal sub-grouping methods, but they may not always make the best decisions when doing so. Sub-grouping in research allows clarification and validation of clinical strategies and a measure of the effects of an intervention on
selected patients. Through sub-groups, trends in the LBP population may become clearer and shed further light on underlying pain mechanisms.

There are three primary methods of sub-grouping LBP patients: diagnostic, prognostic, and prescriptive (Riddle, 1998). The diagnostic approach is based on identifying underlying pain mechanisms or ‘syndromes’ and is built on the premise that there are multiple aetiologies underlying LBP and that it is possible to accurately identify these. Prognostic sub-grouping usually aims to identify groups of patients who will become chronic pain sufferers or who have a higher risk of recurrent LBP episodes (Riddle, 1998). The last method takes a very clinical approach by providing suggestions for the most appropriate treatment method for specific sub-groups and bypasses the need to diagnose elusive patho-anatomy. Prescriptive sub-grouping is based on responsiveness to different treatments, acknowledging that even people with the same diagnosis may not respond identically to the same treatment.

Subgroups are often developed and presented in the form of a classification system. According to Binkley et al. (1993), a classification system should do three things: guide clinical decision-making, identify homogenous subgroups for effectiveness studies, and facilitate communication among clinicians. A number of prescriptive classification systems have been developed to date, including the McKenzie Mechanical Diagnosis and Therapy system in 1980 (Donelson, 2004), the Sikorski approach in 1985 (Riddle, 1998), the Delitto system in 1995 (Delitto, Erhard & Bowling, 1995), and more recently the O'Sullivan classification system for chronic LBP (O'Sullivan, 2005). However, not all have been studied and developed to the same extent.

There are two ways to develop classification systems that sub-group LBP patients (Riddle, 1998). All the above systems were developed using a judgmental
approach, where the developers identified subgroups using traditional customs (for example, variables appearing repeatedly in the literature), conventional wisdom (clinicians beliefs), and personal experience (Riddle, 1998). However, there is also another statistical approach that requires collection of many variables and application of multivariate statistical models like cluster analysis or regression to identify groups of patients with similar characteristics. The former method is subjective and may fit with current clinical practices, but may not be accurate or valid. The latter method can be more objective, and can be used to test and improve a judgmental classification system. The Delitto classification system is the only one of the above-mentioned systems that has undergone further development and revision through statistical methods (Fritz, Cleland & Childs, 2007).

Delitto et al. (1995) originally devised a comprehensive system of classification using a decision tree approach that served to identify the most appropriate management for a particular patient. The original system involved initial screening of patients who require referral because of possible underlying spinal pathology. Those patients who could be managed by physical therapists were staged according to pain severity and treatment priority (pain reduction, functional improvement, or training for high-demand activities). Patients in the acute stage, requiring pain reduction, were then assigned to one of four treatment approaches (directional movements, traction, mobilization, or immobilization). Examples of patho-anatomical causes of LBP, and a collection of signs and symptoms were provided to assist practitioners in choosing one of the four approaches.

There are a number of problems with the original Delitto system. On one hand, the system offers little advice on treating chronic pain and the psychosocial factors that influence the experience of pain and its resolution. However, classification systems are dynamic, changeable entities that can continue to evolve with time and further
research. For example, the original Delitto system was developed purely on a
judgmental basis and relied heavily on conventional diagnostic and treatment
methods of the time with little supporting research on their reliability or validity.
The classification criteria have since then been updated based on new research and
improvements have also been made to the interventions used (Fritz, 2009). Much
of this evolution has occurred thorough statistical methods in the form of clinical
prediction rules (Flynn et al., 2002; Fritz et al., 2007; Hicks, Fritz, Delitto & McGill,
2005).

Clinical prediction rules
A clinical prediction rule (CPR) is a set of variables that can indicate the probability
of occurrence of an outcome of interest (Laupacis, Sekar & Stiell, 1997). To
develop a clinical prediction rule, numerous variables that are believed to be
potential predictors of a successful outcome are identified from the literature and
subsequently employed in the study (Childs & Cleland, 2006). These variables are
gained from the participant’s history, physical examination and questionnaires.
Before and after the intervention the outcome (e.g. pain or disability as a result of
LBP) is measured. On completion of the intervention, outcome data is divided into
predetermined groups (e.g. those who showed clinically meaningful change in the
outcome variable and those who did not). Through statistical analysis, predictor
variables for the outcome of interest are identified. Most CPR developers use
regression analyses to identify predictors of outcome, although other methods like
recursive partitioning analysis and discriminant function analysis may also be
employed (McGinn et al., 2000). The clinical prediction rule is then generated
from the combination of variables that has the highest predictive ability.
CPRs are usually described in terms of sensitivity, specificity, and likelihood ratios. The decision on whether to maximise sensitivity or specificity depend on the situation in which the CPR is used (Laupacis et al., 1997). Likelihood ratios estimate the post-test probability of an outcome when using the rule. A likelihood of 1 means that the post-test probability of the outcome occurring, is exactly the same as the pre-test probability (Laupacis et al., 1997). The greater the likelihood ratio, the greater is the probability of the outcome occurring. Likelihood ratios of 2 to 5 have been proposed to indicate small but possibly important changes, ratios of 5 to 10 suggest moderate changes, and ratios greater than 10 suggest large and conclusive changes in likelihood of observing the outcome (Beattie & Nelson, 2006).

Derivation of a rule does not provide evidence of usefulness in a clinical setting (Laupacis et al., 1997). Once a sensible CPR has been developed, a number of further steps are required to ensure that the CPR can be used with confidence. McGinn et al. (2000) have offered a hierarchy of evidence that can be used to determine validity of a CPR. Level 4 evidence means that the rule has been derived in a well-defined population but has not yet been validated and needs further evaluation before clinical use. Level 3 rules have been validated in a similar sample to that of the derivation study and should only be used cautiously and with patients that closely resemble the study population. Level 2 rules have demonstrated accuracy in a large sample with a variety of patients and examiners and can be used with confidence in a variety of settings. Finally Level 1 rules have undergone impact analyses that have demonstrated change in clinician behaviour and improved population outcomes with their use.

It is important to note that CPRs are not classification systems. Rather they are tools that may identify a discrete subgroup that could form part of a classification
system. They are also not clinical practice guidelines, which address multiple issues in patients with a particular syndrome (e.g. back pain) (Reilly & Evans, 2006). Simply, a CPR is a statistically derived tool that provides diagnostic or prognostic probabilities of a particular outcome in a person with a specific presentation and it only exists because of its ability to predict outcome. CPRs are particularly useful when the decision making process is complex, in high-risk situation, or to reduce costs due to unnecessary tests or treatments (McGinn et al., 2000). In medicine, CPRs have been developed for many scenarios. There are CPRs to predict: the need for ankle radiography (Stiell et al., 1992), risk of active TB at the time of hospital admission (Wisnivesky et al., 2005), complications of an acute ischaemic heart disease (Reilly & Evans, 2006), and more. Recently CPRs have also found their way into LBP literature.

CPRs may be particularly useful in recommending treatment choice for LBP as it is a highly prevalent condition, common diagnostic tests are generally unreliable, conflicting information exists regarding the effectiveness of interventions, and there is a belief among researcher and clinicians that subgroups exist and would be useful to research (May & Rosedale, 2008). Numerous studies have developed prescriptive CPRs for use in LBP populations. However, only two of these have been subjected to validation: a study examining responders to manipulation (Flynn et al., 2002), and a study examining stabilization exercise responders (Hicks et al., 2005).

Flynn et al. (2002) derived a 5-variable rule that was successfully able to predict people with acute LBP who showed a 50% improvement in disability following two sessions of spinal manipulation. The rule was able to predict 67% (Nagelkerke $R^2$) of the variance in outcome ($P<.001$). Predictors of a successful outcome were: onset of LBP <16 days ago; at least one hip internal rotation range of motion >35°;
detection of hypomobility during lumbar spine spring test; Fear-Avoidance Beliefs Questionnaire work subscale score <19; and no symptoms below the knee. If at least four of these predictors were present, the positive likelihood ratio was 24.4, indicating high likelihood of improvement in disability. One problem with the study is that the authors failed to blind the assessors of the predictor variables to the outcome.

Four different validation studies (Brennan et al., 2006; Childs et al., 2004; Cleland, Fritz, Whitman, Childs & Palmer, 2006; Hancock, Maher, Latimer, Herbert & McAuley, 2008) have been undertaken on the manipulation CPR, with one independent study failing to support the subgroup characteristic (Hancock et al., 2008). The latter study showed no significant difference in outcomes between those who met the CPR criteria and those who did not ($P_{\text{pain}}=.80$ for pain, $P_{\text{disability}}=.60$ for disability), leading a review to conclude that the evidence for this rule was limited and contradictory (May & Rosedale, 2008). However, this conclusion was perhaps also somewhat limited, as the differences between the studies were not discussed. The study by Hancock et al. (2008) differed significantly in a number of ways from the original derivation study (Flynn et al., 2002) and other validation studies (Brennan et al., 2006; Childs et al., 2004; Cleland et al., 2006). The study was conducted in a different setting, which is appropriate because a variety of patients and clinicians is a requirement for Level 2 validation (Beattie & Nelson, 2006). However, the researchers also varied the treatment protocol considerably. The four comparison studies all used high velocity thrust manipulations targeted to the sacroiliac joints or L4-5 lumbar vertebral joints, as well as prescribing some pelvic tilting exercises, while Hancock et al. (2008) allowed the clinicians to use any manipulation or mobilization techniques and prescribed all patients with a mild analgesic, and a proportion of patients with non-steroidal anti-inflammatory drugs. CPR validation protocols do not indicate that the treatments given should be varied.
(Beattie & Nelson, 2006). In fact, changing the treatment could potentially alter the predictors of success and hence the subgroups indicated for intervention. It is possible that the non-significant results observed by Hancock et al. (2008) resulted from applying an intervention that was different from the studies used to develop the CPR, rather than lack of stability of the CPR. Another study that validated the CPR, albeit in a similar setting to the original study, reported a significant difference in change in disability score at 4 weeks (Childs et al., 2004). Patients receiving manipulation who were positive for the CPR had a better percentage improvement in Oswestry disability score than those who were negative (difference = 15.2, 95% CI: 7.5 to 23.3, \( P < .001 \)). The same did not hold true for participants in the control group (receiving exercise) who were positive or negative for the rule (difference = 6.5, 95%CI: -1.8 to 14.8, \( P = .127 \)).

A clinical prediction rule for stabilization exercises in acute LBP populations has been developed as well (Hicks et al., 2005). The likelihood ratio of the 4-variable rule was only 4.00, indicating small changes in the likelihood of 50% improvement on the Oswestry Disability Questionnaire, and no data demonstrating the model's fit was reported. However, a construct validity study that has shown that spinal motion characteristics measured using digital fluoroscopic video can identify the responders to stabilization exercises (Teyhen, Flynn, Childs & Abraham, 2007), increases confidence in the construct validity of the model.

Only one trial has aimed to validate all the clinical prediction rules based on the Delitto system. Brennan et al. (2006) randomly assigned 123 participants to one of three treatments (manipulation, stabilization exercises, and specific directional exercises; traction was not included). The clinical outcomes for those people matched and unmatched to their treatment groups (according to the CPRs) was then compared. Patients receiving treatment matched to their CPR subgroup
experienced greater improvement in Oswestry disability score than patients receiving unmatched treatment, at four weeks (difference = 6.6; 95% CI: 0.70 to 12.5, \( P < .05 \)) and at 1 year (difference = 8.3, 95% CI: 2.5-14.1, \( P < .01 \)). In light of this study and the above-mentioned trials, subgrouping LBP patients through CPRs appears promising but considerably more research is needed before they can be confidently employed in patient care.

Numerous other CPRs have been developed to identify LBP responders to traction, physical therapy/chiropractic, zygapophyseal joint injections, and multidisciplinary rehabilitation (May & Rosedale, 2008). All of these have not been advanced beyond the derivation stage and none were of high quality (May & Rosedale, 2008). One CPR derivation study for chronic LBP (multidisciplinary treatment) did not actually report a rule, as the results of the regression models did not justify such development (Van Der Hulst, Vollenbroek-Hutten, Groothuis-Oudshoorn & Hermens, 2008). Limitations of the study included too many outcome variables and a limited range of potential predictors. Unfortunately, all other CPR studies have focused on acute LBP, and despite the perplexity of chronic LBP, no specific CPRs exist. It is plausible that similar treatments may be effective for chronic LBP, although outcome predictors may differ. In particular the stabilization exercise CPR may hold great value as exercise has already been shown to be a promising treatment for chronic non-specific LBP.

**Exercise for Chronic LBP**

A Cochrane review has found strong evidence that exercise is at least as effective, if not more effective than comparison treatments in treating chronic LBP, both at short and long-term follow-up periods (Hayden, van Tulder, Malmivaara & Koes, 2005). However, while exercise interventions are effective, the overall effect size is
still small: 3.00 points (95% CI: -0.53 to 6.48) out of 100 compared to no treatment, and 2.37 points (95% CI: 0.74 to 4.0) out of 100 compared to other conservative treatments. Interestingly, the authors do not recommend further research on general exercise therapy for people with chronic LBP. Instead, they recommend that studies should focus on specific exercise interventions in well-defined LBP populations. Hayden, van Tulder and Tomlinson (2005) reviewed numerous exercise programmes, and determined that individualized, supervised programs and those that include stretching and strengthening can yield the greatest improvements in pain and disability. However, Paalanne et al (2008) found no association between trunk muscle strength and LBP, so it is unclear why strengthening exercises would improve outcome.

O’Sullivan (2005) has suggested that one subgroup of patients with chronic and recurrent LBP may have movement control impairments that prevent recovery, and would thus be likely to benefit from interventions that addressed this deficiency. Several studies have examined the effects of movement control exercises (commonly referred to as ‘stabilization exercises’ and recently as ‘motor control exercises’) on LBP, some reporting improvement in disability and pain (Harringe, Nordgren, Arvidsson & Werner, 2007; Rydeard, Leger & Smith, 2006) where as others report no significant improvement (Arokoski, Valta, Kankaanpaa & Airaksinen, 2004). While variations in the type of exercises makes comparison between studies difficult, a number of studies have compared stabilization exercises to other types of exercise. These studies concluded that exercise was better than placebo but that the effects of the different exercises are comparable with each other (Cleland, Schulte & Durall, 2002; Miller, Schenk, Kames & Rousselle, 2005). A review by May and Johnson (2008) concludes that stabilization exercise interventions for people with chronic LBP show superiority to passive treatments (limited therapist input or limited/unmonitored patient participation in
management), but perform comparably to other active interventions including manual therapy and other exercise programmes. However, certain subgroups of LBP patients could exist that respond better than others to particular active interventions. For example, Koumantakis, Watson and Oldham (2005) found no greater benefit of combined stabilization exercises and general exercise compared to general exercise alone, unless subjects had clinical signs of instability. Another, more recent study, by Rasmussen-Barr et al. (2009), showed that graded stabilization exercises were better than daily walks at improving disability in people with recurrent LBP. While they demonstrated that there was no significant difference in the number of people who showed minimal clinically important change (MCIC) immediately after the intervention ($P=0.26$), at 12-month post-intervention 53% of those in the graded stabilization exercise group showed MCIC in disability compared to only 26% of the walking group ($P=0.02$). So perhaps, if exercise programmes and target patients meet certain criteria, the interventions can be more effective.

Stabilization exercises are aimed at training activation of deep trunk muscles, specifically the transversus abdominis and the deep fibres of the multifidi, as well as improving coordination between contraction of deep and superficial trunk muscles, while gradually increasing the demand of the exercise tasks (Richardson, Hodges & Hides, 2004). This approach is based on the notion that changes in trunk muscle coordination have occurred in people suffering from chronic LBP. Numerous studies give evidence to the presence of motor control impairment in patients with chronic and recurrent LBP, with changes in trunk muscle activation patterns (Hodges & Richardson, 1998; Hodges & Richardson, 1999; Hodges, Richardson & Jull, 1996; Hubley-Kozey & Vezina, 2002) and reorganisation of the brain's motor cortex (Tsao, Galea & Hodges, 2008). Studies on chronic LBP have consistently observed delayed activity and wasting in deep abdominal muscles and
back muscles and increased activity in superficial abdominal muscles (Ferreira, Ferreira & Hodges, 2004; Hodges et al., 1996; Hungerford, Gilleard & Hodges, 2003). While it is unknown whether the changes are the cause or result of LBP, Cholewicki (2005) suggests that these alterations may contribute to the frequent recurrence of LBP.

There is some evidence that recruitment patterns of trunk muscles can be changed through specific exercises (Stevens et al., 2007; Tsao & Hodges, 2007; Tsao, Galea & Hodges, 2008). Stevens et al. (2007) demonstrated increased abdominal muscle activation after stabilization training in healthy people. In addition, Tsao and Hodges (2007) have reported that voluntary trunk muscle activation can improve activation of trunk stabilizing muscles during trunk perturbation tasks in people with recurrent LBP. The authors have also demonstrated that these changes can persist for up to 6-months, even after cessation of exercises (Tsao & Hodges, 2008). It seems that specific exercises can improve not only voluntary activation of deep trunk muscles, but that the learned skills can also improve automatic contractions.

In addition to physical effects, the graded approach generally used in teaching stabilization exercises, may help in reducing fear-avoidance beliefs. Fear avoidance beliefs are “patients’ beliefs about how physical activity and work affected their low back pain” (Waddell et al., 1993). They have been shown to correlate to the degree of disability and may explain the variance between pain and disability that is frequently seen in chronic LBP (Crombez, Vlaeyen, Heuts & Lysens, 1999; Waddell et al., 1993). Macedo et al. (2008) hypothesize that graded activity exercises may improve disability and reduce fear-avoidance beliefs. So, a graded programme of exercises, that is supervised and includes movement control
exercises and some stretching, may provide the greatest benefit for a subgroup of chronic LBP patients.

**Potential predictors**

To develop a clinical prediction rule, potential predictors of outcome need to be identified. Predictor variables may include: those that are commonly used in clinical practice; those that are popular in the literature and in practice guidelines; and variables that are emergent in research and clinic settings and have the potential to be useful. For the following study, predictors that relate specifically to chronic LBP, movement control impairment, and exercise, will be particularly pertinent.

Demographic variables such as age, gender, work status and level of education, as well as body mass index have all been deemed important factors to consider in the transition from acute to chronic LBP by a group of experts (Pincus, Santos, Breen, Burton & Underwood, 2008). Therefore these variables would be valuable to include as predictors of outcome following an intervention for chronic LBP. For example, Costa et al. (2009) have demonstrated that the prognosis for chronic LBP patients is worse for those with lower education levels. Pincus and co-workers (2008) also recommend assessment of pain intensity and disability as baseline predictors of chronic LBP. Higher pain intensity at baseline is a predictor of poor prognosis and non-completion of treatment programmes (Barnes, Smith, Gatchel & Mayer, 1989; Menezes Costa et al., 2009). Prognosis is also worse for those with high levels of disability at baseline (Menezes Costa et al., 2009).

It is now well recognised that chronic LBP is a multidimensional condition, and psychosocial factors form a strong part of the pain experience. Fear-avoidance beliefs and distress are associated with disability levels and are particularly high in
patients with chronic LBP (Grotle, Vølstad, Veierød & Brox, 2004; Waddell et al., 1993). Mannion et al. (2001) have shown that fear-avoidance beliefs and distress each explain almost 10% of the variance in disability following an active therapy for chronic LBP. Higher levels of depression are seen among patients who fail to improve following a functional restoration programme (Barnes et al., 1989) and have been shown to be general predictors of poor prognosis (Pincus, Burton, Vogel & Field 2002). A heightened belief in possible negative consequences (catastrophizing) has also been associated with poor outcome following active therapies for chronic LBP patients (Mannion et al., 2001).

There is evidence that physical signs and symptoms are not predictors of chronic disability (Hunter, Smith & Gribbin, 2001), but musculoskeletal examination findings form an important part of clinical decision making. A selection of tests including lumbar spine segmental mobility assessment, a prone instability test, passive straight leg raise range of motion, and lumbar flexion range showed predictive value in a previous CPR for stabilization exercises in acute LBP (Hicks et al., 2005). These may also predict outcome in a chronic LBP population following a similar exercise programme.

Because movement control exercises aim to improve disability partly by addressing altered postural adaptations, tests such as those examining aberrant motions on forward bending (Hicks, Fritz, Delitto & Mishock, 2003), and movement control tests described by Luomajoki et al. (2007) may be able to predict outcome. Hicks et al. (2005) showed that the presence of aberrant motions on forward bending was a predictor of success following stabilization exercises in people with acute LBP. Luomajoki et al. (2008), showed that LBP patients had significantly more positive (inability to perform the movement correctly) tests than healthy controls (difference 1.8, 95% CI: 1.02 to 1.34, \( P<.001 \)). Furthermore,
chronic LBP patients also had significantly more positive tests than acute LBP patients (p<.01). Therefore, both of these groups of tests may be useful predictors of outcome in people with chronic LBP, following an exercise intervention.

Lack of muscle strength and endurance may play a role in the propagation of chronic LBP. It is recognised that deep spinal muscles play an essential role in stabilizing the spine, but the superficial muscles may also become dysfunctional in LBP (Barr, Griggs & Cadby, 2005). Trunk muscle strength and body sway have not shown significant association with LBP (Paalanne et al., 2008). However, muscle endurance times are frequently decreased in people with LBP when compared to healthy individuals (Ito et al., 1996; Latimer, Maher, Refshauge & Colaco, 1999; McGill, Childs & Liebenson, 1999; Schellenberg, Lang, Chan & Burnham, 2007).

A multitude of variables exist that could be potential predictors of treatment outcome in people with chronic LBP. It is unfeasible to test all possible variables, and therefore the selection outlined above were deemed most promising predictors and chosen for inclusion in the following research project.
Conclusions

LBP is very common. Chronic pain and disability in particular lay a heavy burden on the individual and society as a whole. While current evidence of treatment effectiveness is regrettable, development of subgroups through clinical prediction rules may provide solutions for future management of LBP. There is some evidence that specific movement control exercises are effective in improving disability, and numerous studies variables may predict treatment response.

For these reasons, a study to identify variables that predict change in disability rating in people with chronic non-specific LBP following a graded programme of movement control exercises, and the development of a clinical prediction rule to identify a subgroup of patients likely to benefit from such an intervention is both relevant and timely.

Section two of this thesis reports on the investigation.
References


Section 2: Manuscript

Note: This manuscript has been prepared in accordance with the instructions for authors for the Journal of Bodywork and Movement Therapies [see Appendix H].
Predictors of functional improvement in people with chronic low back pain following a graded programme of movement control exercises
Predictors of functional improvement in people with chronic low back pain following a graded programme of movement control exercises

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Abstract

Objectives. i) To determine predictors of change in disability of people with chronic low back pain following a graded programme of movement control exercises and ii) to develop a simple clinical rule that predicts outcome. Methods. Fifty-five people from a community sample with non-specific chronic low back pain were examined before undergoing a graded 6-week programme of movement control exercises. Predictors of change in disability, as measured by the Patient-Specific Functional Scale, were identified through regression analysis and used to develop a clinical prediction rule. Results. Clinically important improvement in disability was predicted by four variables that explained 48% of the variance in outcome (P<.001): gradual rather than sudden onset of low back pain, patient-specific functional score <3.7 points, absence of aberrant motions on forward bending, and body mass index >24.5. Failure to show clinically meaningful improvement was predicted by three variables that explained 40% of the variance in outcome (P<.001): sudden onset of low back pain, patient-specific functional score ≥3.7, and difference between left and right active straight leg raise >7°. Conclusion. A combination of five, easily measured variables are able to predict disability outcome following a graded programme of movement control exercises in people with chronic low back pain.
Introduction

Back pain is very common. Up to two thirds of the population are affected by low back pain (LBP) in a 1-year period (McBeth and Jones 2007). While most people show rapid improvement in pain and disability within the first month of experiencing LBP, in about 10% of cases LBP becomes chronic, persisting for more than 3 months, and many more will continue to experience recurrent episodes of pain for at least one year (Carey, Garrett and Jackman 2000; Pengel et al. 2003).

LBP is often accompanied by disability (functional limitations). Disability is the expressed combination of physical impairment, distress, and illness behaviours (Bogduk 2006). Therefore, many factors within each of these three domains may influence disability levels and response to therapy. Mannion et al. (2001) have identified and measured a number of predictors of disability. They determined that psychological factors, including distress, fear-avoidance beliefs, and pain intensity, were the strongest predictors, while back muscle activation, spinal range of motion and gender also showed correlation with disability levels, albeit to a lesser extent.

Many studies have been undertaken to investigate the benefits of various treatments on LBP, but few have been found to be effective (Bogduk 2004; van Tulder, Koes and Malmivaara 2006). Numerous authors suggest that this may not be a reflection of the treatments themselves, but an indication of the heterogeneity of the low back pain population (Brennan et al. 2006; Bouter, van Tulder and Koes 1998; Delitto 2005). Consequently, it has been suggested that subgroups should be identified to determine those people who are most likely to respond to a particular intervention (Bouter, van Tulder and Koes 1998; Delitto, Erhard and Bowling 1995).
O'Sullivan (2005) has distinguished one potential subgroup of chronic LBP patients that is characterized as demonstrating signs of motor control impairments. Numerous studies give evidence to the presence of motor control impairment in patients with chronic and recurrent LBP, with changes in trunk muscle activation patterns (Hodges, Richardson and Jull 1996; Hodges and Richardson 1998; Hodges and Richardson 1999; Hubley-Kozey and Vezina 2002; Tsao, Galea and Hodges 2008) and reorganisation of the brain's motor cortex (Tsao et al 2008). There is also some evidence that exercise training may induce changes in the motor cortex (Adkins et al. 2006) and in the recruitment patterns of trunk muscles (Stevens et al. 2007; Tsao and Hodges 2008). A number of reviews have concluded that exercise is effective in reducing LBP-related disability (Hayden, van Tulder and Tomlinson 2005; Slade and Keating 2007; van Tulder et al. 2000), but clarification is needed to determine which exercises bring the greatest benefits for subgroups of LBP patients (Bell and Burnett 2009; Henchoz and Kai-Lik So 2008). The identification of subgroups is currently an area receiving considerable attention in the back pain literature and may shed light on this question (Billis, McCarthy and Oldham 2007; Delitto 2005).

One method of subgroup identification that has become popular in LBP literature is the development of clinical prediction rules. A clinical prediction rule (CPR) is a set of variables that, when present, indicate the probability of occurrence of an outcome of interest (Laupacis, Sekar and Stiell 1997). To develop a CPR, a number of variables that are believed to be potential predictors of the outcome are identified from the literature and measured before an intervention. Through regression analysis, predictor variables for the selected outcome (e.g. disability) are identified. The CPR is then generated from the set of variables with the highest predictive ability.
The purpose of this study was to identify variables that predict clinically meaningful changes in disability rating in patients with chronic non-specific LBP following a graded programme of movement control exercises. In addition, CPRs to identify subgroups of patients likely to benefit, or not benefit from such an exercise programme were developed by determining a subset of predictor variables which maximise specificity and sensitivity of a successful or unsuccessful outcome.
Methods

Study sample
Participants were recruited from the local community through convenience sampling in the form of advertising posters. All participants were required to be between 25 and 65 years of age with current LBP of at least 6 months duration or current LBP of less than 6 months duration with repeated pain episodes in the last year. Exclusion criteria were: known or suspected pregnancy; osteoporosis; any signs of spinal pathology (e.g. tumour, infection, fracture); signs of nerve root compression; history of spinal or abdominal surgery within the previous year; any contra-indications to exercise; or any previous regular involvement in Pilates or back-exercise classes. Prior to enrolment all participants were informed of the study procedures and gave written informed consent. The study was approved by the institutional research ethics committee.

Pre-intervention Assessments
One week before the intervention, LBP-related disability was measured using the Patient-Specific Functional Scale (PSFS) (Stratford et al. 1995). The PSFS requires patients to self-nominate three to five activities that are important to them, and rate them on an 11-point scale. The scale has been shown to be a highly reliable (ICC=.97) (Stratford et al. 1995) and responsive outcome measure (Pengel, Refshauge and Maher 2004). The PSFS ranges from 0 (unable to perform activity) to 10 (able to perform activity at pre-injury level). An average PSFS score of ≤6 was required for inclusion in the study.

In the week before the intervention commenced, participants completed a booklet of questionnaires and underwent a physical assessment to measure variables that were potential predictors of outcome. The measures included demographic and anthropomorphic variables; characteristics of pain; activity interference, beliefs,
and reported behaviours; other psychosocial factors; musculoskeletal examination findings; flexibility measures; movement control tests; and trunk muscle endurance tests (see appendices A and B). Physical examination variables were collected by an independent examiner. The exercise practitioner was blinded to the scores of the predictor and outcome variables.

**Outcome Assessment**
The PSFS was again administered one week after completion of the intervention. An improvement of 4.3 points on the average score has been found to equate to a ‘large’ change on the global rating of change scale (a measure of the patient’s perception of change) (Stratford et al. 1995) and an improvement of ≥4 points was therefore used as an indicator of clinically important improvement (classified as ‘success’). A change of 0.8 points correlates with a small change on the global rating of change scale (Stratford et al. 1995). As a small change was not considered clinically meaningful, patients with improvement of ≤1 point were classed as failing to respond (classified as ‘failure’). The term ‘improvement’ is used to identify participants who showed clinically meaningful improvement but not clinically important improvement (change in PSFS score of <4 points but >1 point).

**Intervention**
The programme consisted of 12 exercise classes of 1-hour duration, scheduled over a period of six weeks. Every participant attended one mat class and one reformer class per week. The mat class is performed while lying supine or side-lying on the ground or in a 4-point kneeling position and sometimes includes small props to support or to challenge the participant during exercises. The reformer (see Figure 1) is a spring-loaded carriage on which the participant lies, sits or stands, that can be used to provide either external resistance or assistance. The classes were supervised by a trained Pilates instructor and conducted in groups of 2-7
participants for the reformer classes and 5-16 participants for the mat classes. Catch-up sessions were provided for any missed classes, ensuring a 100% attendance rate for every participant.

The exercises were graded and were designed to improve body awareness and movement control. They progressed from awareness of breathing and contraction of pelvic floor and abdominal muscles, through to maintaining control of spinal movement whilst performing dynamic tasks that involved leg and arm motion. Other exercises encouraged spinal mobility and stretching of the hip and leg muscles. More challenging exercises that incorporated control of the spine in seated and standing positions were also practiced on the reformer in the latter stages of the intervention. See Appendices C and D for an overview of the exercises.

Data Analysis

Data were analysed using SPSS version 15 (SPSS Inc., Chicago IL). Potential predictor variables were grouped into categories in order to assess univariate relationships with the outcome variables (‘success’, ‘failure’ or PSFS change) and with each other using Pearson’s product-moment correlations. Variables with significance levels of $P<.10$ when correlated with any one of the three outcome measures were included. When two potential predictors from the same category were found to be correlated with each other ($r>.30, P<.05$), only the variable with the higher univariate correlation with one of the outcome variables was chosen for further analysis.

Linear and logistic regression models were developed to identify variables that predicted outcome. A stepwise multiple linear regression model was used to identify determinants of change in PSFS score. Two logistic regression models
were also applied to determine predictors that increased the probability of ‘success’ and predictors that increased the probability of ‘failure’. Backward entry procedures were used for the initial regression models ($P_{out}<.05$, $P_{in}=.05$) and each model was confirmed by re-running the regression procedure with statistically redundant determinants removed, using a stepwise entry procedure.

The continuous predictor variables identified through logistic regression analysis were plotted on receiver operating characteristic (ROC) curves. The point on each ROC curve that is closest to the upper left hand corner presents the cut-off point giving the highest accuracy of positive/negative prediction, and each point was chosen by consensus between the investigators. Using the cut-off scores, all predictive variables were dichotomized. Logistic regression models for ‘success’ and ‘failure’ were applied to the appropriate dichotomized variables to eliminate any variables that were unstable, and to calculate Hosmer and Lemeshow $R^2$ values that estimate the model fit. Chi-squared tests were run for each of the outcome variables (‘success’ and ‘failure’) with different combinations of their predictors. Sensitivity and specificity values were calculated and, if necessary, a value of 1 (i.e. 1 person) was added to all cells used to calculate these figures to avoid division by zero errors. The combinations with the highest likelihood ratios were used for the clinical prediction rules for ‘success’ and ‘failure’.
Results

Out of 67 participants who were interviewed, 55 were eligible and able to commit to the class times. Five people failed to complete the study due to work commitments \((n=2)\), family illness \((n=1)\) and because the classes aggravated their pain \((n=2)\). A further two data sets were unusable because participants had significantly altered some questions. Therefore, data from 48 people, 32 (67%) females and 16 males (33%), were included in the analyses. Their baseline characteristics are outlined in Table 1. The average PSFS score was 3.5±1.3 (mean ± standard deviation) at baseline, and improved to 6.3±2.0 following the intervention. According to the participants’ changes in PSFS score there were 14 ‘success’ cases, 16 ‘improvement’ cases, and 18 ‘failure’ cases classified.

Eleven out of 43 variables were retained after univariate correlation analysis (Table 1). Two of these were removed due to significant correlation with another predictor: history of traumatic onset of LBP showed correlation with gradual/sudden mode of onset of LBP \((r=-.48, P<.001)\); and average lateral trunk muscle endurance time showed correlation with spinal extensor muscle endurance time \((r=.38, P<.01)\). Nine potential predictors remained for analysis.

Regression models

The potential predictors were entered into logistic regression models for ‘success’ and ‘failure’, and into the multiple linear regression model. There was no interaction between these variables in the regression procedures. Variables retained in the success model were: age (positive predictor); BMI (positive); gradual mode of onset of LBP (positive); PSFS score (negative); and presence of aberrant motions on forward bending (negative). Cumulatively, these explained 45% of variance in the probability of ‘success’ \((P<.001)\). Variables retained in the failure model were: age (negative); gradual mode of onset of LBP (negative); PSFS
score (positive); left/right active SLR difference (positive); and spinal extensor muscle endurance time (positive). These cumulatively explained 44% of variance in the probability of ‘failure’ \((P<.001)\). Five variables were also retained in the multiple linear regression model: age (positive); gradual mode of onset of LBP (positive); PSFS score (negative); presence of aberrant motions on forward bending (negative); and spinal extensor muscle endurance time (negative) (Table 2). These five variables cumulatively explained 52% of variance in PSFS change \((P<.001)\).

**Clinical Prediction Rules**

In order to simplify the arising clinical prediction rule, cut-off values for continuous variables and direction of the relationship were determined for each of the predictors in the logistic regression models for ‘success’ and ‘failure’. Logistic regression analyses were repeated using these dichotomized predictor variables. After dichotomizing the variables, age (cut-off = 40yr) was no longer a predictor of ‘success’ or ‘failure’, and spinal extensor muscle endurance time (cut-off = 75s) was not a predictor of ‘failure’. The remaining four variables for ‘success’ explained 48% of the variance in outcome \((P<.001)\), while the three ‘failure’ variables explained 40% of the variance in outcome \((P<.001)\) (Table 3). The predictors of ‘success’ were PSFS score <3.7 points; BMI >24.5; gradual onset of LBP; and absence of aberrant motions on forward bending; while the predictors of ‘failure’ were PSFS score ≥3.7; active SLR difference ≥7°; and sudden onset of LBP.

Using the dichotomized variables, two clinical prediction rules were constructed, one to predict ‘success’, and one to predict ‘failure’. Accuracy statistics, likelihood ratios and probability of outcome were calculated for each rule (Tables 4 and 5). The probability of ‘success’ for the entire sample was 29%. When at least three of the four success predictors were present, the probability of ‘success’ increased to
73%, and when participants were positive for all four predictors, their probability of 'success' was 82%. The probability of 'failure' for the entire sample was 38%, but when all three failure predictors were present, the probability of 'failure' increased to 80%.
Discussion

Prescriptive clinical prediction rules have received much attention in recent LBP literature and they are now emerging for common treatment modalities for acute LBP (May and Rosedale 2008). However, no equivalent rules yet exist for those with chronic and recurrent LBP. This preliminary study investigated change in disability in people with chronic LBP following a 6-week movement control exercise programme and identified five variables that were able to predict outcome. These are: pre-intervention functional score; mode of onset of LBP; aberrant motions on forward bending; BMI; and a difference between left and right active SLR range of motion. All of these variables are easily and quickly assessed in a clinical setting, and in most cases already form part of a standard examination procedure. High pre-intervention functional limitations, gradual onset of LBP, absence of aberrant motions on forward bending, and high BMI were predictors of success in showing clinically important improvement in functioning, while low pre-intervention functional limitations, sudden onset of LBP, and moderate difference between the left and right leg active SLR predicted failure to show clinically meaningful improvement. Participants who met the criteria of either one of the two CPRs increased their chances of 'success' or 'failure' from less than 40% to greater than 80%.

Individual Predictors

The single strongest predictor of outcome was the pre-intervention PSFS score. A low score, meaning high levels of disability, predicted 'success', while a higher score, identifying lower levels of disability, predicted ‘failure’. This result was unexpected, as a higher level of disability when seeking care is generally seen as a predictor of poor prognosis for chronic LBP patients (Costa et al. 2009b). However, this is not the first time such a result has been reported. Bendix (1998) determined
that patients who had greater limitations in activities of daily living at baseline, showed greater improvement, of an unspecified magnitude, following a functional restoration program than those who had lower levels of limitation. A study by Walsh et al. (2002) suggests that patients who favour a belief in ‘organic’ concepts about pain (e.g. ‘pain is the result of tissue damage’), as opposed to ‘psychological’ concepts (e.g. ‘anxiety makes pain worse’), report higher levels of disability at baseline and show a greater reduction in disability following a multidisciplinary treatment programme. It is plausible that the present study included a similar group of people with higher baseline disability and belief in ‘organic’ concepts of pain, who were positively influenced by the intervention. The active intervention, which emphasises control of movements, stretching and strengthening, is likely to be congruent with their belief system that a mechanical problem (e.g. weak abdominal muscles, poor posture etc.) can be improved by specific exercises with such aims.

Mode of LBP onset was another consistent predictor of outcome. Gradual onset predicted ‘success’, while sudden onset predicted ‘failure.’ In acute LBP patients, a history of sudden onset of LBP favours rapid recovery with general practitioner care (Macfarlane et al. 1999). However, the same concept cannot be extrapolated to patients with chronic LBP. The present data suggest that there may be a subgroup of people with sudden onset of LBP in whom pain persists following an exercise intervention, possibly as a result of undetected underlying pathology or cognitive-behavioural factors that prevent recovery. The role of gradual onset of LBP in predicting ‘success’ remains unclear. While an association has been identified between gradual LBP onset and psychological problems (Smedley et al. 2005), the impact of this intervention on psychological factors cannot be determined.
In this study, the absence of aberrant motion during forward bending was found to be a predictor of clinically important improvement in disability, and a moderate difference between the right and left leg active SLR was a predictor of ‘failure’.

Both tests have been hypothesised to measure ability to maintain appropriate lumbopelvic control when performing movements (O'Sullivan 2000; O'Sullivan et al. 2002). A study by Moseley and Hodges (2005) concludes that observed motor control changes are a result of altered postural adjustments in response to pain. Because the absence of altered lumbopelvic control predicted success and asymmetrical control predicted failure following this intervention, it is likely that the exercises did not effect changes in postural adjustment. The relatively brief (six-week) exercise programme undertaken here, may have provided insufficient stimulus for change in a chronic pain population and it is also possible that the intervention did not address the underlying causes of altered movement strategies like fear of pain (Hodges and Moseley 2003). In acute LBP, alterations in adjustment have occurred recently and may be more responsive to improvement by specific exercise, explaining the contrasting results by Hicks et al. (2005). They reported that the presence of aberrant motions on forward bending predicted success and their absence predicted failure to show improvement in disability in an acute LBP population following stabilization exercises.

Higher BMI was associated with improvement in function following the exercise intervention in this study. A previous study (Mangwani et al. 2010) examining the influence of BMI on change in disability following an imprecisely described physiotherapy intervention demonstrated no significant association. However, obesity and chronic LBP may be co-morbid conditions that share similar risk factors, such as inactivity (Shirei et al. 2010) and low self-efficacy beliefs (Annesi 2010; Main et al 2010). The current intervention may have positively influenced
overweight participants by providing manageable amounts of exercise that might have improved their mood, self-efficacy, and self-concept (Annesi 2010). The same factors have been linked to recovery from LBP (Main et al. 2010). Annesi (2010) suggests that people with higher bodyweights show greater benefits from a manageable low-intensity exercise programme than others, because they begin with a lower perception of their self-efficacy and physical competencies.

**Non-predictors**

A large number of variables included for analysis were not retained in the final clinical prediction rules. Notably these included: age; gender; duration of LBP; LBP intensity; various musculoskeletal examination findings; endurance tests; and numerous psychological factors. The first four variables as non-predictors are consistent with findings by Denison et al. (2004), who found that age, gender and LBP duration were not related to disability, and pain intensity only explained a small proportion of the variance in disability ratings. Previous investigators (Ferreira et al. 2009) have also reported that spinal stiffness holds no value in predicting disability following general or motor control exercises, findings that are consistent with the results of this study. The conclusions of studies investigating trunk muscle endurance in relation to disability are contradictory. Evans (2005) found one-sided lateral muscle endurance deficits to be predictors of recurrent LBP in golfers and Enthoven (2003) found that extensor muscle endurance times at 4-weeks, but not at baseline, predicted disability at 12 months when ‘no specific treatment’ was given. On the other hand, Mannion et al. (2001) found that extensor muscle endurance times were not predictive of disability levels with one of three active therapies, and the endurance tests did not appear in a CPR for stabilization exercises in an acute LBP population (Hicks et al. 2005). Therefore it appears that, in a normal LBP population, endurance tests at baseline are not predictors of disability following active interventions.
On the other hand, psychological factors such as fear of pain and movement, catastrophizing, distress and depression have been found to play a strong role in the development and maintenance of LBP-related disability (Burton et al. 2004; Leeuw et al. 2007; Main, Foster and Buchbinder 2010; Picavet, Vlaeyen and Schouten 2002). Therefore it is unexpected that none of these variables predicted change in disability following an exercise intervention. If active treatments have an effect on fear-avoidance beliefs and psychological distress, as Mannion et al. (2001) suggest, then it is possible that their status at baseline may not predict outcome following the intervention if they change in proportion to the change in disability.

**Limitations of the study**
The range of predictors selected for inclusion in the study was extensive, but not exhaustive. It is likely that other predictors of outcome may exist. Several potentially important predictors that were not examined in this study are self-efficacy beliefs and outcome expectations. Self-efficacy is the belief in ones ability to perform a task or activity and appears to explain the relationship between fear-avoidance beliefs and disability (Woby, Urmston and Watson 2007). Main et al. (2010) recommend that self-efficacy should be measured in addition to fear-avoidance beliefs in those with persistent back pain, and indeed Denison et al. (2004) conclude that self-efficacy beliefs are more important determinants of disability than fear-avoidance beliefs. Maine et al. (2010) also argue that patient expectations of, and preference for, a particular treatment have an influence on the outcome. Therefore these variables may act as predictors of outcome following an exercise programme.

One consistent shortcoming of CPR development studies for LBP is the small sample size. Ten participants per prospective predictor are generally suggested for regression procedures (Peduzzi et al. 1996). While these sample size
recommendations have been followed for validation studies in LBP research (Brennan et al. 2006; Childs et al. 2004), derivation studies where a distinct treatment method was examined, have fallen short of this ratio, with 54-71 participants (Flynn et al. 2002; Fritz et al. 2004; Fritz et al. 2007; Hicks et al. 2005). However, these sample size recommendations may be even more important for derivation studies in order to have sufficient statistical power to identify all potentially relevant predictors and avoid predictors entering the rule by chance, as well as avoiding association of variables in the wrong direction (Peduzzi et al. 1996). Based on nine univariate predictors entered into the regression models, the present study with 48 participants fell short of the recommended number of 90 participants. However, a second regression procedure was undertaken with only five dichotomized variables, which is very close to the recommended ratio of variables to participant. This step allows greater confidence in the predictors that have been included in the rule.

**Generalizability**

Participants in the study self-selected to take part and only those who completed the intervention were included in the regression analyses. Therefore, the applicability of the derived CPRs is restricted to patients who will actually complete an exercise programme. Patient preference for a particular treatment may affect outcome (Main, Foster and Buchbinder 2010) and this may account for the greater changes in PSFS score observed in this study compared to a similar intervention by Costa (2009a). Further, adherence rates are commonly poor in exercise interventions (Jack et al. 2010) and it is important to identify, in advance, whether patients are likely to complete the programme. Questionnaires that can predict compliance, such as one developed by Howard and Gosling (2008), may allow practitioners to make informed decisions with regard to recommending exercise programmes.
**Further research**

It should be noted that the developed clinical prediction rules are not yet appropriate for use in a clinical setting. Validation studies, and ideally impact studies, need to be conducted to determine the true value of these rules (Beattie and Nelson 2006). It would also be useful to re-develop the rules by including the most significant and sensible predictors from this study, identifying and including further potential predictors, and then determining which predictors are useful in a different population with an intention-to-treat protocol. Medium (3-12 months) and long term (>12 months) outcomes should also be assessed.

If clinical prediction rules are to be investigated further, a number of supporting studies also need to be conducted, addressing potential predictor variables and interventions. In particular, brief, single-question psychological measures and physical tests that are easy to learn and simple to perform are more useful in a clinical setting, and for use in CPRs, than extensive questionnaires and complicated tests. Control-group trials are also required to explain the relationships between the predictor variables, the intervention, and the outcomes. Lastly, this study explored predictors for one type of exercise intervention, but there continues to be uncertainty regarding the ‘effective ingredient’ in exercise protocols and whether one form of exercise is better than another (Henchoz and Kai-Lik So 2008). Development of CPRs should focus on the most promising exercise interventions.
Conclusions

Two clinical prediction rules with moderate predictive ability were developed for a chronic LBP population following a graded programme of movement control exercises. The rules showed that a combination of high disability levels, history of gradual onset of low back pain, absence of aberrant motions on forward bending and higher BMI score is best able to predict clinically important improvement in disability, while low levels of disability, history of sudden onset of low back pain, and differences between left and right active straight leg raise may predict failure to show clinically meaningful improvement. Follow-up studies are required to confirm these results in a wider population and over a longer follow-up period.
References


and breathing pattern during active straight leg raising. J Manipulative Physiol Ther 30, 270-278.


Table 1. Participant characteristics at baseline and their correlation with change in Patient-Specific Functional Scale for low back pain-related disability

<table>
<thead>
<tr>
<th>Variable</th>
<th>All subjects (n=48)</th>
<th>Success with treatment (n=14)</th>
<th>Improvement with treatment (n=16)</th>
<th>Failure with treatment (n=18)</th>
<th>r</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>41 ± 11</td>
<td>45 ± 11</td>
<td>42 ± 12</td>
<td>38 ± 8</td>
<td>.27</td>
<td>.07</td>
</tr>
<tr>
<td>BMI</td>
<td>26.4 ± 4.7</td>
<td>28.2 ± 5.7</td>
<td>24.9 ± 4.5</td>
<td>26.3 ± 3.8</td>
<td>.25</td>
<td>.09</td>
</tr>
<tr>
<td>Mode of onset (% gradual)</td>
<td>35%</td>
<td>64%</td>
<td>31%</td>
<td>17%</td>
<td>.38</td>
<td>.01</td>
</tr>
<tr>
<td>* Traumatic onset (% yes)</td>
<td>29%</td>
<td>7%</td>
<td>31%</td>
<td>44%</td>
<td>-31</td>
<td>.03</td>
</tr>
<tr>
<td>Fear-avoidance beliefs about work</td>
<td>14 ± 12</td>
<td>16 ± 11</td>
<td>18 ± 14</td>
<td>10 ± 8</td>
<td>.31</td>
<td>.03</td>
</tr>
<tr>
<td>PSFS functional score</td>
<td>3.5 ± 1.3</td>
<td>2.9 ± 0.9</td>
<td>3.3 ± 1.3</td>
<td>4.3 ± 1.2</td>
<td>.47</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Increased segmental mobility (% present)</td>
<td>40%</td>
<td>21%</td>
<td>44%</td>
<td>50%</td>
<td>-36</td>
<td>.01</td>
</tr>
<tr>
<td>Aberrant motions on forward bending (% present)</td>
<td>42%</td>
<td>21%</td>
<td>62%</td>
<td>39%</td>
<td>-26</td>
<td>.07</td>
</tr>
<tr>
<td>Active SLR difference (deg.)</td>
<td>5 ± 5</td>
<td>4 ± 4</td>
<td>3 ± 3</td>
<td>7 ± 7</td>
<td>-.27</td>
<td>.06</td>
</tr>
<tr>
<td>Spinal extensor muscle endurance time (s)</td>
<td>126 ± 61</td>
<td>108 ± 59</td>
<td>125 ± 67</td>
<td>141 ± 56</td>
<td>-.31</td>
<td>.03</td>
</tr>
<tr>
<td>* Lateral trunk muscle endurance time (s)</td>
<td>49 ± 34</td>
<td>38 ± 26</td>
<td>45 ± 34</td>
<td>61 ± 39</td>
<td>-.25</td>
<td>.08</td>
</tr>
</tbody>
</table>

Note: Values are mean ± SD unless otherwise stated

*Success = improvement in PSFS score by ≥4 points; Improvement = improvement in PSFS score by 2-3 points; Failure = improvement in PSFS score by ≤1 point

BMI = body mass index; PSFS = Patient-Specific Functional Scale; SLR = straight leg raise

* These variables were not entered into the regression models due to correlation with another potential predictor.
Table 2. Predictors retained in the multiple linear regression model for PSFS change

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSFS functional score</td>
<td>-0.64**</td>
<td>0.20</td>
<td>-.37</td>
</tr>
<tr>
<td>Gradual vs sudden onset of LBP</td>
<td>1.51**</td>
<td>0.53</td>
<td>.33</td>
</tr>
<tr>
<td>Aberrant motions on forward bending</td>
<td>-1.14*</td>
<td>0.52</td>
<td>-.25</td>
</tr>
<tr>
<td>Age</td>
<td>0.07**</td>
<td>0.02</td>
<td>.33</td>
</tr>
<tr>
<td>Spinal extensor muscle endurance time</td>
<td>-0.01*</td>
<td>0.00</td>
<td>-.29</td>
</tr>
<tr>
<td>(Constant)</td>
<td>3.42*</td>
<td>1.32</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: Model $R^2 = .52$, * $P<.05$, ** $P<.01$

$B$ = unstandardized beta co-efficient, $SE$ = standard error, $\beta$ = standardized beta co-efficient

PSFS = Patient-Specific Functional Scale; LBP = low back pain
Table 3. Dichotomised predictors retained in the logistic regression models

<table>
<thead>
<tr>
<th>Predictors</th>
<th>B</th>
<th>SE</th>
<th>Exp B (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Success model (Hosmer &amp; Lemeshow $R^2 = .48$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSFS functional score &lt; 3.7</td>
<td>3.95**</td>
<td>1.40</td>
<td>51.91 (3.33 to 808.95)</td>
</tr>
<tr>
<td>Gradual onset of LBP</td>
<td>2.98*</td>
<td>1.23</td>
<td>19.69 (1.75 to 221.32)</td>
</tr>
<tr>
<td>BMI &gt; 24.5</td>
<td>3.09**</td>
<td>1.33</td>
<td>22.03 (1.64 to 295.66)</td>
</tr>
<tr>
<td>No aberrant motions on forward bending</td>
<td>2.02†</td>
<td>1.05</td>
<td>7.52 (0.97 to 58.61)</td>
</tr>
<tr>
<td>(Constant)</td>
<td>-8.15**</td>
<td>2.44</td>
<td>-</td>
</tr>
<tr>
<td>b) Failure model (Hosmer &amp; Lemeshow $R^2 = .40$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSFS functional score &gt; 3.7</td>
<td>2.54**</td>
<td>0.83</td>
<td>12.71 (2.49 to 64.73)</td>
</tr>
<tr>
<td>Sudden onset of LBP</td>
<td>1.79†</td>
<td>0.91</td>
<td>5.98 (1.00 to 35.80)</td>
</tr>
<tr>
<td>Active SLR difference &gt; 7°</td>
<td>1.73*</td>
<td>0.88</td>
<td>5.65 (1.01 to 31.54)</td>
</tr>
<tr>
<td>(Constant)</td>
<td>-3.59**</td>
<td>1.09</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: †$P<.06$, *$P<.05$, **$P<.01$

$B$ = beta co-efficient; $SE$ = standard error; $Exp B$ = exponential beta co-efficient

PSFS = Patient-Specific Functional Scale; LBP = low back pain; BMI = body mass index; SLR = straight leg raise
Table 4. Clinical prediction rule for success

<table>
<thead>
<tr>
<th>Combination of Variables</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive LR</th>
<th>Probability of success</th>
</tr>
</thead>
<tbody>
<tr>
<td>All 4 variables present</td>
<td>.31*</td>
<td>.97*</td>
<td>11.25*</td>
<td>82%</td>
</tr>
<tr>
<td>At least 3</td>
<td>.79</td>
<td>.88</td>
<td>6.68</td>
<td>73%</td>
</tr>
<tr>
<td>At least 2</td>
<td>1.00</td>
<td>.35</td>
<td>1.55</td>
<td>39%</td>
</tr>
<tr>
<td>At least 1</td>
<td>1.00</td>
<td>.06</td>
<td>1.06</td>
<td>30%</td>
</tr>
</tbody>
</table>

Variables: Gradual onset of LBP, no aberrant motions on forward bending, PSFS functional score <3.7, BMI >24.5

Note: Probability of success for all participants was 29% *value of 1 added to all cells used to calculate this value to avoid division by zero error

LR = likelihood ratio; LBP = low back pain; PSFS = Patient-Specific Functional Score; BMI = body mass index
### Table 5. Clinical prediction rule for failure

<table>
<thead>
<tr>
<th>Combination of variables</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive LR</th>
<th>Probability of Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>All 3 variables</td>
<td>.22</td>
<td>.97</td>
<td>6.67</td>
<td>80%</td>
</tr>
<tr>
<td>At least 2</td>
<td>.83</td>
<td>.80</td>
<td>4.17</td>
<td>72%</td>
</tr>
<tr>
<td>At least 1</td>
<td>1.00</td>
<td>.30</td>
<td>1.43</td>
<td>46%</td>
</tr>
</tbody>
</table>

Variables: Sudden onset of LBP, PSFS functional score >3.7, Active SLR difference >7°

Note: Probability of failure for all participants was 38%

PSFS = Patient-Specific Functional Scale; Active SLR difference = difference between left and right active straight leg raise.
The Reformer is a spring-loaded carriage that can be used to provide assistance or resistance during exercises.
### Appendix A

<table>
<thead>
<tr>
<th>Variable</th>
<th>Explanation</th>
<th>Measurement Tool</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic and Anthropomorphic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>ranging from 25-65</td>
<td>single question</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>male or female</td>
<td>single question</td>
<td></td>
</tr>
<tr>
<td>Body Mass Index†</td>
<td>weight(kg)/height(m)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>scales and standing height measurement</td>
<td></td>
</tr>
<tr>
<td>Education Level</td>
<td>7 categories ranging from ‘no formal schooling’ to ‘postgraduate degree completed’</td>
<td>As recommended by Pincus et al. (2008)</td>
<td></td>
</tr>
<tr>
<td>Work Status</td>
<td>9 categories including full-time, part-time or reason for not working</td>
<td>As recommended by Pincus et al. (2008)</td>
<td></td>
</tr>
<tr>
<td><strong>Characteristics of pain</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LBP intensity</td>
<td>11-point scale question bothersomeness of LBP over the past week</td>
<td>11-point numeric rating scale (Farrar et al. 2001)</td>
<td></td>
</tr>
<tr>
<td>Leg pain intensity</td>
<td>11-point scale question bothersomeness of leg pain over the past week</td>
<td>11-point numeric rating scale (Farrar et al. 2001)</td>
<td></td>
</tr>
<tr>
<td>Mode of onset of LBP*</td>
<td>gradual or sudden</td>
<td>verbal history</td>
<td></td>
</tr>
<tr>
<td>History of traumatic onset of LBP*</td>
<td>yes or no</td>
<td>verbal history</td>
<td></td>
</tr>
<tr>
<td>Duration of LBP</td>
<td>Initial onset of LBP (in years)</td>
<td>verbal history</td>
<td></td>
</tr>
<tr>
<td>Failure of multiple treatments</td>
<td>Failure to respond to more than 2 types of physical interventions for LBP</td>
<td>verbal history</td>
<td></td>
</tr>
<tr>
<td>Troublesomeness of LBP</td>
<td>5-point Likert scale rating troublesomeness of LBP</td>
<td>Troublesomeness Questionnaire (Parsons et al. 2006)</td>
<td>ICC=.59-.91</td>
</tr>
<tr>
<td><strong>Activity interference, beliefs and reported behaviours</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fear-avoidance beliefs about physical activities</td>
<td>Questionnaire subscale examining fear avoidance beliefs in relation to physical activities</td>
<td>Fear-avoidance Beliefs Questionnaire (Waddell et al. 1993)</td>
<td>( \kappa = .74 )</td>
</tr>
<tr>
<td>Fear-avoidance beliefs about work*</td>
<td>Questionnaire subscale examining fear avoidance beliefs in relation to work</td>
<td>Fear-avoidance Beliefs Questionnaire (Waddell et al. 1993)</td>
<td>( \kappa = .74 )</td>
</tr>
<tr>
<td>Work satisfaction</td>
<td>7-point Likert scale</td>
<td>As recommended by Pincus et al. (2008)</td>
<td></td>
</tr>
</tbody>
</table>
### Disability as a result of LBP
- Measures perceived restriction in common activities of daily living as a result of LBP
  - Oswestry Disability Questionnaire (Davidson and Keating 2002)
  - ICC=.80

### Patient-specific disability rating*†
- Rating of functional status of 3-5 self-selected activities affected by LBP
  - Patient-Specific Functional Scale (Stratford et al. 1995)
  - ICC=.97

### Involvement in leisure activities
- Questionnaire subscale examining self-rated level of involvement in social and leisure activities
  - West Haven-Yale Multidimensional Pain Inventory (WHYMPI) (Kerns, Turk and Rudy 1985)
  - $r=.83-.91$

### Pain interference
- Questionnaire subscale examining pain interference in activities of daily living
  - WHYMPI (Kerns, Turk and Rudy 1985)
  - $r=.86$

### Psychosocial Factors (not directly related to activity)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
<th>Measure</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophizing</td>
<td>Patient administered questionnaire examining thoughts and feelings when in pain</td>
<td>Pain Catastrophizing Scale (Lamé et al. 2008)</td>
<td>ICC=.73</td>
</tr>
<tr>
<td>Depression</td>
<td>Patient administered questionnaire examining depression status over the past week</td>
<td>CES-D scale (Radloff 1977)</td>
<td>$r=.57$</td>
</tr>
<tr>
<td>Perceived life control</td>
<td>Questionnaire subscale</td>
<td>WHYMPI (Kerns, Turk and Rudy 1985)</td>
<td>$r=.68$</td>
</tr>
<tr>
<td>Affective distress</td>
<td>Questionnaire subscale</td>
<td>WHYMPI (Kerns, Turk and Rudy 1985)</td>
<td>$r=.69$</td>
</tr>
<tr>
<td>Troublesomeness of body pains</td>
<td>Total score of troublesomeness rating of pain in 12 body regions</td>
<td>Troublesomeness Questionnaire (Parsons et al. 2006)</td>
<td>ICC=.59-.91</td>
</tr>
<tr>
<td>Interpersonal Issues</td>
<td>Questionnaire subscale</td>
<td>WHYMPI (Kerns, Turk and Rudy 1985)</td>
<td>$r=.62-.91$</td>
</tr>
</tbody>
</table>

Note: * Significant ($P<0.10$) univariate predictor, † Predictor in the clinical prediction rules, LBP = low back pain
## Appendix B

<table>
<thead>
<tr>
<th>Variable</th>
<th>Explanation</th>
<th>Measurement Tool</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Musculoskeletal Examination Findings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg length difference</td>
<td>Difference between left and right leg length measured from the anterior superior iliac spine to the medial malleolus</td>
<td>Supine leg length discrepancy measurement (Levangie 1999)</td>
<td>ICC=.71</td>
</tr>
<tr>
<td>Lumbar spine flexion</td>
<td>While participant stood in a neutral position, two points were marked on the spine, 10cm above and 5cm below the line of the posterior superior iliac spines. The participant then flexed the spine as far as possible and the distance between the two points was measured.</td>
<td>Modified-modified Schober test (Tousignant et al. 2005)</td>
<td>ICC=.91</td>
</tr>
<tr>
<td>Increased* and/or decreased mobility on posterior-anterior segmental mobility assessment</td>
<td>Participant lay prone while examiner applied posterior to anterior pressure at each spinous process of the lumbar spine. Each segment was judged hypermobile, normal, or hypomobile. Increased mobility if at least one segment was judged hypermobile. Decreased mobility if at least one segment was judged hypomobile.</td>
<td>PA mobility testing (Fritz, Childs and Flynn 2005; Hicks et al. 2003)</td>
<td>( \kappa=.30-.48 ) hypomobility ( \kappa=.18-.38 )</td>
</tr>
<tr>
<td>Lumbar segmental instability</td>
<td>Participant lay prone with trunk on plinth and feet on the ground. Practitioner applied moderate pressure to each spinous process of the lumbar spine. At any painful segment the patient was asked to lift both legs to a horizontal position and pressure was again applied to the segment. The test was positive if the pain was not reproduced on repeated testing.</td>
<td>Prone Instability Test (Fritz, Childs and Flynn 2005; Hicks et al. 2003)</td>
<td>( \kappa=.69-.87 )</td>
</tr>
<tr>
<td>Passive straight leg raise difference</td>
<td>The participant lay supine while practitioner passively flexed patient’s hip with knee extended. Degree of flexion was measured with an inclinometer placed on distal tibia. Difference between left and right hip was calculated.</td>
<td>Digital inclinometer (Fritz, Childs and Flynn 2005)</td>
<td>ICC=.70</td>
</tr>
</tbody>
</table>

### Flexibility

<table>
<thead>
<tr>
<th>Variable</th>
<th>Explanation</th>
<th>Measurement Tool</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward bending flexibility</td>
<td>Standing on a 20cm box, the participant bent forward trying to reach fingertips down to the ground as far as possible while maintaining extension at the knee. Participant had to hold end position for at least 3s. Distance of fingertips from ground measured.</td>
<td>Fingertip-to floor test (Perret et al. 2001)</td>
<td>ICC=.99</td>
</tr>
<tr>
<td>General ligamentous laxity</td>
<td>Level of flexibility at nine joints/body regions assessed as described by Hicks et al. (Hicks et al. 2003).</td>
<td>Beighton’s Ligamentous Laxity Scale (Fritz, Childs and Flynn 2005; Hicks et al. 2003)</td>
<td>ICC=.72-.78</td>
</tr>
</tbody>
</table>
Average passive straight leg raise  | Passive leg raise was measured as above and average of left and right leg was calculated | (Fritz, Childs and Flynn 2005)  | ICC=.70

### Movement Control Tests

| Aberrant motions on forward bending**† | Positive if examiner noted occurrence of at least 1 sign of aberrant motions on standing forward bending: painful arc on flexion or return to erect posture; segmental shift or hinging; using hand on knee to assist return to erect posture; or bending knees before returning to erect posture. | Aberrant Motions Test (Hicks et al. 2003)  | κ=.60

| Movement control  | Positive if subject could not perform at least 1 of 5 tests correctly: sitting knee extension without flexing spine, rocking back or forward while 4-point kneeling without flexing or extending spine, prone knee flexion without flexing spine or rotating pelvis. As described by van Dillen et al. (1998) | Movement control tests (Luomajoki et al. 2007; van Dillen et al. 1998)  | κ=.43-.78

| Active straight leg raise difference*† | Participant lay supine and actively flexed one hip (unassisted) as far as possible without flexing knee. Degree of flexion was measured with an inclinometer placed on distal tibia. Difference between left and right hip was calculated. | Digital inclinometer  | κ=.70

Pain on active straight leg raise  | Sharp pain reported in low back during mid-range flexion of at least one side of the above test

### Muscle Endurance Tests

| Spinal extensor muscle endurance*  | Participant lies supine with arms along sides and raises arms and upper body off the table, holding this position for as long as possible to a maximum of 3 minutes | Modified Biering-Sorensen Test (Ito et al. 1996)  | \(r=0.93-.95\)

| Trunk flexor muscle endurance  | Participant is seated with hips and knees flexed to 90°, feet pinned to ground by examiner, then leans back with spine straight and arms reaching forward until examiner judges incline to be 60°. Participant hold this position for as long as possible to a maximum of 2 minutes | Modified McGill flexion endurance test (McGill, Childs and Liebenson 1999)  | \(r=.93-.97\)

| Average lateral trunk muscle endurance*  | Participant lies on side, legs straight, elbow and forearm on the ground, lifting hips off the ground and holding this position as long as possible to a maximum of 2 minutes. Repeated on opposite side. | Sorensen side-support test (McGill, Childs and Liebenson 1999)  | \(r=.96-.99\)

| Lateral endurance difference  | Calculated difference between left and right side of the above lateral endurance test

| Ratio of lateral endurance over extensor endurance  | Calculated ratio of average lateral endurance time over the extensor endurance time as measured by the above tests

Note: * Significant (\(P<0.10\)) univariate predictor, † Predictor in the clinical prediction rules
Appendix C

A pictorial overview of exercises from the mat classes
Appendix D

A pictorial overview of exercises from the reformer classes
Section 3: Appendices
Appendix A: Ethics Approval for this project
Claire O’Brien and Leyla Okyay
12 Powell Street
Avondale
Auckland

30 March 2009

Dear Claire and Leyla

Your file number for this application: 2009-923
Title: This is a joint project entitled “Pilates exercise for low back pain”. The individual project titles are: The effectiveness of a 6 week Pilates exercise programme for adults with chronic non-specific low back pain 2) Development of a clinical prediction rule to determine successful outcome following a Pilates-based exercise programme in adults with non-specific chronic low back pain.

Your application for ethics approval has been reviewed by the Unitec Research Ethics Committee (UREC) and has been approved for the following period:

Start date: 3 April 2009
Finish date: 2 April 2010

Please note that:
1. the above dates must be referred to on the information AND consent forms given to all participants
2. you must inform UREC, in advance, of any ethically-relevant deviation in the project. This may require additional approval.

You may now commence your research according to the protocols approved by UREC. We wish you every success with your project.

Yours sincerely

[Signature]

Deborah Rolland
Deputy Chair, UREC

cc: Rob Moran
Appendix B: Information Sheet for Participants
INFORMATION SHEET

Pilates Exercise for Chronic Low Back Pain

About this research
You are invited to take part in a research project that is being undertaken as part of the Unitec Master of Osteopathy degree. We will be studying the effects of a 6-week pilates programme on chronic low back pain. The research will also seek to identify factors that may predict a reduction in low back pain.

The Researchers
The researchers are Claire O’Brien and Leyla Okyay, both in their final year of the Master of Osteopathy degree. Claire O’Brien will be your pilates instructor. She has been teaching pilates for 4 years and is certified through Pilates International, Australia. The research is supervised by Rob Moran, Associate Professor Andrew Stewart and Senior Lecturer Craig Hilton of the School of Health Sciences.

What will participation involve?
Once you have agreed to participate in the project and have signed the consent form, you will need to attend an initial appointment at the Unitec Osteopathy Clinic (Building 41, Entry 3, Carrington Rd, Mt Albert). The appointment will take about one hour and will involve the completion of some questionnaires, a brief interview and a physical assessment. These will help us to collect detailed information about your low back pain, medical history and daily activities. At this point we will make sure that there is nothing preventing you from participating in the pilates programme. For the physical assessment you will be required to undress down to your underwear. We will provide you with loose-fitting shorts if you require. The physical examination might cause some discomfort but should be no more painful than activities you perform everyday.

You will then need to attend a pilates programme consisting of 2 classes per week for 6 consecutive weeks. The classes are 1 hour long and held at the Pilates Body Studio, 2/141 Wellesley Street West, Freemans Bay, Auckland. You will need to arrange your own transport to the studio, but you will be be provided with a $20 petrol voucher to cover some of the transport cost. Parking outside the studio costs $1 per hour, you will receive $12 to cover parking costs. The classes carry no charge. Class sizes may vary from 5-12 people and include both men and women. One week after the pilates programme you will need to complete a final questionnaire and a flexibility test at the Unitec Osteopathy Clinic which will take about 20 minutes.

The researchers may contact you between 3 and 12 months after completion of the programme for a short telephone follow-up about your low back pain.

Your involvement in this research will help to determine whether Pilates is an effective treatment for low back pain and if there are indicators that may predict a decrease in pain and disability. This information will be useful to doctors, therapist and patients in choosing treatments for back pain.

Selection of Participants

In order to participate you need to meet the following criteria:

- Be between 25-65 years of age
- Currently experience low back pain, and have had persistent or frequently recurring back pain for at least 6 months
- Are able to undertake non-vigorous exercise

You cannot participate if:

- You are already involved in regular pilates classes, or a rehabilitative exercises programme
- You are pregnant (or suspect that you might be)
- You have been diagnosed with osteoporosis
• You have had any of the following in the last 12 months: a spinal fracture, spinal tumour, spinal infection, surgery to your spine, or abdominal surgery

**Potential Risks to Participants**
Any form of exercise carries the risk of potential injury. To minimise harm we will screen for any medical problems that may make participation in physical exercise inappropriate. All exercises in this programme are designed for people with low back pain and will be individualised to suit your level of ability. The pilates exercises should cause you no pain. However, if you are uncomfortable with performing any of the exercises you need to inform the pilates instructor immediately. The instructor will provide you with an alternative exercise or give you some time to rest. You can withdraw from the programme at any time, for any reason.

**Confidentiality**
Confidentiality and your anonymity will be protected in the following ways:

• As many of the questions are of a personal nature we ask that you do not write your name anywhere on the questionnaire. This is important to protect your anonymity.

• You will be given an ID number on enrolment in the study, which is printed on the questionnaires. This is so that we can compare your pain measurement at the beginning and end of the pilates programme with your answers to the questions. Your name, or any other information that could identify you, will be stored separately.

• The completed questionnaires will be seen only by the researchers.

• Once the research has been completed, your name and your questionnaire number will be deleted from all records so that you cannot be identified. All computer records will only be accessible by passwords held by the researchers. All hard copies will be stored in a locked file, accessible only by the researchers.

• Information gathered during this research will be held for 5 years before being destroyed.

You have the right to withdraw your data from this research project at any time within 1 week of your final data collection (1 week after the final interview). This can be done by contacting one of the researchers listed below.

A summary of the final report of the study will be available to you if you are interested.

**Information and concerns**
If you require any further information about the project please contact us by phone or email:

Claire O’Brien  Leyla Okyay  Rob Moran
Tel.: 09 550 3212  Tel.: 09 550 3212  Tel.: 09 815 4321 ext 8642
Mob.: 021 55 84 55  Mob.: 021 142 42 61  Tel.: 09 815 4321 ext 8642
pilates.research@gmail.com  pilates.research@gmail.com  rmoran@unitec.ac.nz

Finally, we would like to thank you for your interest in contributing to this research project.

**UREC REGISTRATION NUMBER: 2009-923**
This study has been approved by the UNITEC Research Ethics Committee from 3rd April 2009 to 2nd April 2010. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the Secretary (ph: 09 815-4321 ext 7248). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Appendix C: Telephone Screen for Eligibility
**TELEPHONE SCREENING QUESTIONS**

**Hi, Who am I speaking with? Name ______________________ Age? ______

Blurb about research: Pilates for low back pain by Unitec Master of Osteopathy students. Part of a research team trying to find out if pilates is able to decrease low back pain. 

Interested? Great, can I ask you a few questions to make sure that you can take part in the study?

1. Do you currently have LBP? Yes go to Q4
2. When was the last time you had LBP?
3. How long did it last (duration of episode)?
4. How long have you had LBP for? < 6 months - exclude
5. Would you be willing to commit to attending 2 x 1hr sessions per week for 6 weeks in Freemans Bay, Auckland (near Victoria Park Market)?
6. Are you currently participating in regular Pilates classes? Or having treatment/doing exercises specifically for low back pain? Yes, explain? ______________________ How often? _____ Exclude if treatment more than 1/month
7. **Women only:** Are you currently pregnant or is there a possibility that you might be pregnant or are planning on becoming pregnant during the next 2 months? Yes - exclude
8. Has your doctor recommended that you abstain from participating in physical activity? Yes - why? ______________________ Exclude if yes for non-vigorous exercise
   If yes, what / when? ______________________ Less than 1 year ago - exclude
10. Has there been any concern about your bone density? Yes - exclude
11. What effect does coughing/ sneezing/ straining have on the pain? ______________________
   Active Disc Herniation
12. Recently, have you experienced any symptoms in your legs - like pain, weakness, stiffness or numbness?
   Yes, please explain ______________________ Stenosis, Nerve root compression, Rheumatologic
13. Do you have stiffness or pain in the morning when you wake up?
   If yes, duration? ______________________ > 1 hour - exclude
14. Do you have any numbness or tingling in your groin/inside thighs? Yes - exclude
15. Is your pain better, worse or unchanged for activity ______________________
16. Is your pain better, worse or unchanged for rest ______________________
17. Do you have trouble urinating or controlling your bowel and bladder? Yes – exclude
18. Do you have unrelenting pain at night? recent unplanned weightloss? Yes - exclude
19. Have you ever been diagnosed with cancer, including skin cancer?
Type/ Location?_____________________ Yes - exclude
20. Do you have a history of psoriasis, diarrhoea, eye trouble, or severe pain in the joints of hands or feet joints? ______________________ Psoriatic arthritis, Reiters.
21. Have you recently been feeling unwell? Details
Appendix D: Consent Form
PARTICIPANT CONSENT FORM

Pilates Exercise for Chronic Low Back Pain

This research project examines the effects of a 6-week Pilates programme on chronic low back pain, and will determine what indicators might predict a successful outcome. The research is being conducted by Claire O’Brien and Leyla Okyay, Master of Osteopathy students at Unitec, and will be supervised by Rob Moran, Associate Professor Andrew Stewart and Senior Lecturer Craig Hilton.

Name of Participant: ........................................................................................................

I have seen the Information Sheet for participants in the project titled “Pilates Exercise for Chronic Low Back Pain”. I have had the opportunity to read the contents of the information sheet and to discuss the project with a member of the research team and I am satisfied with the explanations I have been given. I understand that taking part in this project is voluntary (my choice) and that I may withdraw from the project at any time (refer below) and this will in no way affect my access to the services provided by the Unitec Osteopathy Clinic or Unitec NZ.

I understand that I can withdraw from the study, for any reason, up to 1 week after the last data collection, but no later.

I understand that my participation in this project is confidential and that no material that could identify me will be used in any reports on this project.

I have had enough time to consider whether I want to take part.

I know whom to contact if I have any questions or concerns about the project.

The researchers for this project are:
Claire O’Brien Tel.: 09 550 3212 Mob.: 021 55 84 55 pilates.research@gmail.com
Leyla Okyay Tel.: 09 550 3212 Mob.: 021 142 42 61 pilates.research@gmail.com
Rob Moran Discipline Leader - Osteopathy Tel.: 09 815 4321 ext 8642 rmoran@unitec.ac.nz

Participant Signature: ................................................................. ..........................(date)

Project explained by: .................................................................

Researcher Signature: ................................................................. ..........................(date)

The participant should retain a copy of this consent form.

UREC REGISTRATION NUMBER: 2009-923

This study has been approved by the UNITEC Research Ethics Committee from 3rd April 2009 to 2nd April 2010. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the Secretary (ph: 09 815-4321 ext 7248). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Appendix E: Pre-intervention Questionnaire
QUESTIONNAIRE

Pilates Exercise for Chronic Low Back Pain

Welcome and thank you for participating in this study.

Please take time to read the questions carefully and answer them truthfully. If you are not sure how to answer a question, please mark it with a question mark (?) and we will clarify during the interview.

To protect your anonymity please DO NOT write your name anywhere on the questionnaire.

Section 1:
Date of Birth: _____/_____/______  Gender:  Male □  Female □

1. What is the highest level of education that you have completed?
   □ No formal schooling
   □ Less than primary school
   □ Primary school completed
   □ Intermediate school completed
   □ High School (or equivalent) completed
   □ Tertiary degree or diploma completed
   □ Postgraduate degree completed

2. At present are you working?
   □ Yes, full-time
   □ Yes, part-time
   □ Not working, reason:  □ Homemaker/ caring for family
                           □ Looked but can’t find a job
                           □ Doing unpaid work/ voluntary activities
                           □ Studies/ training
                           □ Retired/ too old to work
                           □ Ill health
                           □ Other (please state) ____________________________
3. During the last 12 months what has been your main occupation?

- ☐ Legislator/ Senior official/ Manager.
- ☐ Professional (engineer, doctor, teacher, clergy, etc).
- ☐ Technician/ Associate Professional (inspector, finance, dealer, etc).
- ☐ Clerk (secretary, cashier, etc).
- ☐ Service/ Sales worker (cook, travel guide, shop salesperson, etc).
- ☐ Agriculture or Fishery worker (vegetable grower, livestock producer, etc).
- ☐ Craft or Trades worker (carpenter, painter, jewellery worker, butcher, etc).
- ☐ Plant /Machine Operator or Assembler (equipment assembler, sewing machine operator, driver, etc).
- ☐ Elementary worker (street food vendor, shoe cleaner, etc).
- ☐ Armed Forces (government military)

4. How satisfied are you with your work in general?
   
   Extremely dissatisfied 0 1 2 3 4 5 6 Extremely satisfied

5. Medical History:

   Do you currently have or have you ever been diagnosed with any of the following?

   - ☐ Arthritis
   - ☐ Asthma
   - ☐ Anaemia
   - ☐ Bowel/Bladder Changes
   - ☐ Balance Problems
   - ☐ Bursitis
   - ☐ Cancer
   - ☐ Diabetes
   - ☐ Dizziness
   - ☐ Fainting
   - ☐ Disc bulge (herniated)
   - ☐ Epilepsy
   - ☐ Gynaecological problems
   - ☐ Heart Attack
   - ☐ Heart Palpitations
   - ☐ Heart Disease
   - ☐ Hypoglycemia
   - ☐ Hypertension
   - ☐ Hypoglycemia
   - ☐ High Blood Pressure
   - ☐ Low Blood Pressure
   - ☐ Numbness/weakness
   - ☐ Osteoarthritis
   - ☐ Osteoporosis
   - ☐ Osteopenia
   - ☐ Migraines
   - ☐ Shortness of Breath
   - ☐ Stenosis
   - ☐ Thyroid Disorder
   - ☐ Kidney Disorder
   - ☐ Visual Disturbances

6. Are you currently taking any medication?
   
   - ☐ No
   - ☐ Yes (please state)

7. Are you currently receiving professional health care services? (eg. Osteopathy, Physiotherapy, Chiropractic, Massage, Medical Treatment)
   
   For low back pain   ☐ No ☐ Yes (please explain)
   For another condition ☐ No ☐ Yes (please explain)
Section 2:
1. Do you get leg pain below the knee? Yes ☐ No ☐

2. In the **past week** how bothersome have the following symptoms been?
   (0–10, where 0 = no pain, 10 = worst pain imaginable)

   a. Lower Back Pain
   
<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

   b. Leg Pain
   
<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

3. I am going to ask you to identify **at least three** important activities that you are unable to do or are having difficulty with as a result of your low back pain. Please choose at least three activities and write them in the chart below, then score each activity from 0-10 according to the scale shown.

   *Examples of activities: running, playing squash, getting out of bed, vacuuming, sitting for longer than 1 hour, playing soccer with your children, gardening, bending down to tie your shoe laces.*

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>
   Unable to perform activity | Able to perform activity at the same level as before injury or problem

<table>
<thead>
<tr>
<th>Activity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
</tbody>
</table>

   **Average Score (we will calculate this)**
### Section 3:

1. During the past week, how troublesome have each of the following symptoms been? (Please put a cross (x) in the appropriate box on each row for each area that you have pain)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>No pain experienced</th>
<th>Not at all troublesome</th>
<th>Slightly troublesome</th>
<th>Moderately troublesome</th>
<th>Very troublesome</th>
<th>Extremely troublesome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head ache</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist / hand pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdominal pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper back pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower back pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip/thigh pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle/foot pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other pains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Location and Distribution of Symptoms

Please indicate where on your body you feel these sensations. Use the symbols below and please mark ALL areas.

- Pins and needles: ooooo
  - -

- Ache: xxxxx
  - -

- Numbness: - - - - -
  - -

- Pain: / / / / /
  - -

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**Section 4:**
This questionnaire is designed to give us information as to how your back pain has affected your ability to manage in everyday life. Please answer every question by placing a cross in the one box that best describes your condition today. We realize that you may feel that 2 of the statements may describe your condition, but please mark only the box that most closely describes your current condition.

<table>
<thead>
<tr>
<th>Pain Intensity</th>
<th>Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I can tolerate the pain I have without having to use pain medication.</td>
<td>□ I can stand as long as I want without increased pain.</td>
</tr>
<tr>
<td>□ The pain is bad, but I can manage without having to take pain medication.</td>
<td>□ I can stand as long as I want, but it increases my pain.</td>
</tr>
<tr>
<td>□ Pain medication provides me with complete relief from pain.</td>
<td>□ Pain prevents me from standing more than 1 hour.</td>
</tr>
<tr>
<td>□ Pain medication provides me with moderate relief from pain.</td>
<td>□ Pain prevents me from standing more than ½ hour.</td>
</tr>
<tr>
<td>□ Pain medication provides me with little relief from pain.</td>
<td>□ Pain prevents me from standing more than 10 minutes.</td>
</tr>
<tr>
<td>□ Pain medication provides me with no effect on my pain.</td>
<td>□ Pain prevents me from standing at all.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Care (eg. Washing, Dressing)</th>
<th>Sleeping</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I can take care of myself normally without causing increased pain.</td>
<td>□ Pain does not prevent me from sleeping well.</td>
</tr>
<tr>
<td>□ I can take care of myself normally, but it increases my pain.</td>
<td>□ I can sleep well only by using pain medication.</td>
</tr>
<tr>
<td>□ It is painful to take care of myself, and I am slow and careful.</td>
<td>□ Even when I take pain medication, I sleep less than 6 hours.</td>
</tr>
<tr>
<td>□ I need help, but I am able to manage most of my personal care.</td>
<td>□ Even when I take pain medication, I sleep less than 4 hours.</td>
</tr>
<tr>
<td>□ I need help everyday in most aspects of my care.</td>
<td>□ Even when I take pain medication, I sleep less than 2 hours.</td>
</tr>
<tr>
<td>□ I do not get dressed, wash with difficulty, and stay in bed.</td>
<td>□ Pain prevents me from sleeping at all.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lifting</th>
<th>Social Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I can lift heavy weights without increased pain.</td>
<td>□ My social life is normal and does not increase my pain.</td>
</tr>
<tr>
<td>□ I can lift heavy weights, but it causes increased pain.</td>
<td>□ My social life is normal, but it increases my level of pain.</td>
</tr>
<tr>
<td>□ Pain prevents me from lifting heavy weights off the floor, but I can manage if the weights are conveniently positioned (eg. on a table)</td>
<td>□ Pain prevents me from participating in more energetic activities (eg. sports, dancing).</td>
</tr>
<tr>
<td>□ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned.</td>
<td>□ Pain prevents me from going out very often.</td>
</tr>
<tr>
<td>□ I can lift only very light weights.</td>
<td>□ Pain has restricted my social life to my home.</td>
</tr>
<tr>
<td>□ I cannot lift or carry anything at all.</td>
<td>□ I have hardly any social life because of my pain.</td>
</tr>
<tr>
<td>Walking</td>
<td>Travelling</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>☐ Pain does not prevent me from walking any distance.</td>
<td>☐ I can travel anywhere without increased pain.</td>
</tr>
<tr>
<td>☐ Pain prevents me from walking more than 1.6km.</td>
<td>☐ I can travel anywhere, but it increases my pain.</td>
</tr>
<tr>
<td>☐ Pain prevents me from walking more than 800m.</td>
<td>☐ My pain restricts my travel over 2 hours.</td>
</tr>
<tr>
<td>☐ Pain prevents me from walking more than 400m.</td>
<td>☐ My pain restricts my travel over 1 hour.</td>
</tr>
<tr>
<td>☐ I can only walk with crutches or a cane.</td>
<td>☐ My pain restricts my travel to short necessary journeys under ½ hour.</td>
</tr>
<tr>
<td>☐ I am in bed most of the time and have to crawl to the toilet.</td>
<td>☐ My pain prevents all travel except for visits to the doctor/therapist or hospital.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sitting</th>
<th>Employment/Homemaking</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ I can sit in any chair as long as I like</td>
<td>☐ My normal homemaking/job activities do not cause pain.</td>
</tr>
<tr>
<td>☐ I can only sit in my favourite chair as long as I like.</td>
<td>☐ My normal homemaking/job activities increase my pain, but I can still perform all that is required of me.</td>
</tr>
<tr>
<td>☐ Pain prevents me from sitting for more than 1 hour</td>
<td>☐ I can perform most of my homemaking/job duties, but pain prevents me from performing more physically stressful activities (eg. lifting, vacuuming)</td>
</tr>
<tr>
<td>☐ Pain prevents me from sitting for more than ½ hour.</td>
<td>☐ Pain prevents me from doing anything but light duties.</td>
</tr>
<tr>
<td>☐ Pain prevents me from sitting for more than 10 minutes.</td>
<td>☐ Pain prevents me from doing even light duties.</td>
</tr>
<tr>
<td>☐ Pain prevents me from sitting at all.</td>
<td>☐ Pain prevents me from performing any job or homemaking chores.</td>
</tr>
</tbody>
</table>
**Section 5:**
Here are some of the things which other patients have told us about their pain. For each statement please circle any number from 0 to 6 to say how much physical activities such as bending, lifting, walking, or driving affect or would affect your back pain.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Completely disagree</th>
<th>Unsure</th>
<th>Completely agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. My pain was caused by physical exercise</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2. Physical activity makes my pain worse</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3. Physical activity might harm my back</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4. I should not do physical activities which (might) make my pain worse</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5. I cannot do physical activities which (might) make my pain worse</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6. My pain was caused by my work or by an accident at work</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7. My work aggravated my pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8. I have a claim for compensation for my pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9. My work is too heavy for me</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>10. My work makes or would make my pain worse</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11. My pain might harm my back</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12. I should not do normal work with my present pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>13. I cannot do my normal work with my present pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14. I cannot do my normal work until my pain is treated</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15. I do not think that I will be back to my normal work within 3 months</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>16. I do not think that I will ever be able to go back to that work</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

The following statements are about how your normal work affects or would affect you back pain.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Completely disagree</th>
<th>Unsure</th>
<th>Completely agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. My pain was caused by my work or by an accident at work</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7. My work aggravated my pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8. I have a claim for compensation for my pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9. My work is too heavy for me</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>10. My work makes or would make my pain worse</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11. My pain might harm my back</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12. I should not do normal work with my present pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>13. I cannot do my normal work with my present pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14. I cannot do my normal work until my pain is treated</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15. I do not think that I will be back to my normal work within 3 months</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>16. I do not think that I will ever be able to go back to that work</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Section 6:
Everyone experiences painful situations at some point in their lives. Such experiences may include headaches, tooth pain, joint or muscle pain. People are often exposed to situations that may cause pain such as illness, injury, dental procedures or surgery.

We are interested in the types of thoughts and feelings that you have when you are in pain. Listed below are thirteen statements describing different thoughts and feelings that may be associated with pain. Using the following scale, please indicate the degree to which you have these thoughts and feelings when you are experiencing pain.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all</th>
<th>To a slight degree</th>
<th>To a moderate degree</th>
<th>To a great degree</th>
<th>All the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I worry all the time about whether the pain will end.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. I feel I can’t go on.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. It’s awful and I feel that it overwhelms me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. It’s terrible and I think it’s never going to get any better.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. I feel I can’t stand it anymore.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. I become afraid that the pain will get worse.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. I keep thinking of other painful events.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. I can’t seem to keep it out of my mind.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. I keep thinking about how much it hurts.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. I keep thinking about how badly I want the pain to stop.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11. There’s nothing I can do to reduce the intensity of the pain.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12. I wonder whether something serious may happen.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Section 7:
Below is a list of the ways you might have felt or behaved. Please tell us how often you have felt this way during the past week.

<table>
<thead>
<tr>
<th></th>
<th>Occasionally or a moderate amount of the time (3-4 days)</th>
<th>Some or a little of the time (1-2 days)</th>
<th>Rarely or none of the time (less than 1 day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I was bothered by things that usually don’t bother me.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. I did not feel like eating; my appetite was poor.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. I felt that I could not shake off the blues even with the help of my family and friends.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. I felt I was just as good as other people.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. I had trouble keeping my mind on what I was doing.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. I felt depressed.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. I felt that everything I did was an effort.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. I felt hopeful about the future.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. I thought my life had been a failure.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. I felt fearful.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. My sleep was restless.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. I was happy.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. I talked less than usual.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>15. People were unfriendly.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>16. I enjoyed life.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>17. I had crying spells.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>18. I felt sad.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>19. I felt that people dislike me.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>20. I could not get “going”.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Section 8:
Some of the questions in this questionnaire refer to your “significant other”. A significant other is a person with whom you feel closest. This includes anyone that you relate to on a regular or infrequent basis. It is very important that you identify someone as your “significant other”. Please indicate below who your significant other is (check one):

- Spouse
- Partner/Companion
- Housemate/Roommate
- Friend
- Neighbour
- Parent/Child/Other relative
- Other (please describe): ____________________________

Do you currently live with this person? Yes ☐ No ☐

When you answer questions in the following pages about “your significant other”, always respond in reference to the specific person you just indicated above.

A. In the following 20 questions, you will be asked to describe your pain and how it affects your life. Under each question is a scale to record your answer. Read each question carefully and then circle a number on the scale under that question to indicate how that specific question applies to you.

1. Rate the level of your pain at the present moment.
   No pain 0 1 2 3 4 5 6 Extreme pain

2. In general, how much does your pain problem interfere with your day to day activities?
   No interference 0 1 2 3 4 5 6 Extreme interference

3. Since the time you developed a pain problem, how much has your pain changed your ability to work?
   No change 0 1 2 3 4 5 6 Extreme change
   ☐ Check here, if you have retired for reasons other than your pain problem

4. How much has your pain changed the amount of satisfaction or enjoyment you get from participating in social and recreational activities?
   No change 0 1 2 3 4 5 6 Extreme change

5. How supportive or helpful is your spouse (significant other) to you in relation to your pain?
   Not at all supportive 0 1 2 3 4 5 6 Extremely supportive

6. Rate your overall mood during the past week.
   Extremely low mood 0 1 2 3 4 5 6 Extremely high mood

7. On the average, how severe has your pain been during the last week?
   Not at all severe 0 1 2 3 4 5 6 Extremely severe

8. How much has your pain changed your ability to participate in recreational and other social activities?
   No change 0 1 2 3 4 5 6 Extreme change

9. How much has your pain changed the amount of satisfaction you get from family related activities?
   No change 0 1 2 3 4 5 6 Extreme change

10. How worried is your spouse (significant other) about you in relation to your pain problem?
Not at all worried 0 1 2 3 4 5 6 Extremely worried

11. During the past week, how much control do you feel that you have had over your life?
No at all in control 0 1 2 3 4 5 6 Extremely in control

12. How much suffering do you experience because of your pain?
No suffering 0 1 2 3 4 5 6 Extreme suffering

13. How much has your pain changed your marriage and other family relationships?
No change 0 1 2 3 4 5 6 Extreme change

14. How much has your pain changed the amount of satisfaction or enjoyment you get from work?
No change 0 1 2 3 4 5 6 Extreme change
☐ Check here, if you are not presently working.

15. How attentive is your spouse (significant other) to your pain problem?
No at all attentive 0 1 2 3 4 5 6 Extremely attentive

16. During the past week, how much do you feel that you’ve been able to deal with your problems?
Not at all 0 1 2 3 4 5 6 Extremely well

17. How much has your pain changed your ability to do household chores?
No change 0 1 2 3 4 5 6 Extreme change

18. During the past week, how irritable have you been?
Not at all irritable 0 1 2 3 4 5 6 Extremely irritable

19. How much has your pain changed your friendships with people other than your family?
No change 0 1 2 3 4 5 6 Extreme change

20. During the past week, how tense or anxious have you been?
Not at all tense or anxious 0 1 2 3 4 5 6 Extremely tense or anxious

B. In this part, we are interested in knowing how your significant other (this refers to the person you indicated above) responds to you when he or she knows that you are in pain. On the scale listed below each question, circle a number to indicate how often your significant other generally responds to you in that particular way when you are in pain.

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ignores me</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2. Asks me what he/she can do to help</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>3. Reads to me</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Never Very often

106
<table>
<thead>
<tr>
<th>Activity</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Expresses irritation at me</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Takes over my jobs or duties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Talks to me about something else to take my mind off the pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Expresses frustration at me</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Tries to get me to rest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Tries to involve me in some activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Expresses anger at me</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Gets me some pain medications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Encourages me to work on a hobby</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Gets me something to eat or drink</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Turns on the T.V. to take my mind off my pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. Listed below are 18 common daily activities. Please indicate how often you do each of these activities by circling a number on the scale listed below each activity. Please complete all 18 questions.

<table>
<thead>
<tr>
<th>Activity</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wash dishes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Mow the lawn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Go out to eat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Play cards or other games</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Go grocery shopping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Work in the garden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Go to a movie</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity</td>
<td>Rare</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Very Often</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------</td>
<td>--------</td>
<td>-----------</td>
<td>-------</td>
<td>------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Visit friends</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>9. Help with the house cleaning</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>10. Work on the car</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>11. Take a ride in a car</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>12. Visit relatives</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>13. Prepare a meal</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>14. Wash the car</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>15. Take a trip</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>16. Go to a park or beach</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>17. Do a load of laundry</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>18. Work on a needed house repair</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>
Appendix F: History and Physical Examination Form
History of Lower Back Pain

<table>
<thead>
<tr>
<th>Description</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode of onset</td>
<td>Gradual / Sudden / Traumatic</td>
</tr>
<tr>
<td>When did it start?</td>
<td></td>
</tr>
<tr>
<td>How?</td>
<td></td>
</tr>
<tr>
<td>Frequency of episodes</td>
<td></td>
</tr>
<tr>
<td>How has it progressed?</td>
<td></td>
</tr>
<tr>
<td>Duration of symptoms.</td>
<td></td>
</tr>
<tr>
<td>How long does the pain last?</td>
<td></td>
</tr>
<tr>
<td>Daily Pattern</td>
<td></td>
</tr>
<tr>
<td>Aggravating Factors</td>
<td></td>
</tr>
<tr>
<td>Relieving Factors</td>
<td></td>
</tr>
<tr>
<td>Response to prior treatments</td>
<td></td>
</tr>
<tr>
<td>Associated Symptoms</td>
<td></td>
</tr>
<tr>
<td>Saddle anaesthesia?</td>
<td>Incontinence?</td>
</tr>
<tr>
<td></td>
<td>Overt loss of balance?</td>
</tr>
<tr>
<td>Height cm</td>
<td></td>
</tr>
<tr>
<td>Weight kg</td>
<td></td>
</tr>
<tr>
<td>Finger tip to floor cm</td>
<td></td>
</tr>
</tbody>
</table>
Standing

Aberrant motions with flexion

☐ Painful arc
☐ Painful arc on return
☐ Gower’s Sign
☐ Instability catch
☐ Reverse Lumbopelvic Rhythm
☐ Hands flat on floor (LLS)

Shober Index ______ cm

Supine

Leg Length (ASIS to med malleolus)

Right ______ cm
Left ______ cm

Seated

Ligamentous Laxity Scale

<table>
<thead>
<tr>
<th>Hyperextension</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow &gt;10°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little finger &gt;90°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thumb to wrist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee &gt;10°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Movement Control Tests

Sitting knee extn ☐

4 point kneeling ☐ Rocking back ?F
☐ Rocking fwd ?E

Prone knee bend ☐ Flexion
☐ Rotation

Prone

Segmental Mobility / Prone Instab

<table>
<thead>
<tr>
<th></th>
<th>↑ Norm</th>
<th>↓ Pain</th>
<th>P.I +ve</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Endurance Tests

Extensor ______ mins/secs
L Lateral ______ mins/secs
R Lateral ______ mins/secs
Flexor ______ mins/secs
Appendix G: Post-intervention Questionnaire
Pilates Exercise for Chronic Low Back Pain

Please take time to read the questions carefully and answer them truthfully. If you are not sure how to answer a question, please mark it with a question mark (?) and we will clarify during the interview. To protect your anonymity please DO NOT write your name anywhere on the questionnaire.

Section 1:
1. Do you get leg pain below the knee?   Yes ☐   No ☐

2. In the past week how bothersome have the following symptoms been?
   (0–10, where 0 = no pain, 10 = worst pain imaginable)
   a. Lower Back Pain

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

   b. Leg Pain

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

Section 2:
1. When we assessed you initially, you told us that you had difficulty with the activities listed below. Today, do you still have difficulty with these activities?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

   Unable to perform activity

   Able to perform activity at the same level as before injury or problem

<table>
<thead>
<tr>
<th>Activity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
</tbody>
</table>

Average Score
**Section 3:**
During the past week, how troublesome have each of the following symptoms been? (Please put a cross (x) in the appropriate box on each row for each area that you have pain)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>No pain experienced</th>
<th>Not at all troublesome</th>
<th>Slightly troublesome</th>
<th>Moderately troublesome</th>
<th>Very troublesome</th>
<th>Extremely troublesome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head ache</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Neck pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Shoulder pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Elbow pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Wrist / hand pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Chest pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Upper back pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Lower back pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Hip/thigh pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Knee pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Ankle/foot pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Other pains</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
**Section 4:**

This questionnaire is designed to give us information as to how your back pain has affected your ability to manage in everyday life. Please answer every question by placing a cross in the one box that best describes your condition today. We realize that you may feel that 2 of the statements may describe your condition, but please mark only the box that most closely describes your current condition.

<table>
<thead>
<tr>
<th>Pain Intensity</th>
<th>Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can tolerate the pain I have without having to use pain medication.</td>
<td>I can stand as long as I want without increased pain.</td>
</tr>
<tr>
<td>The pain is bad, but I can manage without having to take pain medication.</td>
<td>I can stand as long as I want, but it increases my pain.</td>
</tr>
<tr>
<td>Pain medication provides me with complete relief from pain.</td>
<td>Pain prevents me from standing more than 1 hour.</td>
</tr>
<tr>
<td>Pain medication provides me with moderate relief from pain.</td>
<td>Pain prevents me from standing more than ½ hour.</td>
</tr>
<tr>
<td>Pain medication provides me with little relief from pain.</td>
<td>Pain prevents me from standing more than 10 minutes.</td>
</tr>
<tr>
<td>Pain medication provides me with no effect on my pain.</td>
<td>Pain prevents me from standing at all.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Care (eg. Washing, Dressing)</th>
<th>Sleeping</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can take care of myself normally without causing increased pain.</td>
<td>Pain does not prevent me from sleeping well.</td>
</tr>
<tr>
<td>I can take care of myself normally, but it increases my pain.</td>
<td>I can sleep well only by using pain medication.</td>
</tr>
<tr>
<td>It is painful to take care of myself, and I am slow and careful.</td>
<td>Even when I take pain medication, I sleep less than 6 hours.</td>
</tr>
<tr>
<td>I need help, but I am able to manage most of my personal care.</td>
<td>Even when I take pain medication, I sleep less than 4 hours.</td>
</tr>
<tr>
<td>I need help everyday in most aspects of my care.</td>
<td>Even when I take pain medication, I sleep less than 2 hours.</td>
</tr>
<tr>
<td>I do not get dressed, wash with difficulty, and stay in bed.</td>
<td>Pain prevents me from sleeping at all.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lifting</th>
<th>Social Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can lift heavy weights without increased pain.</td>
<td>My social life is normal and does not increase my pain.</td>
</tr>
<tr>
<td>I can lift heavy weights, but it causes increased pain.</td>
<td>My social life is normal, but it increases my level of pain.</td>
</tr>
<tr>
<td>Pain prevents me from lifting heavy weights off the floor, but I can manage if the weights are conveniently positioned (eg. on a table)</td>
<td>Pain prevents me from participating in more energetic activities (eg. sports, dancing).</td>
</tr>
<tr>
<td>Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned.</td>
<td>Pain prevents me from going out very often.</td>
</tr>
<tr>
<td>I can lift only very light weights.</td>
<td>Pain has restricted my social life to my home.</td>
</tr>
<tr>
<td>I cannot lift or carry anything at all.</td>
<td>I have hardly any social life because of my pain.</td>
</tr>
<tr>
<td>Walking</td>
<td>Travelling</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>☐ Pain does not prevent me from walking any distance.</td>
<td>☐ I can travel anywhere without increased pain.</td>
</tr>
<tr>
<td>☐ Pain prevents me from walking more than 1.6km.</td>
<td>☐ I can travel anywhere, but it increases my pain.</td>
</tr>
<tr>
<td>☐ Pain prevents me from walking more than 800m.</td>
<td>☐ My pain restricts my travel over 2 hours.</td>
</tr>
<tr>
<td>☐ Pain prevents me from walking more than 400m.</td>
<td>☐ My pain restricts my travel over 1 hour.</td>
</tr>
<tr>
<td>☐ I can only walk with crutches or a cane.</td>
<td>☐ My pain restricts my travel to short necessary journeys under ½ hour.</td>
</tr>
<tr>
<td>☐ I am in bed most of the time and have to crawl to the toilet.</td>
<td>☐ My pain prevents all travel except for visits to the doctor/therapist or hospital.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sitting</th>
<th>Employment/Homemaking</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ I can sit in any chair as long as I like</td>
<td>☐ My normal homemaking/job activities do not cause pain.</td>
</tr>
<tr>
<td>☐ I can only sit in my favourite chair as long as I like.</td>
<td>☐ My normal homemaking/job activities increase my pain, but I can still perform all that is required of me.</td>
</tr>
<tr>
<td>☐ Pain prevents me from sitting for more than 1 hour</td>
<td>☐ I can perform most of my homemaking/job duties, but pain prevents me from performing more physically stressful activities (eg. lifting, vacuuming)</td>
</tr>
<tr>
<td>☐ Pain prevents me from sitting for more than ½ hour.</td>
<td>☐ Pain prevents me from doing anything but light duties.</td>
</tr>
<tr>
<td>☐ Pain prevents me from sitting for more than 10 minutes.</td>
<td>☐ Pain prevents me from doing even light duties.</td>
</tr>
<tr>
<td>☐ Pain prevents me from sitting at all.</td>
<td>☐ Pain prevents me from performing any job or homemaking chores.</td>
</tr>
</tbody>
</table>

**Section 5:**

*(We will complete this)*

Fingertip to floor _____________ cm

Schober Index _____________ cm
Appendix H: Author Guide for Submission to the Journal of Bodywork and Movement Therapies
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Official journal of the:

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